

Physics in Our Lives

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COMSATS

Commission on Science and Technology for Sustainable Development in the South

7-A

COMSATS' Series of Publications on Science and Technology

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Published: July 2005

Printed by: A.R. Printers

This book is published under the series title *COMSATS' Series of Publications on Science and Technology*, and is number 7-A of the series.

Copies of the book may be ordered from :
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4th floor, Shahrah-e-Jamhuriat
Sector G-5/2, Islamabad, Pakistan
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PHYSICS IN OUR LIVES

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FOREWORD

Throughout world history, different civilizations have attempted to better their living through science and technology. Science and technology have had a fundamental impact on the way people live today, from the early use of the first metal-tools by Neolithic people, to children receiving vaccination-shots today. Different eras in history, like the period of Neolithic Revolution; eras of Classic Civilizations such as, the Greeks, Romans, and Chinese; Renaissance Europe; and the Golden Age of Islam, have been marked by important discoveries in science.

Ever since Galileo, physicists have been pioneers in research and their contributions in this field have ameliorated our way of living. Research in Physics allows us to look forward to a future that holds even more exhilarating breakthroughs and advances. The studies of physicists range from the tiniest particles of matter, to the largest objects in the universe. They have made possible the luxuries and conveniences inside our houses - such as energy-efficient heating-systems, personal computers and CD players. Much of the technological equipment and techniques used by other scientists were also originally developed by physicists, such as, X-rays, MRIs and other medical instruments, to safely study the human body, diagnose and treat diseases. From saving lives to saving our environment, and to promoting knowledge in other areas of science, the contributions of physicists have always been extraordinary.

Keeping in view the importance of Physics in the modern society and in order to celebrate the 100th anniversary of the most famous five papers published by Albert Einstein, the year, 2005, has been declared the 'World Year of Physics' (WYP) by the General Assembly of the UNO (United Nations Organization). WYP-2005 aims to facilitate the sharing of visions and convictions about physics amongst international community of physicists and the public.

In order to commemorate WYP-2005, COMSATS organized a two-day International Seminar on "Physics in Our Lives", on February 23-24, 2005, at Islamabad. This seminar was organized in collaboration with Pakistan Atomic Energy Commission (PAEC) and the National Centre for Physics (NCP), Quaid-i-Azam University, Islamabad. The basic purpose of conducting this Seminar was to bring to light the contributions that physicists have been making and can further make in the future; to improve the quality of life and; to provide a forum for interchange of ideas, between academia, research institutes and the industrial sector, pertaining to Physics and its role in society. Another objective of holding this Seminar was to facilitate the public awareness of physics, its economic necessity, its cultural contributions and its educational importance.

There were a total of 29 speakers in the Seminar who made presentations in five Technical Sessions, of which four were foreign experts representing countries of

Switzerland, Syria, Egypt and Sudan. Other participants included eminent physicists, heads of S&T institutions, scholars and students from various academic and research institutions.

The book contains eighteen papers from the afore-mentioned Seminar on 'Physics in Our Lives', and has been segmented into two broader categories, i.e., 'General Perspective' and 'Contributions of Physics to Specific Fields'. The papers in the first part take stock of the historic evolution of physics, while in the second part field-specific contributions of physics are detailed.

I would like to express my gratitude to Mr. Parvez Butt, Chairman, Pakistan Atomic Energy Commission (PAEC) and Prof. Dr. Riazuddin, Director General, National Centre for Physics (NCP) for their ardent cooperation and support for organizing this conference. Here, I would like to acknowledge the efforts of all the speakers and physicsts and my earnest praise also for Dr. M.M. Qurashi, Ms. Noshin Masud, Ms. Nageena Safdar, Mr. Irfan Hayee and Mr. Imran Chaudhry from COMSATS, whose devotion made possible the publication of this book.

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CULTURAL AND SOCIAL ASPECTS OF SCIENCE

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ABSTRACT

The impact of Physics on human culture, in particular on human intellect and the role of physics in social evolution of human society is described and discussed in the paper.

INTRODUCTION

"The knowable world is incomplete if seen from any one point of view, incoherent if seen from all points of view at once, and empty if seen from no where in particular."

Richard A. Shwder

"Why do Men Barbecue? Recipes for cultural psychology", Dr. Shwder being a social anthropologist is talking of interactions of various cultures in understanding the world. Science is also a part of human culture. How do we define culture? One may say, anything which enriches human-civilization, entirely because of its intrinsic value falls in the domain of culture. The essence of culture is in those things, which from purely utilitarian point of view may be useless. Philosophy: art; literature and music; mathematics and basic sciences are all part of cultural heritage. They generate social capital. Social capital creates an environment for an enlightened, tolerant society which values human life and rule of law. It keeps darkness in human soul in a dormant state. There is another aspect of culture, which is concerned with cultural traits of a society and its social evolution. Science has made tremendous contributions in the social evolution of mankind. Oscar Wilde once said, "a cynic knows the price of everything and the value of nothing. A bigot is a chronic cynic".

In a bigoted society, culture has no value and is least appreciated. In the Science-Year 2005, two plays — 'Galileo' by Bartolet Brechet and 'Copenhagen' by Michael Frayn, will be staged in the west.

Galileo has a very special place in the development of physics. He is regarded as 'father of modern science'. He challenged the authority of Aristotle. By performing a simple experiment by dropping two stones, he proved Aristotle wrong. He discovered 'law of falling bodies' (Terrestrial Gravity). He, thus, re-initiated the scientific method viz deduction of scientific laws from observations and experiments. He challenged the authority of Church and came decisively in favor of heliocentric (Copernican) system in which the Sun is at the centre of solar system and the planets, including the Earth revolve around it. This brought him in conflict with the Church, which regarded the Earth as the centre of the Universe (Ptolemic scheme), in which Earth remains stationary at centre, whereas planets including the Sun and moon revolve around it. Moreover, he came to the conclusion that there is no preferred frame of reference; the laws of Physics are invariant, i.e., have the same form in all inertial frames. To save his skin, he renounced his theory, but when he came out of prison, he said, "but it still moves". Galileo became victim of bigotry in Italy. The significance of Galileo's work is that he challenged the ancient beliefs, intolerance and suppressive social order.

THREE ASPECTS OF SCIENCE

Berchet wrote play about Galileo. The paper describes one scene from this play to illustrate three aspects of science and how they are appreciated (Occasion: Invention of telescope by Galileo), Curator (in his best chamber – of – commerce manner) Gentlemen: Our Republic is to be congratulated not only because this new acquisition will be one more feather in the cap of Venetion culture (Polite applause), not only because our own Mr. Galilei has generously handed this fresh product of his teeming brain entirely over to you to manufacture as many of these salable articles as you please – (considerable applause) – but, Gentleman of the Senate, has it occurred to you that – with the help of this remarkable new instrument – the battle fleet of the enemy will be visible to us full two hours before we are visible to him? (tremendous applause).

In this respect we are not behind, but a step ahead. Every thing is security-driven. It is strange but true that the ugly aspect of science is appreciated more reaching *"A science is said to be useful if its development tends to accentuate the existing inequalities in the distributions of wealth or more directly promotes the destruction of human life*."

G. H. Hardy; An apology of Mathematician with this prelude,

EVOLUTION OF PHYSICS

The paper now discusses evolution of Physics and its impact on society. The Greeks made remarkable contributions to human-civilization. They invented, philosophy, mathematics and science: They introduced the Deductive-method. From axioms, which they regarded "as a priori", they deduced results in a self-consistent manner. Euclidean geometry is one example of mathematics, which they invented. For them, pure thought was much superior than the work with hands or experimentation.

The Greeks also made remarkable contributions to Astronomy. Aristotle argued that the orbit of a planet must be a circle, because the circle is a perfect curve. Between ancient and modern European civilization, the dark ages intervened. Muslims and Byzantines preserved and unproved the apparatus of civilization. From the 12th century to 17th century, Ibn-Sina's treatise was used as a guide to medicine. Ibn-Rushd was more important to Christians than in Muslim philosophy.

From arithmetic's (numbers), which originated in India, a transition to algebra had been made in the Muslim era (Khawarizmi, Al Baruni and Omar Khyam). All these men were dead end for Muslim civilization, but for Christian civilization in Europe, they were a beginning. In the West, the access to Greek knowledge came through the Muslims. Although Muslims were better experimentalists than Greeks, they did not go much beyond observations.

In general, they did not deduce scientific principles from observations. At the most, they deduced empirical laws from them. They were more interested in practical applications, rather than building a scientific edifice. To build a scientific edifice, it is essential to go beyond the existing thought. The ruling-class was not prepared to tolerate any thought, which would have initiated departure from the orthodoxy prevalent at that time.

Europeans also passed through a similar period, but they came out of it by evolving into liberal democracies. Bertrand Russell has called the 17th century the century of science.

Not only were the foundation of mechanics and astronomy laid in this century (Copernicus, Galileo, Kepler & Newton), but some of the tools necessary for making the scientific observations were invented, e.g., Compound microscope (1590), Telescope (1608), Air pump, improved clocks, thermometer and barometer.

Remarkable progress was made in mathematics, e.g., Napier logarithm (1614), Differential and Integral calculus (Newton and Leibniz), Coordinate Geometry (Descartes). These discoveries in mathematics laid the foundations of higher mathematics in later years. It is remarkable that these discoveries were made by persons who were also men of faith: they never believed that their discoveries were in conflict with their religious beliefs.

Nevertheless, their discoveries implicitly implied that science and religion should not be mingled with each other. Their discoveries laid the foundation of a new concept that: natural phenomena can be understood by observation and rational thinking, without invoking the divine will. Magic and superstition thus became things of the past.

There is no space for an authority in science, all laws deduced from observations are tentatively subject to modification or change with new data. Theories are accepted by consensus. This is what Neils Bohr called ‘a republic of science’. It gave a new concept of man’s place in the universe. It was realized that inequalities between human-beings are products of circumstances. The circumstances can be changed through education, hence the importance of education.

PHYSICS IN THE 19th AND 20th CENTURIES

The industrial revolution began at the end of eighteenth century, with the invention of steam-engine. The industrial revolution preceded the science of thermodynamics which was developed in the nineteenth century. Most of the concepts beyond mechanics were developed in the 19th Century.

The 'First Law of Thermodynamics' (1830-1850), was an extension of Law of Conservation of Energy for purely mechanical systems. Clausius in 1850 (based on Carnot's work) stated the Second Law of Thermodynamics "Heat cannot go from colder to warmer body with out some accompanying change". Entropy was also introduced by Clausius in 1865. He then stated both the laws:

"The energy of the world is constant and its entropy strives towards a maximum".

Statistical interpretation of the Second Law was one of the great advances of the 19th century. In particular, Boltzman stated second law in precise form:

"For a time-reversal invariant dynamics (Newtonian Mechanics), macroscopic irreversibility is due to the fact that in the over whelming majority of cases, a physical system evolves from an initial state to a final state which is almost never less probable.

In the approach to equilibrium, the increase in entropy is not the actual but the most probable course of events."

Increase of entropy is linked to increase of disorder, which is irreversible. The irreversibility of evolution in biosphere is an expression of the second law. A simple mutation, such as, substitution of one letter in DNA-code for another, is reversible. However, for an appreciable evolution, a great many mutations successively accumulated at random; because of independent events that produce them, is irreversible. Also in 19th century two great conceptual revolutions, associated with Darwin (theory of evolution) and Maxwell (unification of electricity and magnetism) took place.

Electric environment is man-made. In nature, electricity is seen in lightening. Certain stones called magnetite exhibit magnetic properties. Nothing seems to be common between them. Basic laws governing electromagnetic phenomena were formulated (Coulomb, Ampere, Faraday) in 19th century. Faraday's Law of Electromagnetic Induction is a discovery of great importance, as thus made it possible to generate electricity directly from mechanical energy. Electric energy has a great advantage that it can be easily transported to homes and is used in numerous ways. We live today in an environment created by electricity.

The idea of electric and magnetic fields introduced by Faraday and Maxwell had a profound impact on the development of physics. Maxwell after modifying 'Ampere's Law' with the introduction of displacement-current, wrote the four differential equations, which show a symmetry between electric and magnetic fields. These equations encompass the whole range of electromagnetic phenomena.

A consequence of Maxwell's equations is that electric and magnetic fields propagate through space as waves, with the speed of light. Hertz experimentally demonstrated the existence of electromagnetic waves. His work gave stimulus for practical applications of Maxwell's equations. This is how electronic communication was born. One of the far-reaching impacts of Maxwell's equations is to give birth to a powerful tool in the form of electronic media, to shape the opinion of people for political aims or ideological indoctrination, or for marketing of product, especially by multinationals.

Never in the history of physics, did such an abrupt and unanticipated transition take place as during the decade 1895 - 1905. Roentgens discovered X-rays in 1895.Radioactivity was discovered by Becquerel in 1896. In 1897, J.J. Thomson discovered the electron - the first elementary particle. On December 14, 1900, Max Planck put forward the idea of the quantum. The emission and absorption of radiation from an atom take place in discrete amounts- that he latter called "quanta".

The discovery of atomic nucleus was announced by Rutherford in 1911. Neutron was discovered by Chadwick in 1932. Radioactivity is the only nuclear phenomenon, which is found on the Earth. Nuclear environment exists in star. With the development of nuclear reactors and nuclear weapons, an environment is created by human-beings, which is natural in stars.

The development of nuclear energy and nuclear weapons of mass-destruction have left a strong mark on modern society.

The birth of 'quantum theory' (1900) and 'relativity theory' (1905) marked the beginning of an era, in which the foundation of physical theory needed revision. The Transition from 'Newtonian mechanics' to 'special theory' and 'general theory of relativity' was smooth. Maxwell's equations are consistent with the theory of relativity.

But Newtonian mechanics is not compatible with the special theory of relativity; when it is made compatible with the special theory, one gets Einstein's famous equation $E=mc^2$. Another consequence of special theory was time-dilation, i.e., moving clocks are slowed down. The general theory of relativity is concerned with gravity. Einstein noted that gravity is always attractive, unlike electricity, where an electrically neutral system can exist. But gravity can never be switched off. So it is a property of space-time; due to existence of matter, the space-time becomes curved. He had the mathematical apparatus available in the form of Riemanian geometry to formulate his theory of gravity.

But the transition to 'quantum theory' was not smooth. It was like a revolution. As in a revolution, there is a period of turmoil and it takes sometime to restore a new order; this was also the case for 'quantum revolution'. New order was established by Heisenberg with his discovery of 'Matrix Mechanics' in 1925, and by Schrödinger by his wave-mechanics, a little bit latter. By unifying 'special theory of relativity' with 'quantum mechanics', Dirac predicted the existence of anti-matter. Determinism of classical mechanics is replaced by uncertainty principle, i.e., When events are examined closely, a certain measure of uncertainty prevails; cause and effect become disconnected; causal relations hold for probabilities; waves are particles and particles are waves; matter & anti-matter are created and destroyed (vacuum polarization); chance guides what happens.

The unification of terrestrial and celestial gravity by Newton; the unification of electricity and magnetism by Maxwell; the unification of 'special theory of relativity' with 'quantum mechanics' by Dirac were the hallmark of physics. In the same context, the unification of electromagnetism with radioactivity was achieved by Glashow, Salam and Weinberg in late 1960's, with prediction of a new kind of weak current, called the 'neutral week current', subsequently discovered experimentally in 1978. This unification also predicted the existence of massive week vector bosons called $W^{\pm}$, Z^{0} which mediate the weak force (responsible for radioactivity). W and Z bosons are partners of photon (quantum of electromagnetic field, which is mass-less and mediates the electromagnetic force).

Weak bosons were experimentally discovered in early 1980, at CERN, Geneva. C.P. Snow in his book "Two Cultures" divides the industrial revolution into three phases. The first phase, which began with the invention of steam-engine at the end of 18th Century, was mainly created by handy men, as C.P. Snow calls them. In the second phase of industrial revolution, chemistry played a major role. Giant chemical companies were established in Europe and USA. In the third phase of industrial revolution, atomic particles like electrons, neutrons, nuclei and atoms played a crucial role. This revolution is based on physics of the 20th Century. The birth of 'quantum theory', in the 20th century, had a tremendous impact on future development.

It is hard to imagine that without 'quantum mechanics', transistors, computer-chips and lasers could have been invented. According to Leon Lederman (Former Director of Fermi Lab) "If everything we understand about the atom stopped working, the GNP would go to zero".

Physicist Freeman Dyson calls the fourth phase of revolution 'tool-driven revolution'. Scientists develop new tools and computer-software. The craftsmanship used in their tools may initiate new technologies. Two examples: X-rays and nuclear-magnetic resonance Computed Axial Tomography (CAT), Magnetic- Resonance Imaging (MRI) scanning-technology revolutionized diagnostic techniques in medicine. It may also lead to some landmark discoveries in basic sciences. A prime example is the use of X-rays crystallography to study biological molecules.

Such a study led Crick and Watson to unfold the structure of DNA – the genetic code-perhaps the greatest discovery in biology after Darwin's work. The subsequent developments in DNA-testing, genetic engineering and bioinformatics had made an enormous impact on human society. Another example is the World-Wide Web (www), developed at CERN, for basic research, which has revolutionized the information-technology.

On the other hand, tremendous progress in space-technology has been used to put the probe in outer space, to study the structure of universe.

The paper concludes that science has made such an enormous impact on the human-intellect that it drastically changed human-living. Scientific discoveries are beautiful, but scientific inventions can be good or bad.

IMPACT OF S&T ON HUMAN SOCIETIES

There is no doubt that science and technology have made the remarkable contributions to raise the standard of living and to improve the quality of life. But it has also increased the gap between the rich and the poor. While, on one hand, tremendous progress in the medical sciences, immunology and drugs has alleviated the human-sufferings and has increased the span of life; yet, on the other hand, it has increased the destructive power of man in the form of weapons of mass destruction.

Excessive use of technology has increased industrial pollution several fold. This poses a long-term threat to natural environment, which would effect the quality of life. Science by itself does not guarantee the genuine progress of society, though it is one of the ingredient for progress. Social capital is needed for synthesis of society: to narrow the gap between the rich and the poor.

CONCLUSIONS

It took millions of years for biological evolution through natural selection. Evolution in the biosphere is necessarily an irreversible process. Time-scale for social evolution is much smaller – it took less than 10,000 years for an appreciable social evolution. Is social evolution reversible? We do not have a second law for the social sphere, although social structure is also complex. History tells us that any great civilization, which has decayed, has never come back in its original form. Those who dream to regain lost glory and do not want to go above the past are defying this history.

P. R. Mooney in an article (in the Development Dialogue 1999, published by Dag Hammerskjold Foundation) has expressed the viewpoint that 21st century will be the ETC century. ETC stands for 'Erosion, Technological Transformation and Corporate Concentration'.

Erosion includes not only genetic erosion and erosion of species, soils, and the atmosphere, but also the erosion of knowledge and the global erosion of equitable relations. Technology means new technologies, such as biotechnology, nanotechnology, informatics and neuroscience. Concentration describes the re-organization of economic power into the hands of high-tech global oligopolies. The ETC combination could lead to a world of cyber-cabbages and Nano-kings.

American writer O. Henry described Central American at the dawn of 20th century – a ‘banana republic’. Were he alive, O. Henry might well call the coming world-order, ‘the Binano republic.

Mooney’s predictions are based on linear extrapolation from 20th century to 21st century. But for a complex system, linear extrapolation may not hold. However, the recent trends indicate that some of his observations may soon come through.

“The only sensible thing to say about human nature is that it is “in” that nature to construct its own history.” (Rose, Lewonton and Kamin, “Not in our Genes”).

The Future will tell how human-beings construct their own history.

EVOLUTION AND IMPACT OF PHYSICS ON OUR LIVES

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ABSTRACT

Physics is the most basic of all sciences and its importance in our everyday life cannot be emphasized enough. However, to capture the true picture of physics' contribution to improving mankind's quality of life, one must take a journey back in time and follow the road to the evolution of science and technology in general and physics in particular.

This paper gives an unbiased account of the series of events that led to the evolution and development of physics as we know it today. Starting from the Big-Bang, this paper journeys through various eras during which science developed and thrived. Major contributions by eminent scientists in this connection are highlighted. The fruits of S&T development especially in the field of physics, and its impact on our day-to-day life are also discussed in detail, underlining the involvement of physics in our personal as well as professional lives. Finally, the author details the role of physics in the 21st century and leaves its readers with a list of open-ended questions to further generate knowledge in the field of physics.

"The whole of science is nothing more than a refinement of everyday thinking"
Albert Einstein

1. WHAT IS PHYSICS AND WHAT MAKES A PERSON A PHYSICIST?

The earlier explanations of physical phenomena were ascribed to mythical gods who played key-roles in creating and preserving the world. These myths, elaborated upon and added to by the men who told and retold them from generation to generation, reflected man's continuing need for support. His sentimental responses to his environment largely shaped these myths. The world, as early man knew it, was vastly different from the world we know today, even though the rivers, the oceans, the mountains, the sun and the moon, the planets and stars are all essentially the same. The change has come in man himself. As he changes, he must describe his world differently. To a person born into an age of rapidly evolving technology, physics tends to be associated with the useful devices like, T.Vs, refrigerators, airplanes, ships, rails, rockets, missiles, bombs, electronic equipments used in medical centers, machines in factories. Computers, etc. But in a more complete sense, physics is an intellectual activity rather than being a purely technological one. Physics has explained the energy-mass conversion, time-space relationship, order and disorder, self-organization, chaos, uncertainty, wave-particle duality, etc.

Physics may be thought of as knowledge that has been accumulated from observations of physical phenomena, systematized, and formulated with reference to general statements in the form of 'theories' or 'laws', which provide a grasp or a sense of greater understanding of the world in which we live.

Science (or Physics) looks into the material world objectively. What one person (a scientist) observes or predicts theoretically can be verified by the others, provided the required conditions can be achieved. To elaborate our point, we can just quote one particular example. Different poets will describe the moon in different ways because of subjective vision, while all the physicists will describe the moon in the same way. First-hand observation and personal experience with phenomena are essential elements in sciences.

When we start learning physics, we begin with motion. Velocity, acceleration, force, mass, energy, momentum—these are some of the concepts that are found in an elementary physics course. The principles developed can apply to the motion of anything-planets, electrons, athletes, owls, glaciers…Physics is really the study of everything in the universe.

What Makes a Person a Physicist ?

In principle everybody who asks questions about the physical things and physical phenomena around him is a physicist. Yes a child is also a physicist. Then why only a few persons are called physicists? The answer is very simple but important. A physicist is not only a person who asks questions momentarily and then forgets. A physicist is a person who remains in search of answers to his questions. Physicist speculates, makes hypotheses, and carries out experiments, form theories and laws about the working of nature. A physicist also remains unsatisfied throughout the life due to his curiosity and quest for knowledge.

Physics is an organized way of conversing with nature. Physicists ask questions; nature responds. For many questions, the answers are almost predictable, but when the question is a particularly good one, the answer can be unexpected and gives us new knowledge of the way the world works. These are the moments physicists live for.

To a physicist, the term “absolute truth” is also a relative term. From a physicist's point-of-view, we are absolutely certain of nothing in the real world. There is talk of a “final” theory, a theory of everything. (Right now, we have sort of a patchwork. Quantum mechanics and gravitation are disconnected, for example.) It may happen that we achieve a single theory for all of physics, but we can never be 100% certain that it is exactly correct. It could happen that a final theory will be developed, but we won't know for certain that it is final! When people talk about a final theory, they are not saying that we will know everything. It would in fact be a new beginning in the search for knowledge.

The fundamental ideas of physics underlie all basic sciences: astronomy, biology, chemistry, and geology. Physics also is essential to the applied science and engineering that has taken our world from the horse and the buggy to the supersonic jet, from the candle to the laser, from the pony express to the fax, from the beads of an abacus to the chips of a computer.

Branches of Physics

Since physics is the study of whole universe, therefore, it has been divided into several branches. If we look deeper and carefully then even chemistry and biology would be the branches of physics. But for the sake of clarity and simplicity we have to classify the study of nature into several subjects. Each one of these subjects has the basis on the principles of physics. For example, a very simple view about chemistry can be that it deals mainly with those reactions among elements and compounds, which are due to the electronic structures of atoms and molecules. Similarly biology is the study of living things. But the behavior, development and evolution of living things are based on laws of physics. For example our brain sends electronic signals to different organs of the body, which work for us. At present, we shall assume physics to be a subject different from chemistry, biology, botany, etc. To be specific, we may define physics as the subject that deals with the fundamental forces of nature, and the constituents of matter all over universe. There are several branches of physics, which include:

- Astronomy, Atomic Physics, Cosmology, Dynamics, Electricity, Electrodynamics, Field Theory, High Energy Physics (also known as Particle Physics), Hydrostatics / Hydrodynamics, Magnetism, Mechanics, Nuclear Physics, Optics, Particle Physics (also known as High Energy Physics), Plasma Physics, Quantum Electrodynamics (also known as Quantum Theory of Light or Quantum Theory of Radiation), Quantum Mechanics, Solid State Physics, Statics, Surface Physics, Thermodynamics, Wave Mechanics etc.

If we go back in time, the evolution of physics is inherently driven by the quest of mankind to learn and to know, so it is, a priori, without any other names (business, communications, enegy, defense, etc). The next part of this paper would shed light on the evolution of physics.

2. EVOLUTION OF PHYSICS: HISTORIC PERSPECTIVE

The modern era is characterized by innovation and progress in virtually all walks of live. Over time, almost all sectors of society have experienced dynamic advancements, which have allowed mankind to devise ways and means to improve and uplift the quality of its life. Without a doubt, the modernization that we experience today did not occur over a period of mere years, but evolved over a timeframe of centuries.

Nevertheless, one can safely state that science and technology have been the forerunners of most modern revolutionary achievements, and it is only due to the progress in these fields that one experiences a complete transformation from the stone-age to the current age, distinguished by comfort and sophistication.

2.1 The Greek Period

Early traces of the evolution of science can be dated back to the 7th century BC-Greek era; however, those of technology are difficult to identify. It is often said that technology came before science, because mankind in its primitive ways pursued methods of repetitive hit and trial until a way was found to satisfy the requisite need. The mother of all inventions, need, led man to do technology long before he could or would do science. It is for this reason that some historians and technologists go to the extent of stating that the wheel, which is considered to be the invention that fueled the S&T evolution, was invented by technology and not science!

So, what are the historical patterns that led to the evolution of science, as we know it today? History considers earlier scientists before the Greeks to be mostly philosophers than scientists. It is the Greek era which saw some scientific progress and advancement. The contributions of Pythagoras, Plato, Aristotle and Archimedes, in the fields of astronomy and mathematics during this period, laid the foundations of developing science, especially physics in the future. It is said that Aristotle, Euclid and Ptolemy were the first three great synthesizers of science, who summarized

Table - 1: Questions and Answers at an Ancient Symposium

Question (King of Egypt)	Answers (King of Ethiopia)	Answers (Thales of Greece)
Τiπρεσβυτατον; What is the oldest thing?	Χρονοζ Time	Θεος God
Τμεγιστον What is greatest?	Κοσμοζ The Universe	Χωρος Space
Τiκαλλιστον, What is most beautiful?	Φως Light	Κοσμος The universe
Τσοφωτατον What is wisest?	Αληθεια Truth	Χρονος Time
Τκοινοτατον What is most common?	θανατος Death	Ελπις Hope
Τιωφελιμωτατον; What is most helpful?	θεος God	Αρετη Virtue
Τβλαβερωτατον; What is most harmful?	Δαιμων Demon (An evil spirit)	Κακια Vice
Τι ιαχυροτατον; What is strongest?	Τυχη Luck (Fortune)	Αναγκη Necessity
Τραστον; What is easiest?	Ηδυ Pleasure	Φυσικον The natural

respectively, Greece's contributions to general science, mathematics and astronomy. Aristotle, who was the tutor of Alexander, later became his scientific advisor, claiming the position of first scientific advisor in history. History also records the events of mankind's first scientific symposium, which was held in Corinth, Greece, during the 6th century BC. The agenda of the symposium was to answer the questions of the King of Egypt, Amasis, who posed these questions to both Greece and Ethiopia. The King of Ethiopia and Thales of Miletus answered in response (Table-1) detailing not only the flavor of scientific philosophy outlook maintained by each culture during those times, but also the difference of the nature of scientific inquiry then, as compared to today.

2.2 Romans and Chinese Period

After the Greeks, history experienced the era of the Romans, who were more focused on technology than science and, therefore, this period experienced a little progress in the realms of science itself. During the period of 'After Jesus', the Chinese made noteworthy contributions to science and technology (papermaking, gunpowder), and then came the era of the Muslims.

2.3 Muslim Period

The Muslims helped spreading the influence of science from the Mediterranean eastward into Asia, where it picked up contributions from the Chinese and the Hindus, and westward as far as Spain, where Islamic culture flourished in Córdoba, Toledo, and other cities. Though little specific advances was made in the realms of physics, the Muslims ensured preservation of Greek science and kept it alive during this period.

The much preserved and patronized science kept by the Muslim world made possible the revival of learning in the West, beginning in the 12th and 13th century. During this period, the Muslims experienced their downfall, not only in terms of their dominance in the world, but also in terms of their dominance in science. The Mongols destroyed Baghdad, which was one of the centres of Muslim scientific literature and civilization. Though the Turks continued to patronize science, much of the libraries and books preserved by the Muslim world no longer existed. In the year 1453, Istanbul also fell to the Turks. During this period, the intellectual community of the Muslims (especially those who spoke Latin) fled to Western Europe, more specifically Italy and then on to Greece. With their comfort in communication, they helped spread scientific knowledge in European languages across the western part of the continent.

Some of the books of Muslim scholars and scientists that were even translated into Latin and other European languages are listed in the Table-2.

2.4 Renaissance

During the dark and middle ages of Europe, the Church was in control of the State, and religion guided the society to abide and follow what was divine decree without questioning. As the norms of these ages promoted nothing but blind following, the culture of science in Europe could not develop, as science dwells purely on query. During the period of renaissance, the control of the church weakened and people started questioning religious and societal beliefs. In this environment, scientific queries were also re-generated, which marked the beginning of an era of progress and development in science and its realms.

The period of renaissance also experienced a strange phenomenon, called 'Black Death'. This Black Death was a fatal disease that spread unchecked in much of Europe killing majority of the population, especially the labor class. Given this scenario, an impression arose in Europe to find an alternative to dispensable labor. This is how the era of the machines began and the reign of industrialization originated.

Table - 2: Translations of Muslim Scientists' Books into Latin and other European Languages

NAME	LATIN / ENGLISH / FRENCH / GERMAN TRANSLATION
Jabir Ibn Haiyan (Geber)	The Book of the Composition of Alchemy, Book of Kingdom, Book of the Balances, Book of Eastern Mercury, Sum of Perfection (all translated by Berthelot).
Al-Battani (Albategnius)	De Scienta Stellarum – De Numeris Stellarum et motibus (12th cent.), Al-Zij (Rome, 1899).
Al-Farghani (Al-Fraganus)	Scientia Stellarum, Jawami "The Elements" (Latin 1170-1187; Hebrew 1590; Latin 1669)
Al-Razi (Rhazes)	Continens (1279), Liber Almansoris (1480s, several editions ending in 1890), Nonus Almansuri, Liber Experiimentorum, Al-Judari wa al-Hasabah (London, 1848).
Al-Masu'di	Meadows of Gold and Mines of Precious Stones (London, 1841)
Ali Ibn al-Abbas (Haly Abbas)	LIber Regius (12th cent.)
Al-Zahravi (Albucasis)	Surgical Part of Al-Tasrif li man Ajazaan al-Taalif
	(Venice 1497, Basle 1541, Oxfored 1778)
Al-Haitham (Alhazen)	Opticae Thesaurus (12th cent., also in Hebrew)
Al-Biruni	Al-Biruni's India (London, 1914), Kitab al-Tafhim (Luzac, 1934), Book on Precious Stones (1941), Parts of Kitab al-Saydan (1945)
Ibn Sina (Avicenna)	Canon (1170-87), Sanatio (12th cent.), "A Treatise on the Canons of Medicine of Avicenna (1930), Book of Healing.
Al-Zarqali (Arzachel)	Toledan Tables (12th cent.)
Omar Al-Khayyam	Maqalat fi al-Jabr wa al-Muqabila, Rubaiyat (Quatrains, 1859, Tr. Fitzgerald)

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Ibn Zuhr (Avenzoar)	Kitab al-Taisir fi al-Mudawat wa al-Tadbir, Kitab al-Iqtisad fi Islah Al-Anfus wa al-Ajsad, Kitab al-Aghziya (12-13 th. Cent.).
Al-Idrisi (Dreses)	Al-Kitab al-Rujari (Roger's Book, 12th cent.), another in Latin (Rome, 1619, published using only Translator's name), Nuzhat al-Mustaq fi Ikhtiraq al-Afaq
Ibn Rushd (Averroes)	Colliget (13th Cent.), Almagest (1231 tr. Into Hebrew),.
Nasir Al-Din Al-Tusi	Figura Cata (14th cent.)
Al-Fida (Abdulfeda)	Geographie d'Abouldfeda (Paris, 1848)
Ibn Khaldun	Muqaddimah (Prolegokena) (1981 Prinbceton), Kitab al-I'bar, Al-Tasrif.
Ulugh Beg	Tables of Planetary Motions
Al-Maqdisi	Book of Divisions for the Study of Climate (1897)
Yaqut al-Hamdavi	Mu'jam al-Buldan (Lepzig, 1924), Mu'jam al-Ubada (London, 1913).
Ibn al-Qifti	Tarikh al-Hukuma, (Leipzig, 1903)
Al-Istakhri	Kitab al-Masalik wal Mamalik (abridged) (London, 1800)
Abul Faraj Qudamah	Kitab al-Faraj in Biblioteca Geographorum Arabicorum (Leiden, 1870-94)
Al-Damiri (Zoologist, 1405-)	Hayat al-Hayawan (London 1906, 1908, Tr. Jayakar)
Ahamd Ibn Majid (piloted Vasco da Gama's ship)	Al-Fawaid fi Usul al-Bahr wal-Qawaid (Paris, 1921-23, Tr. Ferrand)

2.5 16th to 19th Centuries

Science in Europe started off in the 16th century, when European scientists re-discovered the 'experimental method', which was a new and alternative way of finding the truth. This new method was a way to systematically test hypotheses and theories and to validate observations and deductions through direct interrogation of nature. Thus, Europe now not only focused on discovering what was new and unexplored but also challenged the established beliefs, thereby laying the foundations of alleviating science as we know it today.

Nicolaus Copernicus is amongst the first scientists who signalled the dawn of science in renaissance Europe. He challenged Ptolemy's geocentric planetary system and proposed instead a heliocentric one. His rejection of an established doctrine is recorded as the first of such major events to have propelled the scientific chain-reaction. This was followed by the astronomical observations of Tycho Brahe (1546-1601), which led Johannes Kepler (1571-1630) to establish his three empirical laws of planetary motion. The seeds of the scientific method, whereby theories and hypothesis were formulated in such a way that they could be tested against accurate observations, were sown during this time. Soon after Kepler, the era of Galileo Galilei (1564-1642) began, during which he developed the telescope, invented the thermometer, used the motion of the pendulum to measure time and established the science of kinematics. This period is justly termed as the era of the development of the scientific technique, where the emphasis was on the appreciation of the power of scientific instruments.

Galileo was born in 1543 and died in the year 1642; coincidently the same year that Isaac Newton was born. The physics of Newton during his era is considered to be remarkable in the true sense of the word. It is from here that the foundations of modern science and modern physics were grounded. The full explanation of celestial and terrestrial motions was not given until 1687, when Newton published his Principia [Mathematical Principles of Natural Philosophy]. This work, the most important document of the Scientific Revolution of the 16th and 17th centuries, contained Newton's famous three laws of motion and showed how the principle of universal gravitation could be used to explain the behavior not only of falling bodies on the earth but also planets and other heavenly bodies. To arrive at his results, Newton invented one form of an entirely new branch of mathematics, the calculus (also invented independently by G. W. Leibniz), which was to become an essential tool in much of the later development in most branches of physics. With Newton began the sharpening of the definitions of the scientific vocabulary, especially the basic concepts of space, time and the derived quantities of velocity and acceleration.

As Snow puts it, dating the scientific revolution is 'a matter of taste'; however, the middle of the 17th century is usually regarded as the beginning. At this stage, the journey of science that originated in mystery, had passed through astrology and astronomy, moved on from geocentric to heliocentric descriptions of the solar system, gone from circular to elliptic orbits of the planets, progressed from kinematics to dynamics and finally reached the grand synthesis of Newton and classical mechanics.

In the 17th century, focused and specific interrelationships between science and technology were quite minimal; however by the end of the 18th century, things improved quite a lot. The basis of industrial revolution, which was established in 1765 when Watt invented the steam engine, was solely propelled by invention and not science. However, by the end of the 19th century, the interaction and inter-linkage of scientific discovery and industrial revolution had materialized. As a result, this intertwining of basic science and technological advancement led to the surfacing of integral industries, such as the chemical, engineering, electrical, electronics and transportation industries, as well as the many industrial uses of atomic particles besides others.

Nevertheless, the period of early 18th century up till early 20th century is appropriately denoted as the time when the foundations of modern science were laid. During these 200 years or so, science moved from Newton on to Einstein, from macrocosmos on to microcosmos and from classical physics to quantum physics. The key characteristics of this era include critical observations, ingenious experiments, unique insight and patient incremental understanding, which ultimately led to amazing and unorthodox synthesis and suggestions. This was an era of gradual

Table - 3: Early Scientiifc Journal

Year	Publication	Details
1665	"Le Journal des Scavans"	• French Journal • One of the earliest scientific journals
1665	"Philosophical Transactions"	• One of the earliest scientific journals • This British Journal appeared a few months after the French Journal
1687	"Principia"	• Newton's great work, which includes his 3 laws of motion and also the law of universal gravitation
1790	"Journal der Physik"	• Considered to be the first specialized journal in physics • First issued in Halle and Leipzig
1798	"Philosophical Magazine"	• English Magazine
1848	"Science Magazine"	• One of the top rated magazines
1869	"Nature Journal"	• One of Europe's most famous journals

evolution, intermittent revolution through discoveries, independent development of fundamental modern scientific fields, as well as intertwined and interlinked progression of cross-disciplinary realms. During this time-frame, science was led by innovation breeding innovation, which materialized the establishment of the broadest laws of science.

Following in the footsteps of Newton, the realms of classical physics and celestial mechanics were further developed by eminent persons such as P.S. Laplace, J.L. Lagrange, J.B. Fourier, W.R. Hamilton, S.D. Poisson, C.G.J. Jacobi and H. Poincaré. New and important mathematical methods, including differential calculus and partial differential equations, and concepts including potential energy were established, forming the basis of modern science, which augmented the emerging fields of electricity, magnetism, heat and thermodynamic equilibrium.

Modern science, especially physics, flourished during this period. In 1788, Charles-Augustin de Coulomb (1736-1806) formulated his inverse square law of force for electric charges, which was an evocation of Newton's law for mass. Also in the 1780's, Luigi Galvani (1737-1798) accidentally discovered an electric current in the sense of a continuous flow of charge that could be set up and controlled at will. Later, Alessandro Volta (1745-1827) showed that if the two dry ends of a copper and zinc rod were immersed in sulfuric acid and connected by a wire, a current flowed through the system. This was the birth of the first battery or the Votaic cell. This discovery laid the foundations of the development of the electrical industry and scientific instruments to measure current and voltage. From here, research in the field of electricity moved from electrostatics on to electrolysis and finally electromagnetism, when in 1820, Christian Oersted accidentally found that an electric current generates magnetism. This discovery was followed by Michael Faraday's discovery of electromagnetic induction in 1831. The discovery of production of an electric current by the motion of a magnet by Faraday and the discovery of the influence on a magnet by motion of electric charge by Oersted demonstrated that electricity and magnetism are interconnected.

However, the final confederacy of electricity and magnetism was achieved through the work of James Clark Maxwell (1831-1879), who was a great synthesizer. He built upon the concepts of Faraday's idea of the field, Gauss's law of electricity, Gauss's law of magnetism and Ampére's law relating to the current flowing in a wire to the magnetic field around it. Maxwell concluded that accelerating electric charges generate electromagnetic waves traveling with the speed c, independent of their wavelengths and that all electromagnetic waves have the same speed when traveling in vacuum. This synthesis of Maxwell consequently became the theory of light. The speed of light c has become one of the most fundamental constants in all science, and is especially crucial to the theory of special relativity, which was postulated forty years later. In 1887, Henry Rudolf Hertz demonstrated the existence of electromagnetic waves and, later, through the Zeeman and Kerr effects relationships between light and electromagnetism were further substantiated.

The end of the 18th century is considered to be the time when chemistry emerged as a scientific discipline and with this emergence came the first evidence that matter is constituted of atoms. Consequently, in 1808 John Dalton proposed the atomic theory of matter. The discovery of the concept that matter comprises atoms paced-up the systematic study of chemical phenomena and culminated in the realization that there is a great degree of order in the chemical behavior of different elements. But perhaps, the most fascinating of all realizations was that everything in the cosmos consists of nothing else but the same and finite elements. It is the infinite combinations of these elements and their recycling that defines the infinite variety of nature.

2.6 Physics of the 20th Century

It was quite clear by the beginning of the 20th century that the most fundamental entities of nature are not atoms. It is indeed a great achievement of mankind to have uncovered the secrets of the inner structure of the atom.

Near to the end of the 19th century, scientists realized that classical mechanics had its limitations and was unable to explain a number of upcoming phenomena. Therefore, it was time for a new fusion and a new era, in which revision of established ideas would take place and a broader vision would be established. This was to be the era of Max Planck and Albert Einstein. Both these scientists had a thorough understanding of the subjects of thermodynamics and statistical mechanics and, undoubtedly, were blessed with great scientific intuition. Quantum physics and light quanta evolved due to the resolution of the new phenomena regarding emission and absorption of electromagnetic radiation by matter. The revision of the concepts of space and time, as well as the establishment of the special theory of relativity was postulated from the resolution of the propagation of electromagnetic waves in empty space. Such were the accomplishments of scientists of this era.

Although, relativity resolved the electromagnetic phenomena conflict demonstrated by Michelson and Morley, a second theoretical problem was the explanation of the distribution of electromagnetic radiation emitted by a black body; experiment showed that at shorter wavelengths, towards the ultraviolet end of the spectrum, the energy approached zero, but classical theory predicted that it should become infinite. This glaring discrepancy, known as the ultraviolet catastrophe, was resolved by Max Planck's quantum theory (1900). In 1905, Einstein used the quantum theory to explain the photoelectric effect, and in 1913 Niels Bohr again used it to explain the stability of Rutherford's nuclear atom. In the 1920s, the theory was extensively developed by Louis de Broglie, Werner Heisenberg, Wolfgang Pauli, Erwin Schrödinger, P. A. M. Dirac, and others; the new quantum mechanics soon became an indispensable tool in the investigation and explanation of phenomena at the atomic level.

Indeed, special relativity has provided a new set of rules for measuring time. Absolute time is not how one defines time. Time is a relative quantity and the rate at which it passes depends on one's motion. A general scientific truth thus emerged, which entailed that the laws of nature remain the same, regardless of the relative motion of the observer. It is not only the concept of time which has been revised, but also those pertinent to mass, space and energy. Now, the concepts of absolute time and space of Newtonian mechanics have been replaced by the new absolutes that speed of light c is a constant, which cannot be exceeded. Special relativity has also unified the concepts of mankind regarding mass and energy, by showing the equivalence of both. The discovery of nuclear fission by Otto Hahn and Fritz Strassmann (1938) and its explanation by Lise Meitner and Otto Frisch provided a means for the large-scale conversion of mass into energy, in accordance with the theory of relativity, and triggered as well the massive governmental involvement in physics that is one of the fundamental facts of contemporary science. The growth of physics, since the 1930s, has been so great that it is impossible in a survey article to name even its most important individual contributors.

Among the areas, where fundamental discoveries have been made more recently are solid-state physics, plasma physics, and cryogenics, or low-temperature physics. Out of solid-state physics, for example, have come many of the developments in electronics (e.g., the transistor and microcircuitry) that have revolutionized much of modern technology. Another development is the maser and laser (in principle the same device), with applications ranging from communications and controlled nuclear fusion experiments, to atomic clocks and other measurement standards.

3. PHYSICS IN OUR LIVES

In the last decades, scientific knowledge and technology have grown at a spectacular rate, and had a dramatic impact on society. There is however, a long and complex way to go between a new scientific discovery and its effects on society. Most citizens will only become aware of such discovery, when it concerns a spectacular new scientific insight and, if the media decide to bring it to the people's attention. And then in most cases they rightly will be told at the same time that it may take many years before we can expect any practical application of this discovery. But it is precisely these practical applications that have an impact on society.

Even if there are no practical applications, scientific discovery still is a cultural enrichment for society. Therefore, science is one aspect of culture. And it would be worthwhile to make this aspect of culture accessible to more people. Nevertheless, scientific discoveries only have a substantial impact on society, if they ultimately lead to attractive new or improved products, with which we will deal in our day to day lives. And for this conversion of science into products, we need technology. Without technology, most of our durable goods, public utilities, consumables and services would simply not exist. And physics is one of the most important sciences that are responsible for these developments.

3.1 Impact of Physics on Mankind

The present age is different from all the previous eras only because of the scientific inventions, which are in daily use of mankind. The life of today's human being is completely dependent upon the machinery and industry. The bicycles, cars, motor vehicles, rails, aeroplanes, telephones, wireless, T.Vs, radios, electrical appliances in houses, hospitals and offices all are due to the application of physical laws. The industrial revolution is based on technology, which is the application of physics and other branches of science. The life is so much dependent upon technology now a days that most of the intellectuals, literary persons (poets and writers) and even the scientists are thinking that the use of mechanics has "made the man himself like a machine". This is an unpleasant aspect of the technological development. We have discussed that the development of science has been continuously in progress since prehistoric times. This speed of development achieved the greatest impetus by the end of 19th century and in 20th century man became able to see into the world of atom and mysteries of galaxies. Man reached moon and explored the deserts of empty space and expanding galaxies.

Moreover, it is hard to maintain that scientific discoveries only have impact on society if they lead to products. One must think about the impact that Galileo had on thinking and religion or the impact of quantum mechanics on philosophy and the arts.

3.2 Physics in Everyday Life

The most basic of the sciences, physics, is all around us. If you have ever wondered what makes lightening, why a boomerang returns, how ice-skaters can spin so fast, why waves crash on the beach, how does a tiny computer deal with complicated problems, or how long does it take the light to travel from a star to reach us? You have been thinking about some of the same things physicists study every day.

Physicists like to ask questions. If you like to explore and figure out why things are the way they are, you might like physics. If you have had a back-row seat in a concert, and could still hear, you experienced physics at work! Physicists studying sound contribute to the design of concert halls and the amplification equipment. Knowing more about how things move and interact can be used to manage the flow of traffic and help cities avoid gridlock.

Lasers and radioactive elements are the tools used against the war on cancer and other diseases. Geophysicists are developing methods to give advance warning of earthquakes. They can explore what is beneath the surface of the Earth and art the bottom of the oceans. The work of physicists made possible the computer chips that are in your digital watch, CD player, electronic games, and hand-held calculator. It is the physics that lets us watch shows movies, matches, games and news at our houses through TV and VCR. There are so many examples where physics is in use in our daily lives that one cannot mention all in a lecture.

3.3 Physics in Professional Careers

Physics offers challenging, exciting, and productive careers. As a career, physics covers many specialized fields from acoustics, astronomy, and astrophysics to medical physics, geophysics, and vacuum sciences. Physics offers a variety of work-opportunities such as lab supervisor, researcher, technician, teacher as well as manager. Physics opens doors to employment opportunities throughout the world in government, industry, schools, and private sectors.

3.3.1Elementary or Middle School Teaching

It has been said that children are born scientists. This is the best illustrated by the questions they constantly ask. Teaching at the elementary or middle school level presents the challenge of keeping their curiosity alive while teaching new ideas.

Why do you get shocks in cold as well as during dry weather? Does a stick of dynamite contain force? What makes rainbow from? How cold can it get? Individuals who themselves appreciate science often have a special gift for teaching young children. Curiosity about the world around us is a common bond of children and scientists.

3.3.2 Sports

When you watch an athlete, you are seeing all the principles of physics in action. The bat hitting the ball, the spiraling football, the bend in the vaulter's pole, and the tension of muscles as a weight is lifted illustrate some of the basic laws of physics, like momentum, equilibrium, velocity, kinetic energy, center of gravity, projectile motion, and friction. Knowing these principles of physics helps an athlete or coach improve performance.

3.3.3 Imaging Techniques

Looking inside the body without surgery is one of medicine's most important tools. X-rays, computed tomography, CT scans, and magnetic-resonance imaging are used to determine bone damage, diagnose disease, and develop treatment for various illnesses.

Technicians who use imaging equipment need to be familiar with the concepts of x-rays and magnetic resonance, and to be able to determine how much of this powerful technology to use. Imaging technicians work at hospitals, medical colleges, and clinics.

3.3.4 Automobile Mechanics

Today's automobiles are a far cry from those put on the road by Henry Ford. Computers play a major role in how cars operate. Computers are also used by mechanics to diagnose auto malfunctions. A basic understanding of computer technology is essential in almost every career.

3.3.5 Environment

The 1990s have been called "Decade of the Environment". Environmental physicists are studying ozone-layer depletion and other problems involving the atmosphere. They use acoustics to try to reduce noise-pollution. They search for cleaner forms of fuel, study how smog forms and how to reduce it, and devise ways in which to dispose of and store nuclear waste safely.

3.3.6 Journalism

Science is one of the most exciting assignments a reporter can have. New discoveries, controversial findings, space research, medical breakthroughs, natural disasters, technological competitiveness, and the environment make up a big part of the news. Reporters who have a background in physics have an advantage in being able to quickly grasp technical issues and communicate easily with researchers. Many major daily newspapers in this country have science sections; in addition, science reporting is featured on radio and television.

3.4 How Physics Can be Popularized: The Role of Teachers

Physics can be "popularized" by emphasizing its relevance to life. There are two major aspects of its relevance that can be discussed. First of all, there is the importance of physics in understanding natural phenomena; and secondly, the need of physics in understanding technological developments.

The teacher must arouse curiosity about nature and natural phenomena. To do this, the teacher can draw attention to the many marvels of nature. If he and his audience have a tilt towards religion, the numerous Quranic injunctions can also be involved to observe and ponder about the natural phenomena. Having aroused curiosity, the teacher can then go on to show how physics has helped us in understanding many of these phenomena. The teacher should also emphasis that the search for truth is an unending one, and there are many areas that need further investigation, which will continue to provide stimulating challenges for generations of physicists to come.

Principles and processes of physics form the basis for most technological devices that have become such an important part of our lives. This includes: automobiles, aircraft, cameras, radio, TV, electrical appliances, computers --- and the list can really go on and on. Again, the teacher should emphasis the fact that to gain a real understanding of the functioning of any or all of these devices one must understand physical principles. Besides devices that we encounter everyday, there is the underlying technological infra-structure that makes all of these things possible and for that again, physics forms the basis.

4. THE ROLE OF PHYSICS IN THE 21st CENTURY

When we talk about the role of physics in the 21st century, there are two things that should be borne in mind.

- Physical principles form the basis for most technological development.
- In general, many new technologies are highly interdisciplinary in character, bringing together concepts from diverse fields. This again blurs the old boundaries and makes it difficult to isolate there role of any one discipline.

The most dramatic technological development of the 20th century was the fabrication of nuclear weapons. It was this, more than any other innovation, that brought physics and physicists to the center-stage in society. Nuclear science has all the powers to develop or destroy the world we live in. It (nuclear science) has been used to build weapons of mass destruction. Despite the continuous efforts during the last half a century to put this genie back into the bottle, there are no signs of it happening. The 21st century will thus, continue to have this technology as one of the major determinants of inter-state relationships. Along with that, the enormous stockpiles of these weapons will continue to represent a serious threat to human-society.

Of course, an understanding of the nucleus has also led to the development of many new technologies that have already benefited us greatly and that have the potential of bringing many more benefits in the next century. Conventional nuclear power from fission based reactors will continue to play an important role, but potentially, perhaps the most significant development for humanity will be the harnessing of nuclear fusion-reactions to generate energy. What is so exciting about this prospect is the fact that fuel for an advanced form of these reactors can be extracted from ordinary water, with a liter of water yielding energy equivalent to more than fifty liters of gasoline. This means that after the development of fusion-reactors, we will have at our disposal a virtually inexhaustible source of energy.

Another source of energy with a large and inexhaustible potential is solar energy. We are already seeing it harnessed on a limited scale, but for the next century, physicists have the challenge of dealing with the limitations of the present technology and developing new methodologies, which will enable a large scale harnessing of this source.

We have already seen nuclear-radiation and radio-nuclides applied extensively to all the three major aspects of our socio-economic structure: industry, agriculture and medicine. They have also become indispensable tools in many disciplines, as diverse as chemistry, biology, hydrology, oceanography, geology, archaeology, paleontology, environmental science, forensics, genetic engineering and so on. The new century will see an even greater flowering of these applications.

Investigations into superconductivity will lead to many new kinds of applications, in areas such as high speed public transportation, efficient transportation and storage of energy and a multiplicity of devices requiring intense magnetic fields.

Continuing research in condensed matter physics promises to yield major dividends in further enhancing the already phenomenal pace of development of computing power.

Lasers have already permeated into countless devices, many of which are found scattered in ordinary homes. Their potential, however, has not yet been fully exploited, and in the next century we can expect to see them being put to many other uses.

Since the discovery of X-rays at the end of the last century, they have been an indispensable diagnostic tool for the medical profession. During the last few decades, many other physical techniques have become a part of the array of diagnostic devices that now doctors have available. These include, ultrasound devices, gamma cameras, single photon emission computed tomography (SPECT), positron-emission tomography (PET), and magnetic-resonance imaging (MRI). The next century will continue to see the power of physics being brought to bear in new ways to illuminate the working of the human body.

It is not just in diagnostics, but for treatment as well that the medical profession has found the great utility of physics and physical devices. Radiotherapy, laser surgery, microsurgical devices, physical implants; all these and many other are already a part of the medical repertoire. But we have just seen the beginning of this trend and in the future we can expect to have a much more extensive range of such applications.

Understanding of physical process within biological organisms – of which the human body is one example - is at present at a relatively primitive stage. The 21st century should see a great upsurge in this area, and with that should come totally new approaches to the age old problems of maintaining and improving human health.

The recently acquired ability of biologists to understand and manipulate DNA, the control-center of life processes, has already led to many dramatic applications. But, the full potential of recombinant DNA-techniques have played a very important role in the development of the technology and will continue to do so in the future.

Space exploration should become a mature and well-established activity during the next century. This will involve numerous interfaces with physics at all stages of development.

A common element of all of the expected developments described above is the fact that these are based on the concepts that have already been developed. From the history of physics, we know that the investigation of nature, inevitably leads to radically new insights and new concepts. The qualitative change in our understanding of natural phenomena then suggests new ways of harnessing nature for our own purposes. A very pertinent example of such a development is provided by the way an investigation of the structure of matter led to the discovery of the nuclear force and then no nuclear fission, a means of liberating that force with all its consequent implications for human society. Just a few years before its actual realization, no one could have predicted such a development. Thus, we should expect the unexpected to arise from the investigations into basic physical phenomena that are going on intensively at present. What impact those new discoveries will have on our understanding of nature, and how that new understanding will affect society at large, cannot be predicted.

CONCLUSIONS

Physics has enormously contributed to the process of development and refinement of not only currently utilized technologies, but also those potentially utilizable technologies that are termed as ‘the Future Technologies’. Physics is considered to be the most basic of the natural sciences. It deals with the fundamental constituents of matter and their interactions, as well as the nature of atoms and the build-up of molecules and condensed matter. It tries to give unified descriptions of the behavior of matter as well as of radiation, covering as many types of phenomena as possible.

It is unanimously agreed that the computer, the transistor, and the World-Wide Web are among the greatest inventions of modern times. We all know that today's global economy is strongly reliant and linked to applications of these technologies. It is a true fact that the day-to-day life of millions of people, across the globe, would be profoundly different without the presence of these technologies to facilitate them. The present status of the USA as an economic superpower is primarily due to its dominance in the realms of computer and information-technology. Moreover, high figures of GDP, in Japan, Taiwan, countries of Western Europe, and others, is also partly due to their acceptance of, and contribution to, the era of the information-age. Interesting to note is the fact that physicists invented the computer, the transistor, the laser, and even the World-Wide Web.

In the world of today, it is a fact that an individual knows more fundamental physics than knowing how to use it presently. The application of this available knowledge to integral fields, such as condensed-matter physics, chemistry, biology, and the associated technologies like material science, electronics, photonics, nanotechnology, and biotechnology, is perhaps the only way to make easy progress now. By doing so, the physicists of the world may well be able to lay the foundation for a new and higher level of fundamental experimental physics.

Learning from the history, we now know that physics impacted positively on our society and culture, it revolutionized our way of living number of times in the past, and possesses the powers to do so many times ahead and lead us to even more thrilling experiences, be it in space science or nano-science. The questions now arise for us, are to ascertain how we can make best use of this existing knowledge of physics, that is to further disseminate and popularize it? What areas of physics should be given high priority for development? What can be done to synergize global efforts to satisfy the quest and thirst for more knowledge, especially in the field of physics? And finally who should take lead and pain in carrying out these activities?

BIBLIOGRAPHY

1. "The Nobel Prize: The First 100 Years", Agneta Wallin Levinovitz and Nils Ringertz, eds., Imperial College Press and World Scientific Publishing Co. Pte. Ltd., 2001.
2. The Nobel Prize in Physics 1901-2000 by Erik B. Karlsson.
3. Europhysics News (2004) Vol. 35 No. 1.
4. Physics in the developing world C.N.R. Rao, President of the Third World Academy of Sciences, The Abdus Salam International Centre for Theoretical Physics, Trieste- Italy.
5. Bromberg J., 1988, Physics Today, October 1988, p.26.
6. Bromley Allan D., “A Century of Physics”, Springer – USA.
7. Glass A.M., 1993, Physics Today, October 1993, p.34.
8. Past, Present and Future – Physics prepares for the 21st century”, 1999, Physics World, Vol-12 No.12, December 1999.
9. Physics Today, June 1993, pp.22-73
10. Stachel J., “Einstein’s Miraculous Year – Five papers that changed the face of Physics”, Princeton University Press.
11. Tubbs M., 1999, “Industry and R&D”, Physics World October 1999, pp 32-36.
12. ‘The Physics of our Universe’, http://www.thinkquest.org/library/site_sum.html?tname=17913&url=17913/
13. ‘The Physics of Materials’, http://www.wsi.tu-muenchen.de/Background_info/chapo.pdf

THE ROLE OF SOME GREAT EQUATIONS OF PHYSICS IN OUR LIVES

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ABSTRACT

The paper will first discuss the ranking of important equations in Physics, in the light of the poll recently conducted. Then I will bring out the unifying power of a great equation. Finally, I will discuss their roles in our lives.

Recently a poll of "Best Equation" was conducted. The result of this poll was published in a British Daily Newspaper, "Gaurdian" on Oct. 06, 2004.

RESULTS OF THE POLL

1. Maxwell's equations:

$$\nabla \cdot D = 0$$
$$\nabla \cdot B = 0$$
$$\nabla \times E = -\frac{\partial B}{\partial t}$$
$$\nabla \times H = \frac{\partial D}{\partial t} + J$$

2. Euler's equation:

$$e^{i} \quad 1 \quad 0$$

"Most profound mathematical statement ever written" said one reader and it contains nine basic components of mathematics in a simple form.

3. Newton's equation:

$$F \quad ma$$

4. Pythagoras's theorem:

$$a^2 + b^2 = c^2$$

The most famous theorem in all mathematics; basis of Euclidean geometry:

5. $H \quad E$

Basic equation of Quantum Mechanics

6. Einstein's relation:

$$E = mc^{2}$$

7. Boltzman's equation:

$$S \quad k \ln W$$

8. $1+1=2$

I will add two more equations for the reasons that I will discuss

9. $R \qquad \frac{1}{2} g \quad R \quad 8 \;\; GT$

Basic equation for Einstein's theory of gravity.

10. Dirac's equation:

$$i \qquad\qquad m \qquad 0\,,$$

Which governs the behavior of the electron. Robert Creat (Department of Philosophy at the State University of New York at Stony Brook), who coordinated the poll said, "The unifying power of a great equation is not so simple as it sounds. A great equation does more than set out a fundamental property of Universe, delivering information like a sign-post, but works hard to wrest something from nature". We will see the illustration of this later.

An equation represents a universal physical law in a simple form that is obeyed by the various physical quantities. The act of writing down a fundamental law, usually in the form of a differential equation, is a rather singular and rare event. But is that all? Some people might think that this is all needed and the goal of theoretical physics would have been achieved by obtaining a complete set of physical laws. In reality we need to have a set of initial conditions that tell us the state of a system at a certain time, to model a physical reality. Neither the initial conditions nor the values of the parameters in the theory are arbitrary, rather they are somehow chosen or picked out very carefully. For example, as stated by Hawking, "if the proton-neutron mass difference were not about twice the mass of the electron, one would not obtain the couple of hundred or so stable nucleides that make up the elements and are the basis of chemistry and biology". Even so, we have been able to solve some of the basic equations only for very simple systems; more often than not, we have to resort to approximations and intuitive guesses of doubtful validity. For example, as pointed by Hawking, "although in principle we know the equations that govern the whole of biology, we have not been able to reduce the study of human behavior to a branch of applied mathematics".

THE ROLE OF EQUATIONS IN OUR LIVES

I will discuss it in chronological order, rather than on the votes obtained in the poll that I mentioned earlier.

Newton's Equation:

$$F \quad ma$$

It is the soul of Classical Mechanics. The right-hand is the product of two terms, mass and acceleration. The acceleration is a purely kinematical concept, defined in terms of space and time. Mass is an intrinsic and measurable property of a body. In modern foundations of Physics, it is energy and momentum which appear rather than force. However, force is the time-derivative of momentum and space-derivative of energy and, as such, not quite so removed from modern foundations. Even so, force is something one can feel, for example, by placing a weight on the front of one's hand.

Together with Newton's Law of Gravitation, a single law of force of considerable simplicity, $F = ma$, provided the greatest and most complete success in planetary astronomy. The astronomical applications of the laws of classical mechanics are the most beautiful, but not the only successful applications. We use these laws constantly in everyday life and in the engineering sciences:

> Bridges do bear their loads, artificial satellites do orbit around the earth, spacecrafts do reach their destinations.

Maxwell's Equations

$$D$$

$$B \quad 0$$

$$E \quad \frac{B}{t}$$

$$H \quad J$$

The laws of electrodynamics, which expressed all known facts at the time Maxwell began his work, are described by:

In the absences of sources

$$0\,, \vec{J} \quad 0$$

Maxwell noticed that the last two equations lack symmetry. Maxwell removed this lack of symmetry by modifying the last equation to:

$$H \quad \frac{\vec{D}}{t}$$

The search for symmetry is part of the “architectural quality of Maxwell’s mind” and that he “was profoundly steeped in sense of mathematical symmetry”. In 1864 Maxwell predicted the existence of electromagnetic radiation, including, but not limited to, ordinary light. Maxwell’s new radiation was subsequently generated and detected by Hertz, two decades later. Maxwell unified electricity and magnetism and, as a result, electromagnetic radiation in the form of light, radio-waves and X-rays provide many of the conveniences of modern life viz., lights, television, telephones, etc. Anybody who switches on a color-TV might reflect on it. Over the 20th century, its development and its marriage with quantum theory has revolutionized the way we manipulate matter and communicate with each other.

For Physicists, for the above reason and for the following one, Maxwell has far higher claims: Maxwell’s Theory defined a preferred velocity, the speed of light, whereas the Newtonian theory was invariant if the whole system was given any uniform velocity. It turned out that the Newtonian theory of gravity had to be modified to make it compatible with the invariance properties of Maxwell’s Theory. This was achieved by Einstein in 1905 for his theory of relativity, and in 1917 when he formulated his *General Theory of Relativity*. No wonder that Maxwell’s equations got the highest number of votes in the poll.

Boltzman’s Equation

“The law that entropy always increases - the second law of thermodynamics - holds, I think the supreme position among the laws of Nature”, Eddington. The entropy of a macroscopic system is a measure of the number of microscopic states in which the system can find itself at a given energy or temperature – it can therefore also be thought of as a measure of disorder.

The Boltzman’s equation,

$$S \quad k \ln W$$

provides an understanding of the second law of thermodynamics in terms of a connection between entropy and probability – one of the great advances of the 19th century.

An immediate consequence is that a particle would like to decay into lighter ones (unless there is some selection-rule to forbid the decay) since the largest number of microscopic configurations has the greatest probability. This is what is observed in nature.

One meets the concept of entropy and the Boltzman equation in communication-theory when we remember that information in communication-theory is associated with the freedom of choice we have in constructing messages. Thus, for a communication-source one can say, just as one would also say of a thermodynamic ensemble: "This system is highly organized, it is not characterized by large degrees of randomness or of choice – that is to say, the information (or the entropy) is low". Thus, the transmission of a message is necessarily accompanied by a certain dissipation of information that it contains – an equivalent of second law of thermodynamics in information theory.

Suppose we have a set of 'n' independent complete messages, whose probabilities of choice are *P*1, *P*2, ... , *P*n, then we have entropy-like expression given by Boltzman equation, which measures information:

$$S \qquad k \qquad \underset{i}{} \quad p_i \ln \; p_i$$

where 'k' is a positive constant, which amounts to a choice of unit of measure. This emphasizes the statistical nature of the whole ensemble of messages, which a given kind of source can and will produce and plays a central role in information-theory as measures of information, choice and uncertainty.

Einstein's Relation

$E = mc^2$,
is an important consequence of Special Theory of Relativity. A question was asked in BBC's program "Brain Test" in 1930's, whether one could think of any practical applications of Einstein's relativity. One could not, until the study of nuclear reactions became possible, where neither mass as such, nor the kinetic energy is conserved, but the relativistic energy is conserved:

$$E \qquad mc^2$$

Kinetic Energy [$E = mc^2$]

$$c^2 \; m$$

(which has disappeared?)
i.e. mass – energy accurately balance off and not convertible to other forms of energy. To illustrate it, let us consider the (D, T) reaction, which is central in achieving controlled nuclear fusion

$$^2H \quad ^3H \qquad ^4He \quad n$$

The total mass on the left side exceeds that on the right side, giving:

$$mc^2 \quad 17.6\,MeV$$

which is the energy released in the reaction. The relativistic energy is conserved although the system is non-relativistic, since no particle is moving with a speed close to the speed of light. If there were no $E = mc^2$, there would be no nuclear power. Another example is that of Stellar Energy. The energy of the Sun is generated through the fusion- reaction:

$$4p \quad {}^4He \;\; 2e \quad 2\,{}_e$$

The energy release per helium atom formed is:

$$[4m_p \quad 2m_e \quad m(He)]c^2 \quad 26.7\,MeV \quad Q$$

About 25MeV heat the Sun. Note that neutrinos are given out, so that the Sun is a powerful source of electron-type neutrinos. Neutrinos interact very weakly with matter, so that nearly all the neutrinos produced in nuclear reactions in the Sun escape into space, reach the Earth and have been detected and resulted in award of the 2001 Nobel Prize to Ray Davis and Koshiba. "If there were no $E = mc^2$ and no neutrinos, the Sun and stars would not shine. There would be no Earth, no moon, no us. Without them we would not be here"—Boris Kayser.

$$H \qquad E$$

this is the basic equation of **Quantum Mechanics.**

The Concept of energy-gaps is purely quantum mechanical – a crucial concept for many applications. The presence of gaps (i.e. energy-bands, where there are no permissible energies) that may occur between energy-levels and the extent to which they are filled by electrons determine the electronic-transport properties of solids. It is a key-concept in building semiconductor devices, which have revolutionized communications, control, data-processing, consumer-electronics and globalization of information. Tunneling is another important concept, which quantum mechanics has made available. Due to quantum uncertainty, on the tiny quantum-scale, particles exist only as a cloud of probability unless they are actually observed. Thus, electron would have to be smeared out with some probability distribution. Thus there is a finite

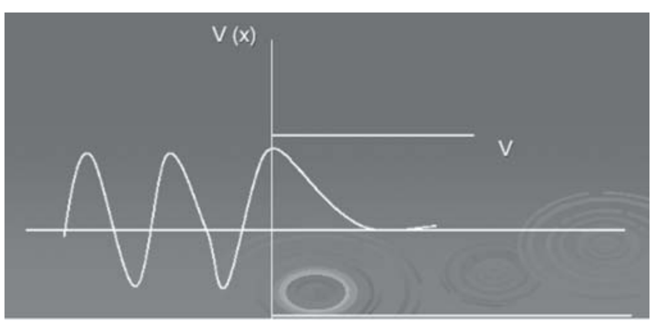

Figure - 1

probability of particle crossing from a classically allowed region of space into one that is classically forbidden (see figure-1), know as tunneling. This has many applications, for example, fusion-reactions in stars where, even at stellar temperature, the nuclei do not have sufficient kinetic energy to overcome their mutual coulomb-repulsion for fusion to occur. Quantum Mechanical-Tunneling through the coulomb-barrier, permits fusion to occur at much lower temperature. Another application is Tunnel Diodes, which respond quickly to the voltage-change.

Einstein's Equation for Gravity:

$$R \qquad \frac{1}{2} g \quad R \quad 8 \;\; GT$$

It is a remarkable equation, relating how matter and energy (determined by fundamental particles and forces) described by the Right-Hand Side (R.H.S.) influence the Left-Hand Side (L.H.S.) representing the curvature of space and time and expansion of the universe and vice-versa. Here, one sees how microphysics determines the evolution of the universe. Thus, this equation can be used for the simulation of the early universe. If we extrapolate backwards the temperature-time relations from Einstein's equation, we can study the early universe by recreating in terrestrial laboratories a little piece of primordial soup, which are the elementary particles produced and studied at accelerators. Such an extrapolation successfully predicts that three minuets after the Big Bang, the primordial neutrons and protons form 75 percent of hydrogen and 25 percent helium, the so called nucleosynthesis. We can now extrapolate back in the laboratories in time at 10^{-10} seconds after the Big Bang and would reach to 10^{-12} seconds after the Big Bang in 2007.

Dirac's Equation:

$$i \qquad\qquad m \qquad 0$$

Dirac combined the special theory of relativity with quantum mechanics and obtained his equation from pure logic. The Dirac equation has profound consequences. It naturally comes out that the particle it represents has spin ½; anti-matter must exist, to each particle there is an anti-particle, and gave a new meaning to vacuum in the microscope world – vacuum is a seething foam of particle-antiparticle pairs, hopping in and out of a united existence, and may be the seed of everything we see in the universe. When the positron, the antiparticle of electron, was discovered Dirac is said to have remark: "This equation is smarter than its inventor."

Anti-matter caught the imagination of science-fiction workers (Star Trek's faster – than-light science-fiction space – ships use antimatter power; antimatter annihilates with ordinary matter, disappearing in a puff of energy and thus provides the perfect fuel). But anti-matter has been used for real. Just to indicate one practical application: PET scan. Positron Emission Tomography can be used to reveal the workings of the brain. In PET, the positrons come from the decay of radioactive nuclei in a special fluid injected into the patient. The positrons than annihilate with electrons in nearby atoms, in the form of 2 gamma rays – which shoot off in opposite directions to conserve momentum.

Both Maxwell's equations and Dirac's equation gave much more than what was put in, purely from mathematical symmetry and analogies: *they wrest some thing from nature*.

HOW EINSTEIN IN 1905 REVOLUTIONISED 19TH CENTURY PHYSICS

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ABSTRACT

In 1905, a hundred year ago, Albert Einstein published four papers that shook the then known universe and overnight hurled the 19th Century physics into the 20th Century. This young rebel genius subjected nearly everything space, time, energy, mass, light to test by his sharp critical mind. His gift for simplicity with precision and his remarkable ability to ask the right questions is the hallmark of the four miraculous papers. These papers are an amazing creation of a human-mind and the physics thereafter is still reeling. Here we shall present how these papers radically changed the pre 1905 physics to what it is today.

1. PHYSICS AROUND 1900

The most basic of our perceptions are that of location in space and the passage of time. We describe the observation, the static and the dynamic measurements and other quantities, such as, motion in the edifice of Euclidean-geometry of a three-dimensional space. The deep underlying structures of space, time and motion are still open-questions hidden in mystery. The meaning of motion of bodies has occupied the thinking minds ever since antiquity. In fact, we owe our very existence to the constant change due to the subtle motion of atoms and molecules, taking place in our bodies. The first quantitative analysis goes back to Galileo Galilei, 1564-1642, who studied motion of bodies by performing many experiments, and discovered several results of kinematics, the most famous being that: bodies of different masses fall at the same rate and that the distance covered under uniform acceleration is proportional to square of the time taken. He was the first to state the principle of 'relativity of motion' that it is not possible to determine if an observer is at rest or in uniform motion. In the current language of physics, we translate this relativity principle as: Physical Laws are the same in all Inertial Frames.

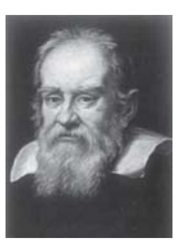

Figure-1: Galileo Galilei (1564-1642)

Figure-2: Isaac Newton (1642-1729)

The next big stride in the understanding of motion of bodies was taken by Newton. His 'first law of motion' that a body continues to be in a state of rest or of uniform motion, until and unless acted upon by some external force, can be regarded as a consequence of the 'Galilean relativity principle'. Newton's laws of motion set the stage for describing the drama of the universe in absolute space and absolute time. Meanwhile progress in natural sciences continued its rapid march with new discoveries in thermodynamics, optics, electricity and magnetism. Maxwell's formulation of electricity and magnetism in the form of a set of equations brought the understanding of electromagnetic phenomena to a level of completeness, comparable to that of Mechanics. Not only did these equations unify the electric and the magnetic force, but also revealed the intimate connection of optics with electromagnetism.

Figure-3: James Clark Maxwell, (1831-1879)

Figure-4: Ludwig Boltzmann (1844-1906)

In the field of thermodynamics, Boltzmann, an Austrian physicist, made significant progress. By inventing statistical mechanics and using probability he was able to describe how atoms determine the properties of matter. His derivation of the 'second law of thermodynamics' from the principles of mechanics, is one of the outstanding contributions of his time. With his statistical mechanics, he was able to explain the phenomenon of heat in terms of the microscopic mechanical motion of atoms/molecules. So, around 1880-90, it was not surprising that many physicists believed that since the physical laws are known, all one needs to do to understand and describe natural phenomenon, is to work out the solution of the associated mathematical equations, coming from the laws of mechanics and electromagnetism.

Let us look at how Galilean relativity principle works. A simple formulation of Galilean Transformations for a primed frame, moving with a velocity 'v' along the 'x' direction, with respect to an unprimed frame may be written as:

$$\begin{aligned} x' &= x - vt \\ y' &= y \\ z' &= z \\ t' &= t \quad . \end{aligned} \tag{1}$$

The reference frames coincide at $t = t' = 0$. The point x' is moving with the primed frame. The Galilean transformation gives the coordinates of the point as measured from the unprimed fixed-frame in terms of its location in the primed moving reference-frame. The Galilean transformation is the common-sense relationship that agrees with our every-day experience. When we subject the Newton's equation of motion:

$$F = m\frac{d^2X}{dt^2} \qquad (2)$$

to Galilean transformations (1), then we find that these equations (2) go over into:

$$F' = m'\frac{d^2X'}{dt'^2}$$

They do not change their form. This tells us that the Newtonian mechanics satisfies the Galilean relativity principle. However, this does not turn out to be the case with Electromagnetism. The Maxwell's equations of electromagnetism are of the form:

$$\begin{aligned} \Delta \bullet E &= 4\pi\rho \\ \Delta \times E &= -\frac{1}{c}\frac{\partial B}{\partial t} \\ \Delta \bullet B &= 0 \\ \Delta \times B &= \frac{4\pi}{c}J + \frac{1}{c}\frac{\partial E}{\partial t} \end{aligned} \qquad (3)$$

where 'E' is the electric field, 'B' is the magnetic field, ρ the charge density, 'J' the electric current and 'c' the velocity of light. When we transform the Maxwell equations according to (1), as we did with Newton's force equation, we find that additional terms have to be added and the form of these equations in the primed reference-frame is different form (3). The Galilean principle of relativity that holds for mechanics does not hold for electromagnetism. Here we have a problem.

The solutions of Maxwell's equations demonstrated convincingly that light was a form of wave and, since waves require a medium to travel through, it was assumed that the whole space was filled with some mysterious medium called 'ether'. A remarkable result of Maxwell's equations was the prediction of the speed of light 'c', in free space to be equal to:

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} \qquad (4)$$

where ε_0 is the premitivity μ_0 is the permeability of free space. This relationship between the speed of light and the electromagnetic quantities ε_0 and μ_0 was later verified for light, radio waves and other electromagnetic waves. The speed of light in vacuum is c = 300,000 meters per second.

Since Maxwell's equations do not satisfy the Galilean principle of relativity, they seemed to single out a reference-frame, in which the form of the equations is the simplest and the velocity of light is equal to that in vacuum. This frame could be considered to be completely at rest. A number of clever experiments were designed to determine the speed of Earth, relative to the absolute-frame, whatever it might be. Michelson and Morley in 1883 performed the most direct measurement of the velocity of light in different direction with an Interferometer, (see Figure-5). It may seem strange in the background of our everyday experience, but they found that the speed of light was the same in all directions. Either the Earth is at absolute rest or there is something peculaiar with how light travels. We, however know from observations that the Earth is not at rest, but moving around the Sun and the Sun is moving around the centre of our galaxy and the galaxy is moving with respect to other galaxies.

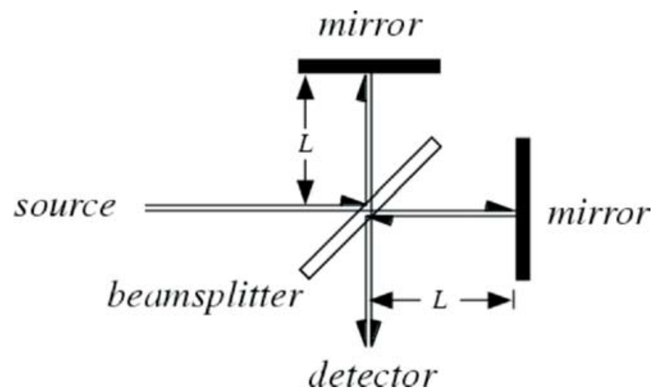

Figure 5: A schematic view of Michelson Morley interferometer.
For the Earth to be streaming in ether with some speed, the speed of light along the two return paths should be different. The measurement revealed no such difference. The velocity of light was found to be the same in all directions. (For details consult "Physics", 4th edition by Haliday, Resnick and Krane, pp 959-961)

To explain the null result of the measurement of the velocity of light was a challenge of the time. The generally accepted view was that of the Dutch physicist, H. A. Lorentz, : The ether is present everywhere and ordinary matter moves through it. The important experimental problem was to measure the motion of Earth through ether. Lorentz's decisive step was to introduce invisible charge-densities of atomic and subatomic sizes; these he initially called 'ions' and later as 'electrons'. They served as sources for electric and magnetic forces that propagate through the ether. Since these forces were assumed to be coupled with matter, they offered a mechanism to understand how electromagnetic forces act on matter. Lorentz developed a comprehensive theory, in which the electric current was the motion of free electrons, while bound electrons functioned as transmitters and receivers of electromagnetic waves. In 1899 Lorentz wrote out transformations (5) between two inertial frames that accounted for this contraction and under which the Maxwell's equations were invariant, that is, these retained their form.

$$
\begin{aligned}
x' &= \frac{x - vt}{\sqrt{1 - v^2/c^2}} \\
y' &= y \\
z' &= z \\
t' &= \frac{t - vx/c^2}{\sqrt{1 - v^2/c^2}}
\end{aligned}
\qquad (5)
$$

These are now known as Lorentz-transformations. Joseph Larmor in 1888 and Voigt in 1887 had also written similar transformations, but Lorentz was not aware of their work. In comparison to the Galilean transformations (1), where time t is absolute and is the same in all frames, in the Lorentz transformation, the time t in the unprimed frame, changes to a new time t' in the primed frame. Lorentz called the transformed time t' as local time. Here Lorentz gives up the idea of absolute-time of Galilean relativity.

With the aid of these transformations and his hypothesis, according to which rigid bodies contract by a factor of $(1-v^2/c^2)^{-1/2}$ in the direction of motion, Lorentz was able to explain the null results of the Michelson Morley experiment.

Figure - 6: H. A. Lorentz (1853-1928)

On the scene during these times was also an astounding French Mathematician and physicist, Jules Henri Poincaré, at University of Paris, generally acknowledged as the last great universalist.

Poincaré, relying on the preparatory works by Lorentz, in 1904 extended the Galilean relativity principle to all natural phenomena. He called the transformations (5) 'Lorentz transformations' and demonstrated that under these transformations Maxwell equations stay invariant, i.e., Do not change their form. Many of the formulae of relativity, as we know them today, may be found in the articles by Poincaré, published in December 1904, Vol. 28,p302; 1905, in Bulletin de Science

Mathematique and Comptes Rendues 1905, Vol.140, p1504.

Figure 7. Jules Henri Poincaré (1854-1912)

Figure 8. Max Planck (1858-1947)

Another revolution taking place at that time in the world of physics, was the making of the 'quantum theory'. It began in 1900, when Max Planck introduced the quantity 'h', a quantum of action, now called 'Planck's constant', in an empirical formula (6) to describe the experimental data of energy density P of radiation as a function of wavelength

$$P_\lambda = \frac{2\pi hc^2}{\lambda^5\left(e^{(hc/\lambda kT)} - 1\right)} \qquad (6)$$

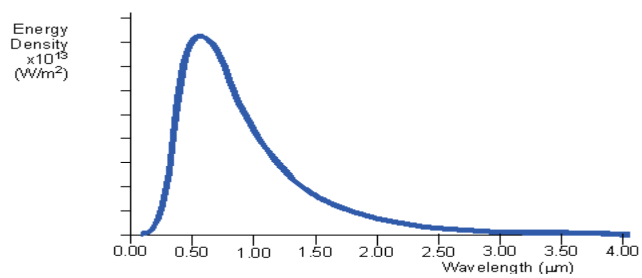

Figure 9. Spectrum of wavelengths emitted by a black- body at some temperature T, as described by Planck black-body radiation formula, equation (6).

Planck soon found the theoretical basis for this formula by assuming that the energy distributed among the mechanical oscillators is not continuous, but instead is composed of finite number of very small discrete amounts, each related to the frequency ' ' of oscillation by:

$$E = nh\nu, \quad n=1,2,3... \qquad (7)$$

Planck's assumption suggests that energy of molecular vibration could only be some whole-number of the product h . At that time the atom was modeled as an electron-oscillator that emits and absorbs radiation. It is in this backdrop that Einstein grew up as a physicist.

2. EINSTEIN 1905

Figure 10. Albert Einstein 1879-1955

Einstein joined Zurich Polytechnic in 1896, and graduated in 1900. In spite of many hectic efforts and recommendations, he was unable to find an academic position. The years 1900 to 1905 were hard for him. From 1900 to 1902 he survived by giving private lessons and as a substitute teacher in schools. Eventually, in June 1902 he found a job in the Patent Office in Bern, as a technical expert, category III. How Einstein, in spite of these financially difficult and demanding circumstances of his patent office, was able to pursue research in physics is truly a marvel of human endeavor. During this period Einstein published many articles in 'Annalen der Physik': on capillarity in 1901, on Kinetic theory of Thermal Equilibrium and the 2nd-law of Thermodynamics in 1902, on a theory of Foundations of Thermodynamics in 1903, and on the General Molecular Theory of heat in1904. It could be assumed that as a part of his official duty in the patent office, Einstein had to inspect and detect the hidden errors in many applications for patents of perpetual-motion machines. He knew that these machines could not work because, if they did, they would violate the Second Law of Thermodynamics. It is, thus, not surprising that three of his scientific papers during this period dealt with statistical aspects of thermodynamics. In these papers, Einstein extended in some ways Boltzman's probabilistic interpretation of entropy. This work represented more of a prelude of what was yet to come. The year 1905 must have been a very busy one for Einstein. In short order, he submitted four memorable works to 'Annalen der Physik' that were to shake the world of physics for all times to come:

17 March: "On a Heuristic Point of View Concerning the Production and Transformation of Light"
30 April: "A new Determination of Molecular Dimensions"
11 May: "On the Movement of Small Particles Suspended in Stationary Liquids Required by the Molecular-Kinetic Theory of Heat", and
30 June: "On the Electrodynamics of Moving Bodies"

This explosive burst of activity is truly more than extraordinary, when one considers the fact that Einstein had to perform official duties forty eight hours a week, in the Patent Office.

In his paper on transformation of light, Einstein made a bold extension of the quantum idea of Planck that the molecules, which were modeled as electron-oscillators, can only have discrete energies. Since molecules emit and absorb light, Einstein reasoned that to conserve energy, the light could only be emitted and absorbed in packets or quanta with an energy $E = h$. Since light comes from radiation sources, this suggests that light is transmitted as tiny packets, now called 'photons'. At that time, wave theory as derived from Maxwell's equations was the established theory of light and it explained all the observed optical phenomena. Wave theory could not however account for the production of cathode rays (production of electrons by X rays, now known as the photo-electric effect) and Planck's black-body radiation law. Einstein's photon hypothesis resolved this puzzle in one stroke and later he was able to derive the Planck's radiation formula (6).

In 1827, Robert Brown observed under the microscope that tiny pollen grains, suspended in water, moved about in tortuous paths, even though the water appeared to be perfectly still. The nature of this 'Brownian movement' is easily explained if it is assumed that atoms of any substance are in continuous motion. In the second and the third paper, Einstein examined Brownian movement from a theoretical point of view. Building on, and in many ways extending, Boltzman's statistical mechanics, and from the fact that water-molecules are constantly in erratic motion, Einstein was able to calculate, from the experimental data, the approximate size of the atoms and molecules. His calculations showed that the diameter of a typical atom is about 10^{-10} meter. The papers very convincingly ended the debate on the nature of matter, in favour of the existence of the atoms, and also gave for the first time an estimate of their dimensions. The atoms thus became a reality.

The paper on the electrodynamics of moving matter presented for the first time a clear formulation of the principle of relativity and worked out its consequences for electric and magnetic fields. Although Lorentz and Poincaré had already derived many of the formulae of relativity, Einstein here put together all the pieces of the relativity puzzle and gave a complete and consistent description of space, time and motion. Einstein starts with two assumptions: 1) The relativity principle that the physical laws are the same in all systems; 2) The velocity of light is the same, whether emitted by a stationary or a moving source. The relativity principle and the constancy of velocity of light have completely changed our perception of space and time. In a sense, every person, every atom, every monad, has his/its own space and his/its own time. Einstein's paper connects the space and time of two observers, moving with uniform velocity, relative to one another. To a stationary observer, the time of the moving observer appears to be contracted and the space shortened. In other words, when observed from a stationary frame, the clocks in a moving frame appear to run slower and lengths appear shorter.

Another consequence of Einstein's relativity is the increase in mass with velocity. When the velocity approaches the velocity of light, the mass approaches an infinite value. Thus, to move some mass, however small, with the velocity of light would require infinite amount of energy. As all sources of energy are limited, nothing can be made to move faster than light. This result has very far-reaching consequences on how our universe functions. It does not permit the reversal of order of cause and effect and forbids time travel.

Einstein does not quote Brown's work in his paper on 'motion of suspended particles' and Lorentz's and Poincaré's work in his paper on electrodynamics of moving bodies. It seems that he worked in isolation, away from the famous centers of scientific excellence, and independently developed his revolutionary ideas into theories that would resolve the many puzzles of his time and catapult the 19th century physics into its present form, in just one year, the year 1905. Perhaps the isolation was one of his secrets of success, because in isolation he was not influenced by the prejudices of the existing establishment of centres of learning.

SUGGESTIONS FOR FURTHER READING:

Discover, September 2004, Special Einstein Issue.

Scientific American, September 2004, Special Einstein Issue.

Physics, 4th edition by Haliday, Resnick and Krane, Chapters 21, 24 and 49

ADVENTURES IN EXPERIMENTAL PHYSICS: PHYSICS IN OUR LIVES

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ABSTRACT

Physics has fascinated the imagination of scientists, engineers and technologists, because of its immense potentialities and its positive impact on the way people live today.

This paper reviews some of the innovative, unconventional and adventurous experimentation involved in the discovery of the transistor-effect, first-fusion- neutrons from a thermonuclear weapon device, Omega-Meson - first neutral vector meson, discoveries in high-energy physics and high-T_c Superconductors for Magnet and energy technology, which brought the latest industrial revolution in the 20th century. It continues to be hoped that the recent advances in the field of Applied Physics, may lead to a better scientific understanding and development of emerging technologies that would ultimately benefit all mankind.

INTRODUCTION

The 17th through 19th centuries saw the great developments in mathematics, instrumentation, and ideas that brought us to the 20th century revolutions are ‘relativity’ and ‘quantum-mechanics’ presented by Einstein.

- It’s only natural that a man (Einstein) who showed how to bend space and stretch time, should become a titan of science.
- The 20th century developments included the transistor and solid-state electronics, which are the technological offspring of revolution in Physics that started with Planck and Einstein’s work.
- The other world inhabited by physicist is one where the knowledge, techniques, and tools of physics get diffused throughout society. New physical understanding leads to new approaches and progress in areas such as, medicine, energy, various industries, manufacturing, environment, and military applications.
- The intellectually stimulating world of physics, today, is curiously fascinating. Our world is the popular perception of academic physics, focusing deeply on diverse and profound questions of matter, energy, forces, and fields.
- We are rapidly gaining new knowledge of the Earth, the operation of its physical system and of various perturbations to those systems.

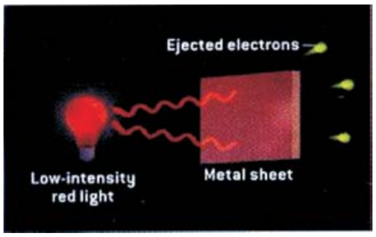


Figure -1(a): Red light sends electrons flying off a piece of metal. In the classical view, this is a continuous wave whose energy is spread out over the wave.

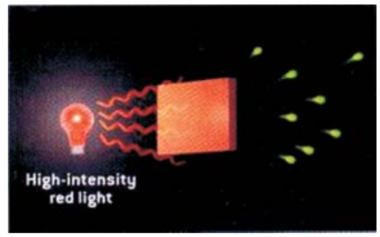


Figure-1(b) Increasing the brightness ejects more electrons. Classical physics also suggests that ejected electrons should move faster with more waves to ride – but they don't

- Our knowledge of the world at the atomic scale is growing rapidly, along with our ability to manipulate matter at that scale, to create new structures and materials, to take on as-yet-unknown dimensions.

THE PHOTOELECTRIC EFFECT

The ability of light to dislodge electrons from a metal surface is called photoelectric effect. The speed of the ejected electrons depend on the color of the light, not its intensity. Classical physics, which describes light as a wave, cannot explain this feature. The Phenomenon can be explained by deducing that light acts as a discrete bundle of energy, i.e., a particle. Einstein successfully accounted for this observation.

The schematic of the photoelectric effect and experimental results are shown in Figure-2.

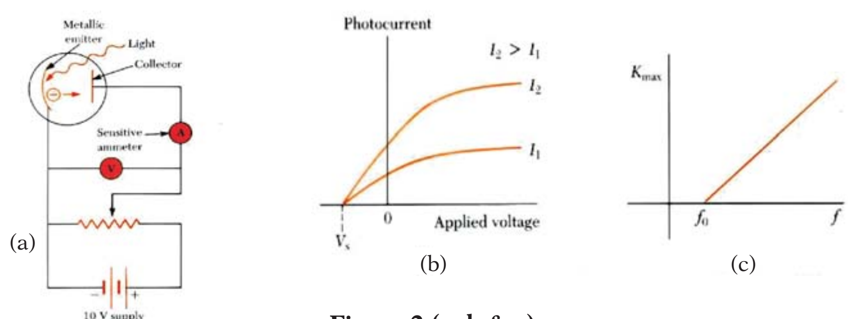


Figure-2 (a, b & c)

(a) Photoelectric Effect Apparatus

(b) Plot of photocurrent vs. Applied voltage. The graph shows that K_{max} is independent of light intensity 'I' for light of fixed frequency.

(c) A graph showing the dependence of K_{max} On light frequency. Note that the results are independent of 'I'.

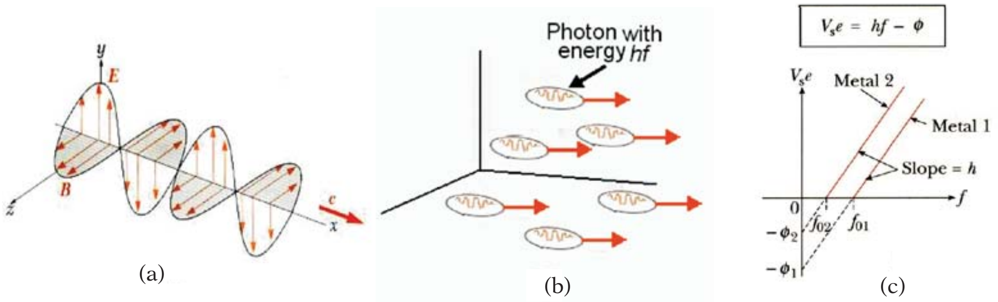


Figure - 3 (a, b & c)

(a) A classical view of a traveling light-wave as explained by Maxwell and Hertz.

(b) Einstein's photon-picture of "a travelling light-wave".

(c) Universal characteristics of all metals undergoing the photoelectric effect.

Photons are considered to be the discrete bundles or packets of energy, having energy 'hf'. This description helps in understanding the phenomenon of photoelectric effect.

- Einstein's explanation of light consisting of photons was brilliant.
- Maxwell's classical theory describes the progress of light through space over long time-intervals.
- Light-energy is related to Kinetic energy of electrons in the photoelectric-effect equation.

$$K_{\max} = \frac{1}{2} m_e v_{\max}^2 = eV_S$$

Applications of Photoelectric Effect

Photomultipliers: Photomultipliers are devices that operate on the principle that photons fall on the photocathode, resulting in the emission of photoelectrons. The photoelectrons are attracted by dynodes; each dynode is at higher potential than the previous one, so large number of electrons reach the anode.

They exploit the photoelectric effect to convert illumination into electrical impulses.

The photomultiplier tube is an essential part in video-cameras.

Photomultiplier tubes help in saving lives.

Schematic of photomultiplier tube is shown in the Figure-4.

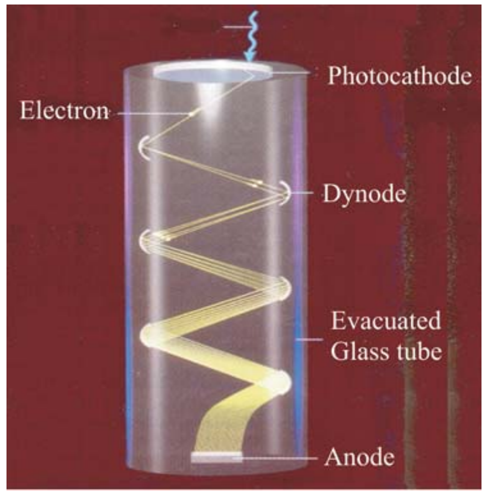
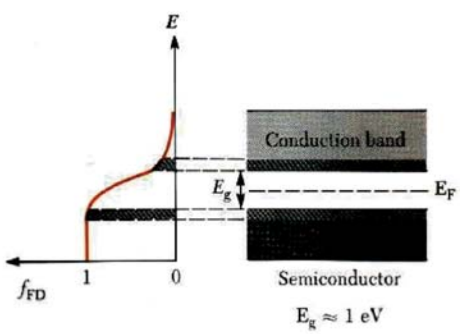


Figure - 4: Schematic Diagram of Photomultiplier-tube

Bipolar Junction-Transistor (BJT): Bipolar devices are semiconductor devices in which both electrons and holes participate in the conduction process.

BJT was invented by Bardeen, Brittain and Shockley at the Bell Laboratories in 1948, as part of a post-war effort to replace vacuum-tubes with solid-state elements. Their work led them first to the point-contact transistor and then to the junction-transistor. The principle of operation of BJT is shown in the Figure-5 below:

Whenever a photon is incident on a semiconductor, three types of processes may take place, as shown in Figure-6 (a, b & c).



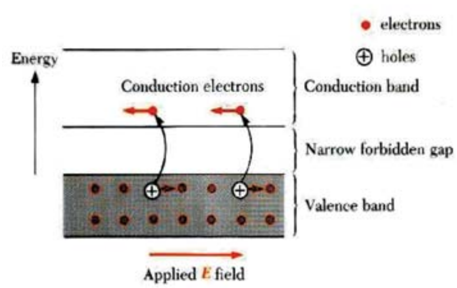


Figure - 5(a) **Figure - 5(b)**

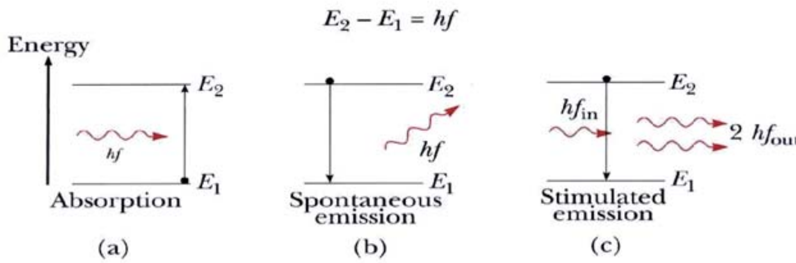


Figure 6. (a) Absorption (b) Spontaneous emission (c) Stimulated emission.

a. *Absorption*
b. *Spontaneous emission:* The lifetime of the upper state is tS, and the photon is emitted in a random direction.
c. *Stimulated emission:* In this process, the emitted photons are in phase with the stimulating photon, and all have the same direction of travel.

Applications of bipolar junction transistor, we come across in daily life, includes:

- Switches;
- Amplifier;
- Oscillator;
- Constant Current Sources, etc.

P-N-P Junction-Transistor

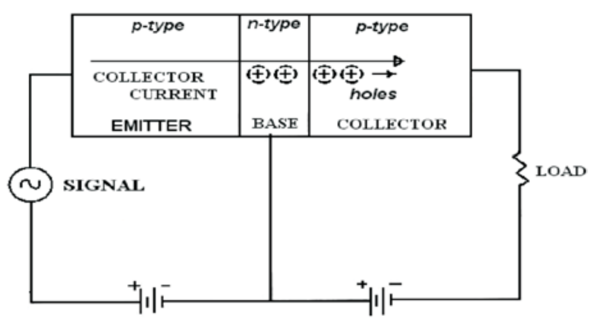


Figure - 7: Schematic Diagram of P-N-P Junction-Transistor, Emitter-to-Base Junction is Forward Biased, Collector-to-Base Junction is Reversed-Biased

The Hall Effect

If a magnetic field is applied perpendicular to the direction in which the carriers drift, the path of the carriers tend to be deflected; due to this path-deflection, an electric field is established inside the conductor, called 'Hall Field', and the phenomenon is called 'Hall Effect'.

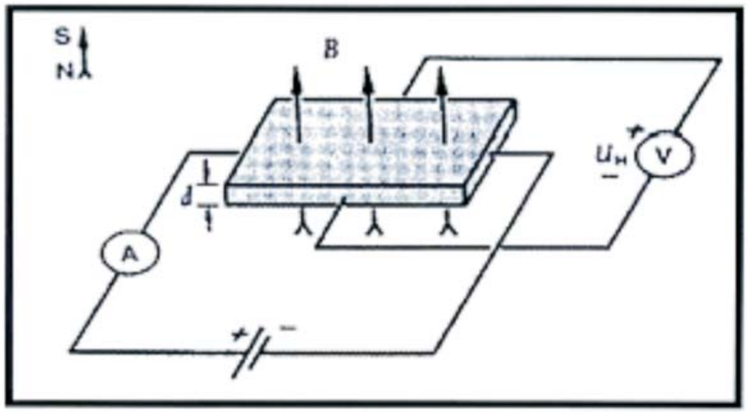


Figure - 8: Hall effect of rectangular section. The polarity-sign of the Hall-voltage shown, applies when the carriers are negatively charged

The electrical parameters of a semiconductor that can be measured are:

- The conductivity ‘s’ (or resistivity ‘r’ = 1/s),
- Energy-band gap,
- The majority carrier concentration,
- The conductivity type (N or P),
- The mobility,
- The diffusion constant, and
- The lifetime

Semiconductor devices make use of the following classes of property:

- Electrical, e.g. diodes and transistors, thyristors;
- Optical, e.g., Photoconductive cells, solar cells;
- Mechanical, Strain gauges, pressure transducers;
- Minority carrier lifetime;
- Energy-band gap, etc

They are characterized by some of the following parameters:

- Room-temperature resistivity and Hall effect,
- Change carrier-density and mobility,
- Minority-carrier lifetime,
- Electron-hole mobilities,
- Energy-band gap,
- Optical absorption edge.

Applications of the Hall Effect

Hall-probe for detection and measurement of magnetic fields produced by current-carrying conductors.

e /m Ratio of an Electron (J.J. Thompson): In an evacuated chamber, electrons emitted by a cathode are attracted towards the anode and gain potential. This beam of electrons, when subjected to electric and magnetic fields, deflect from its path.

Electrons subjected to an electric field alone, land at D, while those subjected to a magnetic field alone, land at E. When both electric and magnetic fields are present and properly adjusted, the electrons experience no net-deflection and land at *F*.

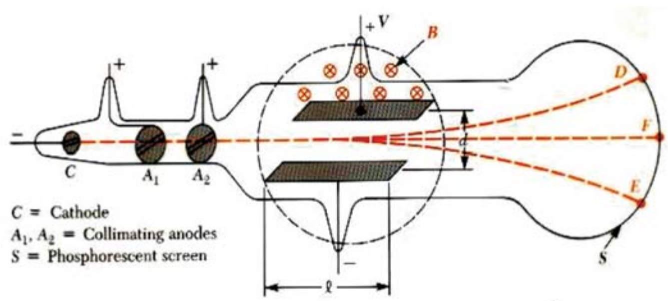


Figure - 9: A Diagram of Thomson's e/m tube (patterned after J.J. Thomson)

$$\theta \approx \frac{V\ell}{v_x^2 d}\left(\frac{e}{m_e}\right) \qquad -(i)$$

$$qE = qv_x B$$

$$v_x = \frac{E}{B} = \frac{V}{Bd} \qquad - \quad (ii)$$

Substituting Equation (ii) into Equation (i), immediately yields a formula for e/me entirely in terms of measurable quantities.

$$\frac{e}{m_e} = \frac{V\theta}{B^2 \ell d} \quad - \quad (iii)$$

The currently accepted value of e/me is 1.758803 x 1011C/kg.

Applications in daily life

- Television screen,

- Monitors,
- Oscilloscope, etc.

THE COMPTON EFFECT AND X-RAYS

Einstein did not treat the momentum carried by light (quanta of energy) in (1905-06). Holly Compton in 1922 found that, “If a bundle of radiation causes a molecule to emit or absorb an energy-packet ‘hf’ then momentum of quantity ‘hf/c’ is transferred to the molecule” $eV = hf = hc/\lambda_{min}$

$$\lambda_{min} = hc/eV$$

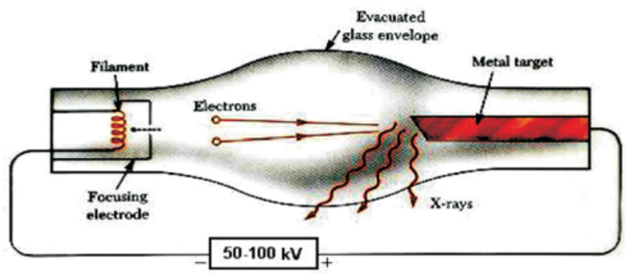


Figure - 10: Schematic diagram of an X-ray tube

X-rays are produced by bombarding a metal target (Copper, tungsten and molybdenum) with energetic electron-energies >> 50 to 100 keV.

BRAGG’S LAW

Radiations falling on a metal surface get scattered from the atoms in different planes and reflect back. The path-difference between the rays reflected from adjacent planes is given as, $2dSin \quad = n$. Inter-planar spacing and lattice constants can be calculated with the help of Bragg’s law.

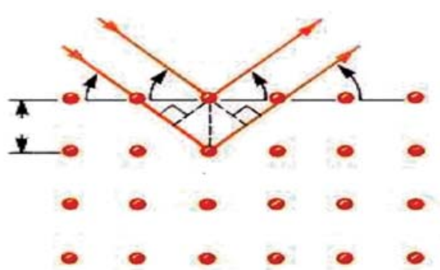


Figure - 11: Bragg Scattering of X-rays

Applications

- The X-rays are widely used in the field of medical science to take clear image of the broken bones, kidney-stone, etc.,
- X-rays are used to detect defects and cracks in heavy metal-sheets,
- At airports and other checking points, x-rays are used to detect metal-items without opening the luggage,
- Very important research technique to find the crystal structure and related properties, etc.

NUCLEAR FISSION (Discovered by John Allred and Louis Rosen)

The Leitz Ortholux microscope was used to analyze the nuclear emulsions from their experiment to detect the first neutrons from a thermonuclear-weapon explosion.

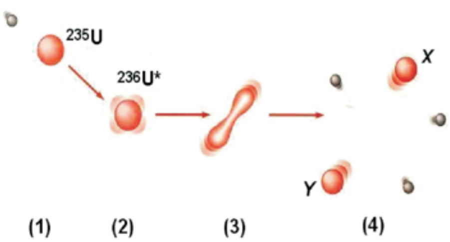


Figure-12(a) The stages in a nuclear fission event as described by the liquid-drop model of the nucleus.

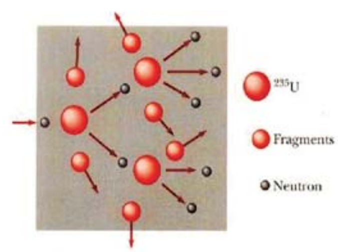


Figure-12(b) A nuclear chain-reaction initiated by the capture of a neutron. Many pairs of different isotopes are produced.

Applications

- Nuclear reactors use the principle of controlled fission to generate power,
- Atom bombs – uncontrolled nuclear fission causes a massive destruction,
- Applications in nuclear medicine, etc.

EVOLUTION OF VARIOUS STAGES OF MATTER

With the progress in science and research, the focus of interest shifts to particles of smaller dimensions.

High-Temperature Superconductivity: A superconductor is a material that loses all resistance to the flow of electric-current when it is cooled below a certain temperature, called the 'critical temperature' or 'transition temperature'. Above this temperature, there is usually little or no indication that the material might be a superconductor. Below the critical temperature, not only does the superconductor suddenly achieve

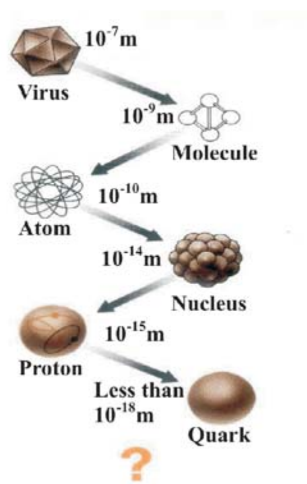


Figure -13: Evolution of various stages of matter.

zero-resistance, it gains other unusual magnetic and electrical properties.

The phenomenon of zero-resistance at low cryogenic temperatures was discovered in 1911, by Prof. H. K. Onnes, in the Netherlands, in the course of studying the low-temperature properties of metals. During the period up to 1973, numerous metallic materials were found to have superconducting transition-temperatures up to 23.2 K. Today these materials are referred to as low-temperature superconductors (LTSs). In 1986, certain oxide-based materials were shown by J. G. Bednorz and K. A. Müller to be superconducting up to appreciably higher temperatures, with T_c up to 35 K. This was quickly followed by demonstrations early in 1987 of materials with T_c of about 90 K, for which cheap and easily available liquid-nitrogen could serve as the refrigerant, since it boils at 77 K at sea-level. The materials with s above 23 K are collectively called 'high-temperature superconductors' (HTSs).

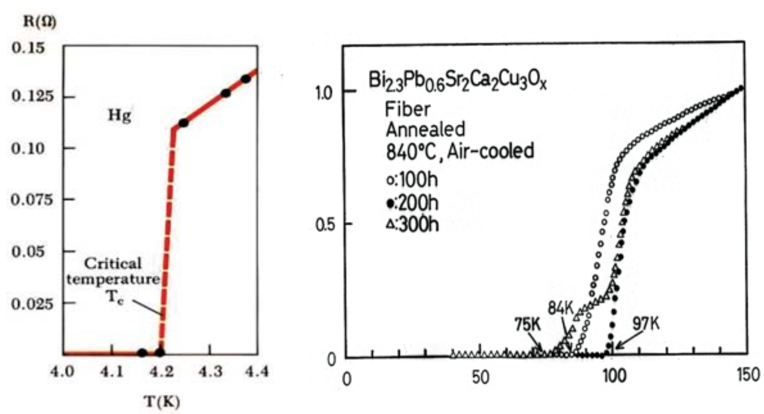
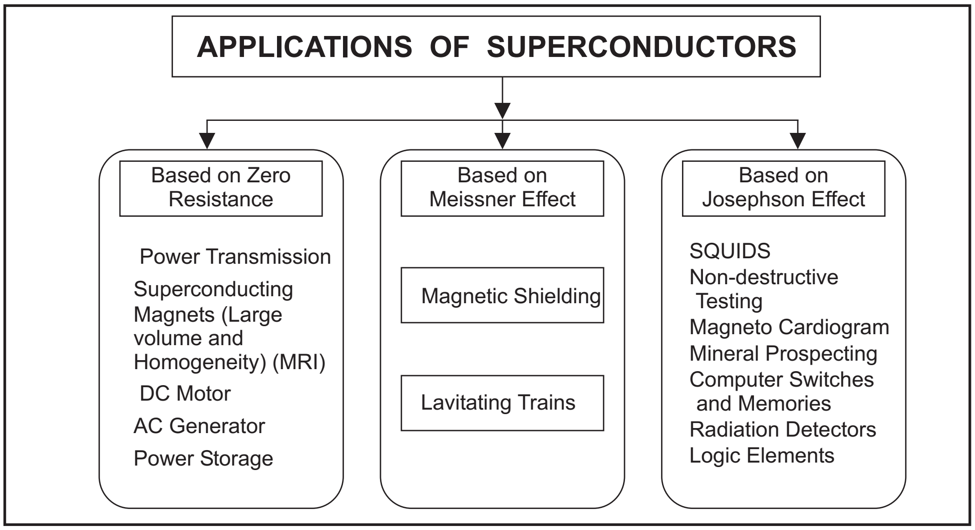


Figure-14: Resistance vs Temperature Plot of superconductors



Box - 1: Applications of Superconductors

Electronic Applications

- *SQUIDS:* Superconducting Quantum-Interface Devices (SQUID) have long been the best technology for detection of extremely weak magnetic fields, down to 11 orders of magnitude below the Earth's magnetic field. The sensitivities are even sufficient to observe fields generated by the human-brain that are measured outside the skull. Applications range from science, engineering and medicine.
- *Superconducting Analog-Digital Converters:* A key component of a high-speed communications system is the analog-to-digital (A/D) converter. They appear in many systems; a new thrust is to perform the A/D conversion closer to the antenna at RF frequencies and then to process the signals digitally. This requires ultra fast sampling and large dynamic range. The single-flux quantum-circuits allow extremely fast switching, natural quantization, quantum-accuracy and low-noise, all at low power.
- Today the main role of HTS materials in electronics applications is as thin film microwave-filters that are used in cellular base-station receivers.
- Because of its fast switching properties, the Josephson-junction can be used as a computer element, producing high speed and compact chips for the computers.
- Superconductor – insulator – superconductor (SIS) junction is used for millimeter wave-detection and mixing. In this application the Josephson-current must be suppressed to avoid noise-degradation.
- Quantum computing is an active current research topic, for which superconducting devices are contenders.

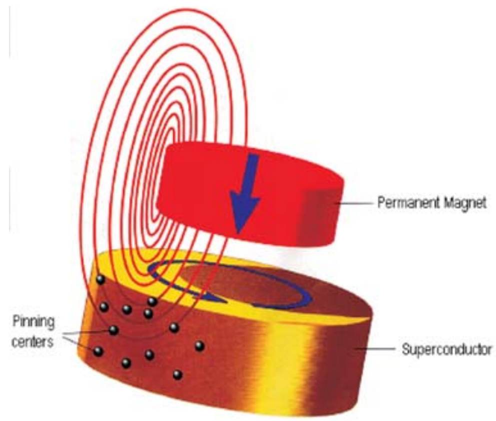


Figure - 15: This Schematic Diagram of Superconducting Levitation Basics show flux pinning. Small vortices of Current Flow around Pinning Centers, or Imperfections in the Superconductor, Trapping Quantized Flux-Lines

Large Scale Applications

Practical superconductors for large-scale applications are type-II materials, with the feature that the magnetic flux is pinned within the atomic structure. These sources of pinning are referred to as 'pinning centers'. The effect of the pinning centers is to allow a material to carry a significant current at an elevated magnetic field.

- *Electric-power applications of superconductivity:* Superconducting power-applications include, superconducting cables, superconducting magnetic-energy storage (SMES), fault-current limiters, and transformers. If power transmission lines could be made super-conducting, these DC losses could be eliminated and there would be substantial saving in energy-cost.

- *Superconducting Magnets:* The most familiar large-scale application of superconductors is in the production of magnetic fields. These include magnets for accelerators that have circumferences of 10s of kilometers, detector-magnets that are tens of meters in circumference, containment magnets for fusion research, and magnets for levitation.

The Phenomenon of Magnetic Levitation can be exploited in the field of transportation, without any polluted atmosphere.

Magnetic-resonance imaging (MRI) devices, which use magnets that are large enough for patient access, and produce fields of 0.5 to 3 T. Magnets for the separation of impurities in a variety of industrial processes. Small superconducting magnets that deliver fields of up to 16 T for measurements of a variety of physical characteristics in research labs.

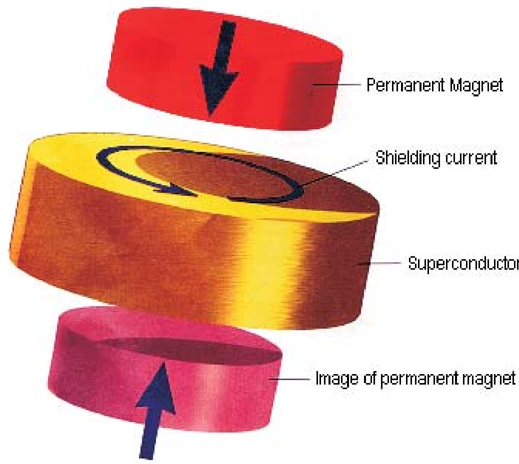


Figure -16: This Schematic Diagram of superconducting Levitation Basics Show Diamagnetic Response. The Shielding Current Acts to Form in Effect a Mirror Image of the Actual Magnet, Producing a Repulsive Force

- *Superconducting generators / motors:* These use superconducting field-windings. These windings are part of the rotor and carry a DC current that produces a magnetic field that also rotates.

In particular, bulk superconductors, in combination with permanent magnets, provide bearings for rotating machines with lower losses than any other technology.

PHYSICS IN MEDICAL SCIENCE (PHYSICS FIGHTING THE CANCER)

- *Physics and Cancer:* The fundamentals of cancer are the fundamentals of growth. Physics offers biological tools and techniques to attack the disease, but both sciences must work together on the basic problems of growth.

- *Radiation in the Treatment of Cancer:* The art of cancer treatment is finding the right balance between tumor-control and injury to normal tissues.

- *The Physics of Intensity-Modulated Radiation-Therapy:* By specially varying the intensity of an x-ray beam, IMRT enables careful sculpting of radiation-treatments around sensitive tissues.

- *Cancer Treatment with Protons:* Once an obscure area of academic research, proton-therapy is developing into an effective treatment-option for use in hospitals.

PHYSICS IN INDUSTRY

- *Metal Foams find Favor:* Lightweight yet stiff, metal foams are used in applications ranging from automobiles to dental implants.

- *Amorphous semiconductors usage in digital X-ray imaging:* The same photoconducting materials that made photocopying possible in the 1960's, are now poised to provide a basis for convenient, fully digital radiography.

CONCLUSION

This paper was presented in the context of the 'World Year of Physics – 2005'. This paper discussed the adventures of Experimental Physics and the revolutions, which Physics brought in our lives.

REFERENCES

- J.G. Bednorz and K.A. Muller "Z. Phys. B 64 (1986) 189
- John Banhart and Denis Weaire, Physics Today, July 2002, p 37
- John Rawlands and Safa Kasap, Physics Today, Nov 1997, p 24
- Proceedings of the IEEE, Vol. 92, No. 10, October 2004
- Physics Today, September 2002, p 5,34,39,45,53

HOW SCIENCE AFFECTS OUR LIVES

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ABSTRACT

We are living in a time when our picture of the structure of matter, of the birth and evolution of the Universe and of life is going through a major revolution. Through science, humankind is getting a better perspective of its place in the universe. What most citizens of the world do not realize is that the advancement in the fundamental understanding of nature is driving what we commonly call "progress". Fundamental research is the engine of innovation, and in turn, technological development, stemming from innovation, provides fundamental research with better tools, for pushing further the frontiers of knowledge. This unlimited feedforward process, to which physics is strongly contributing, will continue unless it is stopped by accident, or by the inability of mankind to control it's increasing power.

1. SCIENCE: A FEW DEFINITIONS

- *Science*
  "Coherent ensemble of knowledge related to certain categories of facts, objects or phenomena obeying laws and verified by experience"

- *Science and Technology*
  Science should not be confused with technology!
  "Too often science is being blamed for the misuse of technology it allows" (quote R. Oppenheimer)

- *Fundamental (basic) Research*
  "The process by means of which science progresses"

- *Applied Research*
  "Development of innovations based on the results of fundamental research"

Fundamental Research

- Fundamental research is the expression of human curiosity, of the need to understand:

Note: Since the full text of this very interesting paper was not available, extract from Dr. Revol's presentation is given here.

The structure of matter (nuclear physics, particle physics, solid-state physics, etc.)

Life (botany, chemistry, molecular biology, etc.)

The structure of the Universe (astrophysics, cosmology, etc.), in order to decode our past, predict our future.

- For instance, my laboratory, CERN, is entirely dedicated to fundamental research. (in practice, there is also applied research at CERN)
- Curiosity is the motivation of physicists. It is presumably this curiosity that is the basis for the evolution of humankind. Human evolution is linked to the ability to ask questions.

2. HOW DOES SCIENCE AFFECT OUR LIVES?

- The main benefit of science to society is satisfying human curiosity, and expanding the knowledge of our place in the Universe, from the village, the Earth, the Solar System, the Milky Way (our galaxy), the Local Group of galaxies, the entire Universe:

  Galileo (1564-1642): new place of the Earth in the Universe (a process that prove costly sometimes (G. Bruno));

  Einstein (1905): relativity implying a new relation between space and time (i.e. cosmic muons, GPS);

  The 'Expanding Universe', as opposed to a 'Static Universe' (Hubble, 1929, leading to the Big Bang model);

  Crick and Watson (1953): discovery of the double-helix structure of DNA, the fundamental molecules of life;

  Recent discovery that 96% of the content of the Universe is of unknown nature;

  The realization that space and time were perhaps both created due to the Big Bang. (difficult even for physicists)
- The strongest justification for fundamental research is the quest for knowledge, which brings society a most unique cultural value, while playing an essential educational role. (Most often, association with universities)
- However, there is another strong justification for fundamental research, which has to do with innovative technologies that will be discussed later on.

3. THE ROLE OF OBSERVATION IN THE PROGRESS OF KNOWLEDGE

- Today physicists study the Universe over dimensions, varying by 45 orders of magnitude. This requires many different types of instruments.

Instruments: The Two Ends of the Scale

- Today we know how to build giant telescopes such as Hubble, and we know how to build huge instruments such as the LHC and its detectors at CERN.

4. THE STUDY OF LIFE

- In 50 years, molecular biology went from discovering the double-helix structure of DNA (Crick and Watson, 1953, the same year the CERN convention was signed!), to sequencing the entire genome for a variety of forms of life including humans (2001).
- The spectacular progress was mainly due to improved instruments (X-rays, electronic microscope, gel electrophoresis, etc.), combined with cross-fertilization between fields (Francis Crick and Maurice Wilkins, medicine Nobel prize laureates in 1962 together with James Watson were both physicists). i.e. "DNA Chips" borrowed from Printed Circuit Board technology.

"DNA Chips"

- Relative levels of expression of several hundred genes across ~200 cancerous tissue-samples, including breast (BR), (BL), central nervous system (CNS), colon cancer (CO), leukemia (LE), (LU), lymphomas (LY), metastasis (ME), (ML), ovarian (OV), pancreatic (PA), prostate (PR), renal (RE), uterine (UT), as measured by "DNA chips''.

The Study of Life also Takes other Aspects

- The search for extraterrestrial life: do living organisms exist elsewhere in the Universe?
  - In meteorites
  - On planets or moons in our Solar system (Mars, Titan, etc.)
  - Recent discoveries suggest rocky planets similar to Earth may be common in the Universe
  - Search for signals from other civilizations (SETI).
- Could other intelligent beings exist somewhere else in the Universe? Are we unique?

  Positive answers to any of these fascinating questions would certainly change the perspective of our place in the Universe.
- We are living at an exceptional time, when progress in life-studies is exciting and faster than ever expected.

5. THE STUDY OF THE STRUCTURE OF THE UNIVERSE

- At the larger end of the physics scale, the 20th century saw a huge revolution, from a 'Static Universe' (Einstein's blunder which turns out not to be a blunder any more) to an 'Expanding Universe'.
- The Big-Bang model, became the "Standard Model" of the Universe, now it is very well established:

  Red shifts increasing with distance (E. Hubble expansion 1929);

Abundance of light elements from nucleo-synthesis from Big-Bang works well.

The 2.725°K microwave background radiation, discovered by Penzias & Wilson in 1965, a relic of light, which decoupled from matter 379,000 years after the Bing-Bang, and whose very small fluctuations (1/104) reflect the fluctuations in the density of matter at the time of decoupling.

Wilkinson Microwave Anisotropy Probe (WMAP)

- An impressive series of results:

  Age of Universe: 13.7 billion years, (1% accuracy)

  First stars igniting at 200 million years

  Decoupling of photons at 379,000 years

  Ho = 71 (km/sec)/Mpc, (5% accuracy)

  New evidence for Inflation (in polarized signal)

  Universe geometry is flat (it will expand for ever) (W = 1), etc.

What is the Universe Really Made of?

- The result of our brilliant observations is rather frustrating: 96% of the content of the Universe is not known! But again, this is tremendous progress!

6. THE STUDY OF THE STRUCTURE OF MATTER

The Building Blocks

Type of force	Relative intensity of forces	Particle exchanged (field quantum)	Typical
Strong	~ 1	8 Gluons (no mass)	phenomenon
Electro-magnetic	~ 10^{-3}	Photon (no mass)	Electricity
Weak	~ 10^{-5}	Bosons Z0,W+, W- (heavy)	Atomic shell
Gravitational	~ 10^{-38}	Graviton?	Radioactive β decay

Do all the Forces Become One?

- Main discoveries by CERN:

  Weak Neutral Currents (Gargamelle, 1973)

  W&Z bosons (C. Rubbia, S. Van der Meer 1983)

  Confirmation of the existence of 3 neutrino species (LEP, 1989)

The Standard Model

- The Glashow-Salam-Weinberg model has been tested to unprecedented precision at LEP (only mass generating mechanism left to test (Higgs)).
  - Z0 mass known to 2 parts in 100 000!
  - More than 12 parameters measured with a precision of 1% or better.
  - Largest difference with model prediction is 2.3 standard deviations (FB asymmetry of b quarks)
- The precision is such that it gives information on particles beyond the kinematical reach of LEP, in particular on the top quark and Higgs masses:
  - Top quark: 173^{+12+18}_{-13-20} GeV;
  - Higgs: 91^{+58}_{-37} GeV;
  - $M_H < 202$ GeV.
- The low Higgs mass value obtained is precisely what one would expect with Supersymmetry!

Beyond The Standard Model (SM)

- However, the SM is only a low-energy approximation and we already know that it must break down:
  - There is no unification of e.m., weak and strong forces; furthermore gravitation is not included.
  - Stabilization of gauge hierarchy (m_W « m_{Planck} ~ 1019 GeV?). No explanation for the apparently low Higgs mass (if the Higgs exists!).
  - No Dark-Matter present in SM
  - Perhaps discrepancy in muon anomalous magnetic moment (MUON g-2 Collaboration).

7. THE MAIN QUESTIONS OF PHYSICS

- Why are there so many kinds of particles?
- What is dark-matter?
- What is dark-energy? Is it related to the Higgs field? To a cosmological constant (variable?)
- What is the mass-spectrum of neutrinos, do they conform to the pattern of ordinary matter?
- What happened to anti-matter?
- What triggered the Big-Bang? Was there a unification of all forces including gravity, and how was it realized? How did space, time, matter and energy take the form, we see today?

LHC will Help Solving Some of these Questions

Elementary particles	-	Origin of mass? Higgs particle?
The 11 microsecond old Universe	-	Nuclear collisions
Dark-matter	-	Supersymmetry?
Origin of matter	-	Matter-antimatter asymmetry?

LHC will explore entirely new territories of physics …
This is a 'no-lose' scenario

Are There Extra Dimensions of Space?

- Superstring theory does not work in 4 dimensional space. Additional dimensions (6, 7, curled on themselves?) are necessary. At which scale?˜ 1/MPlanck?

The LHC Challenge

- The LHC is the most ambitious project in particle-physics
- It is a great challenge in many different fields!
    - accelerator,
    - detectors,
    - computing,
    - financing,
    - organization, etc.

It involves about 6,000 collaborators, in 450 laboratories in 80 countries, including Pakistan.

The LHC Detectors

- ATLAS
- CMS
- TOTEM
- ALICE
- LHC

8. THE USEFULNESS OF SCIENCE

- Besides satisfying our thirst for knowledge, is fundamental research of any use to Society?
- History shows that it is fundamental research, hence, human curiosity, that drives the development and progress of society, and that the success of a civilization depends on its support to science:
    - Greek civilisation (first to make the search for knowledge a value);
    - Pre-medieval Arabic civilization;
    - 15th century Chinese civilization:

* Debate between Eunuques and Confucianists: Why go look at what's going on elsewhere?

The size of Zheng He's armada did not exceed five centuries.
(28,000 sailors, 300 ships (some 130 m long)

Michael Faraday

- First half of 19th century: Faraday, English physicists (1791-1867) contributed brilliantly both to applied research and to fundamental research.
- Faraday was mainly interested in understanding various electric and magnetic phenomena.

Casimir

Innovation

"I think there is hardly any example of twentieth century innovation which is not indebted in some way to basic scientific thought"

Prof. Casimir, Philips Research Director,
Symposium on Technology and World Trade, 1966

- Certainly, one might speculate idly whether transistors might have been discovered by people who had not been trained in, and had not contributed to, wave mechanics or the quantum-theory of solids. It so happened that William Shokley, John Bardeen and Walter Houser Brattain, the inventors of transistors, in 1947, were versed in and contributed to the quantum-theory of solids.
- One might ask whether basic circuits in computers might have been found by people who wanted to build computers. As it happens, they were discovered in the thirties by physicists dealing with the counting of nuclear particles, because they were interested in nuclear physics. (1943: Americans J.-P. Eckert and J. Mauchly build the first electronic computer ENIAC (Electronic Numeral Integrator and Calculator)
- One might ask whether there would be nuclear power because people wanted new power-sources or whether the urge to have new power would have led to the discovery of the nucleus. Perhaps - only it didn't happen that way.

Mechanisms of Innovation

- Direct: Faraday's work. The discovery of the spin of the proton opened the way to medical imaging by Nuclear Magnetic Resonance, etc.
- Indirect: The tools developed for fundamental research often find applications in other areas:

  Application of detector technology in medicine
  e^+e^- Tomography (CERN & Hospital Cantonal in Geneva)

Hadron therapy (cyclotrons) [Centre Lacassagne, TERA …]
Production of radioactive isotopes for medicine & industry

- Application of accelerator technology and simulation techniques to the development of “hybrid” nuclear systems (Energy Amplifier proposed by Carlo Rubbia)
- Inventions: "World Wide Web" at CERN 1989-90 (The Economist, which awarded its 2004 innovation prize to Tim Berners Lee for the invention of the Web, wrote: “WWW … changed forever the way information is shared”)

CERN, Internet and the WWW

- The GRID: A necessary solution to CERN computing needs with LHC
- The objective of the LHC Computing GRID project funded by the European Union is to provide LHC experiments with the computing resources they need for data analysis while at the same time building the next generation computing infrastructure. WWW >>> Sharing information GRID >>> Sharing computing resources

9. FEEDBACK PROCESS

- Innovation allows the construction of much more powerful tools, thereby, allowing the exploration of new territories of physics:
  Pixel detectors at LHC borrow from the microchip technology;
  Computer technology allowing the processing of huge amount, many Petabytes, of data (LHC, Astro- hysics, SETI, molecular biology, etc.);
  Lasers which were offspring of atomic physics are now powerful tools for fundamental research (laser interferometry in search for gravitational waves, etc.)
- We can be sure that the new science projects will directly or indirectly produce their share of innovations, in a strong feedforward process.

10. CONCLUSIONS

- Fundamental research brings society a most unique cultural value and provides exceptional training grounds for students, who will then transfer their skills to other domains of society (industry, education, economy, politics, etc.)
- Fundamental research is a key to the development of Society; without fundamental research there is no innovation.
- It is a good sign for the future, that a country like Pakistan celebrates fundamental research on the occasion of the ‘World Year of Physics’, thus, strengthening the legacy of Abdus Salam.
- It makes sense for developing countries to contribute at the forefront of fundamental research, and nothing less than the forefront.
- Science is universal and can bring the people of the world to cooperate peacefully, as they already do at CERN.

USES OF BASIC PHYSICS

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ABSTRACT

A brief history of industrial development in Europe and, in particular England, with the role played by basic physics is traced. Some examples of development resulting from basic physics and the impact of the works of basic physicists and their research methods and approaches are highlighted. The indelible imprint made on the fabric of development by the revolutionary and fundamental contributions of physics in the 20th century are also discussed. In this context, since this paper is dedicated to 'World Year of Physics 2005', it highlights the contributions of Einstein, in particular, and their impact on development at present and in the future. In the end, summary of the discussion and some recommendations are given.

INTRODUCTION

Physics is a study aimed at unravelling the laws of nature and how they operate. The methods employed by basic physics or what is equivalently known as 'fundamental physics' are designed to study the frontiers of knowledge. However, in the wake of its potential analytic power and search for simplicity of principles, at the root of natural phenomenon, it has evidently become established, historically, as a field of far-reaching import and applicability, both directly and through spin-offs[1] to the development of technology and in turn to industry. Exploring frontiers of knowledge from its basic concepts, such as nature of matter and energy, it examines and utilizes discrete particle nature of this phenomenon to reveal mind-boggling characteristics, which lead to new and emergent technologies. To mention a few existing well-tried industrial developments hitherto discovered, we have electronics, lasers, communication- technology, energy resources, semi-and super-conductors, computers. These technologies in the last millennium, which were based on fundamental physical principles, have revolutionized society and have left a deep and indelible imprint on the fabric of human development.

The role of physics and physicists in the R&D work is highly significant. Fundamental physics, in particular, imparts special intellectual training and creates a typical mind-set to develop and analyze scientific methods that can be applied to development of technology to be used in industry.

This paper first traces history of industrial revolutions in Europe, beginning in the 18th Century in the next section. In section III, we give examples of some major discoveries in Physics, which entailed contemporary technological developments and resulting industrialization. This section is divided into two parts, the second part, in particular, gives examples of scientific and technological 'breakthroughs' based on Nuclear and Particle Physics. In section IV, paper discussed possible futuristic and emerging technologies that are based on Einstein's Theories. These theories are currently being celebrated in the World Year of Physics 2005, to which this article is dedicated. Einstein's Relativity Theory not only has impact on the dynamics of particles moving with speeds close to that of light, but also on those that possess spin, a relativistic degree of freedom. Taking this property of electrons moving in an electric field, efforts are on to make what are called "Relativistic chips", to be utilized for 'MRAM' effects in what may become important new and emerging technologies. This section also briefly mentions how Global Positioning Satellites (GPS) carry out relativistic time-corrections for accurate position measurements. In addition, other measurable effects, based on Einstein's theories as applied to new technologies, are also referred to, here. Section V focuses on research methodology which training in basic physics yields. In section VI, we discuss some recommendations for improvement of R&D effort in national institutions and universities in the light of our analysis in this paper.

I. BRIEF HISTORY OF DEVELOPMENTS

The revolution in basic sciences, in general, and Physics in particular, during the last couple of centuries after industrial breakthrough in Europe, has completely transformed our outlook towards the things around us. The developments that have taken place in understanding Physics, the role played by physicists and its impact on development, can be divided into three phases:

18th Century: 1st Phase of Revolution

The concepts of Newtonian Mechanics and Thermodynamics were already established before the beginning of 18th century. During this century, steam-engines, textile mills and metallurgical techniques were developed. This was handy-man's work mostly based on hit and trial basis, viz:

"In fact thermodynamics owes more to steam-engines than steam-engines owe to science" George Porter (Nobel Laureate in Chemistry). Such thinking, unfortunately, led some people to believe in the anti-linear model rather than the linear model, in which technology follows science. However, this is not generally true in the history of science and technology where, many a time, basic science played a leading role.

History of science and technology, however, is replete with examples of development rising nonlinearly, in fact exponentially, as a result of interaction of science and technology, as we shall see later. Intimate relationship between science and technology, where both sectors are abundantly and intensely available to partake in development, is now a must for industrial growth. Typical example relevant here is the Bell Telephone Laboratory of USA, where basic and applied sciences go hand-in-hand with technologies.

19th Century: 2nd Phase of Revolution

The second phase of industrial revolution followed Maxwell's equations of electrodynamics, which unify electric and magnetic forces in a beautiful set of four equations. In this phase of development, Chemistry and structure of molecules played the leading role, which is a manifestation of the electromagnetic phenomena.

20th Century: 3rd Phase of Revolution

This phase started with the discovery of electron, atomic and nuclear phenomena as well as quantum mechanics. J. J. Thomson who discovered the electron, in a speech delivered in 1916, describes the role of basic sciences[2] as:

"By research in pure science, I mean research made without any idea of application to industrial matters, but solely with the view of extending our knowledge of the Laws of Nature. I will give just one example of the 'utility' of this kind of research, one that has been brought into great prominence by the World War: I mean the use of X-rays in surgery ...." he continues: *"Now how was this method discovered? It was not the result of research in applied science, starting to find an improved method of locating bullet wounds. This might have led to improved probes, but we cannot imagine it leading to the discovery of the X-rays. No, this method is due to an investigation in pure science, made with the object of discovering what the nature of Electricity is"*.

He went on to say that applied science leads to improvements in old methods, and that *"applied science leads to reforms, pure science leads to revolutions; and* ***revolutions, political or scientific, are powerful things if you are on the winning side"***.

An inference from here for planners and science-funders is to be on the winning side. Continuing to explore further examples of direct or indirect results of basic-science research is the computer. We all know that *"discoveries in fundamental Physics, which underwrite modern electronics, development in mathematical logic and the need of nuclear physicist in the 1930's to develop ways of counting particles"* (C. H. Llewellyn Smith, former Director General, CERN[2]).

Now we discuss some examples of science and technology inter-relationship.

II. EXAMPLES FROM SCIENCE AND TECHNOLOGY

General Examples

At this point in tracing the history of development and finding usefulness of basic science, in particular basic physics, to society, it may be relevant to enumerate a list of uses, direct or indirect (spin-offs), of basic-science research as laid down by H. B. G. Casimir[2,3], former Director Research, Philips, Netherlands, the person who discovered the Casimir effect.

- *Transistors:* Schrödinger's Wave Mechanics, Quantum Mechanics and Quantum Theory of Solids (work of Bloch, Peierls, Wilson, Bethe, Born, etc.), and of course the contribution coming from industry on solids-band structure, the role of donors and receptors that led to the discovery of the transistor, which in turn enriched Solid-State Physics. The discovery of transistor provides us with a typical example of the impact of basic physics on development in a non-linear, rather exponential growth of technology and industry.

- *Circuits in Computers:* Basic knowledge of circuits is required to build computers, which as pointed out before in turn, were made due to the need of counting and handling huge data in nuclear reactions; of course computers in turn have resulted in tremendous understanding of science itself, e.g., human-genome mapping and biotechnology.

- *Nuclear Power:* Could there be nuclear power without discovery of the nucleus and study of its physical properties? Here a natural question arises in relation to contribution of fundamental physics to nuclear technology.

- *Electronics:* The same way one could ask the question whether the electronics industry could follow without the discovery of electron by J. J. Thomson and H. A. Lorentz.

- *Faraday's Law of Induction:* This is the Law that led to the induction-coils and their use in industry.

- *Electromagnetic waves and Telecommunications:* These followed from the work of Hertz, who was guided by the results of Maxwell's theory.

There is hardly any example of 20th century development, which is not impacted by the concepts or thinking of basic sciences, and in particular basic physics, beyond Newtonian era.

III. EXAMPLES OF SPIN-OFFS FROM BASIC PHYSICS

Now mentioned here are some spin-offs from the techniques developed in basic-research in nuclear and particle physics that turned out to have useful industrial applications.

Particle accelerators, using electrons, protons, ions, etc.:
- semiconductor industry, sterilization of food, medicine, sewage, by irradiating samples
- radiation processing
- non-destructive testing
- cancer therapy
- incineration of nuclear waste by conversion into daughter nuclides

- source of synchrotron-radiation, with uses in biology, materials science, condensed-matter physics
- source of neutrons, with again uses in biology, materials science, condensed-matter physics

Particle Detectors: crystal detectors, with uses in medical imaging, security, non-destructive testing

Multi-wire Proportional Counters: used in container-inspection

Informatics: world-wide web (www) invented by Tim Berners Lee of CERN, Geneva

- grid computing, which is used both for software as well as hardware development in parallel processing and distributed computing, networking, fast algorithms, super- computing, PC's clustering. This is developing fast at CERN and other places

Superconductivity: conventional and high T_c superconductivity, multifilament wiring / ducting, cabling, nuclear magnetic resonance-imaging

Cryogenics, vacuum technology, electrical engineering, etc.

IV. FUTURISTIC TECHNOLOGIES

Celebrating Einstein's legendary and revolutionary contributions to basic physics, in the World Year of Physics-2005, we would like to list here the possible, present and future, impact of his theories, and role in developments of photoelectric effect, Brownian motion and Bose-Einstein condensate.

A Santa Barbara California group involving David Awschalom is exploring relativity theory for application to computer-chips. The electron spin is studied for the development of non-erasable memory called MRAM, where fast-moving relativistic electrons see electric field as partly magnetic, causing their spin-axes to precess. The speed of the electron and strength of electric field can be varied at the gates, a relativistic microchip might create spintronic 'Phits' (phase digits) that can take a much wider range of values than just 0 or 1. Currently, research work is being done on the basis of semiconductor spintronic chips. They involve 15 different spin-precessing states, when a relativistic electron turns through different azimuthal angles, with respect to the direction of the applied electric field[4]. Fast and efficient microchips possessing MRAM are already used in some laptops. The work on spintronic logic-gates has been initiated in the Paul Drude Institute in Berlin. Such chips and transistors use and dissipate less energy than traditional transistors. Using 'Phits', such machines may turn out to be much faster, more powerful and handy than the existing computers.

Engineers are still far from mastering relativity as a design-tool for spintronic microcircuits. But since the intensities of the electric fields involved are not very high, therefore, this certainly is an area where microchips may be modified in hetero-structure (two or more layers) to study preparation of Phits as a pilot-project in a developing world's laboratory.

Another area where Einstein's relativity theory, both special and general, has given a break-through is telecommunication in Global Positioning System (GPS) satellites[4] that have atomic clocks on board, which measure highly accurate time at high orbital velocities and relatively less gravity. These clocks suffer a slowness of time by 7 μs per day (Special Relativity) and time gain by 45 μs per day (General Relativity). Thus, these clocks are retarded by a net time-rate lag of 38 μs per day within 15 m for doing their positioning functions. This task is accomplished by Wider Area Augmentation System (WAAS) with a network of earth-based clocks.

Einstein's famous paper "On the Quantum Theory of Radiation" (1919) predicted masers/lasers, which are now found in all house-hold appliances, medical technology and industry. Laser-like propagation of Bose-Einstein condensate found work in gravity mappers and gyroscopes.

Brownian motion was discovered by Einstein's insight into molecular motion and has resulted in its application to quick DNA-separation in biotechnology or separation of solids from water.

V. RESEARCH METHODOLOGIES

Research in basic physics provides an excellent training in problem-solving for those aspiring to join industry. For physicists, an observation is the starting point. A set of hypotheses is given in support of observations. Based on this, a deductional framework or an analytical model is given, which in turn is based on mathematical logic. All relevant and already existing observations and experimental data are explained in the deduced framework. Predictions for comparison with future experimental results are made in agreement with observations. A more general set of hypothesis follow if future experiments do not confirm the existing framework, this requires new deduction, logic and supporting mathematical framework, in this way one looks for a new theory, which is more general and elegant, and hopes to explain larger set of data of experimental observations.

This is a common technique among basic physicists. Thus, here one looks for an elegant and simple way, which can describe laws of physics in terms of equations that are powerful enough to explain a wider set of data from experimental observations. Brief history of development underscores the role of basic physics and its educational, scientific, and cultural impact on the society. Thus, a successful theory must confront experimental observations and should be able to make predictions.

Basic Physics has, therefore, sound educational value in research-methodology. It leads to precision, consistency and mathematical accuracy in scientific approach and endeavor.

VI. SUMMARY AND SOME RECOMMENDATIONS

This brief history of development underscores the role of basic physics and its educational and cultural impact on society. One notices that the applications of new knowledge may have time-lag in its utility-value, but it is indeed there as its direct or indirect outcome. Strength of educational base is a top priority in obtaining these benefits from the power of Physics. This would require high literacy, sound primary and secondary, and quality tertiary level education.

Adequately equipped labs and libraries are necessary for quality science, in particular Physics education. We need highly qualified, inspiring, well-motivated and dedicated teachers in Physics. The curricula and teaching in Physics has to be compatible with international standards. The government seems to have made a start in the right direction. But the goals are a long way off and only a sustained and uninterrupted effort, which ensures basic-science development, in particular Physics, will show us the way to progress. Science-policies have existed over the years in Pakistan, but these have not been implemented due to lack of funds or rapid changes in the government. There should be a national consensus on universal education in Pakistan, to compete with fast-moving scientific world.

Research in Physics is primarily curiosity-driven and its culture cannot be created with merely inducement, e.g. material gains. A sustainable and uninterrupted effort is required to ensure basic-science development, and R&D work. Further it is strongly recommended that the following three factors for ensuring breakthrough of R&D work in our institutions be stressed:

i **Linkage and Sponsorship by Industry:** There can be no breakthrough without the involvement of industry, as universities and industries must go together hand-in-hand in this endeavor.

ii **Linkage with Foreign Universities, Regional and International Labs** like CERN, AS-ICTP, Elettra (Trieste Synchrotron Light Source) and major US and other international universities for the training of manpower and research projects.

iii **Indigenization of efforts in R&D work in the universities**, both public and private, should be promoted by the governments.

Finally, summing up the linkages of Physics to other disciplines, as well as its various applications to industrial and technological aspects, which is shown in the following flow-diagram:

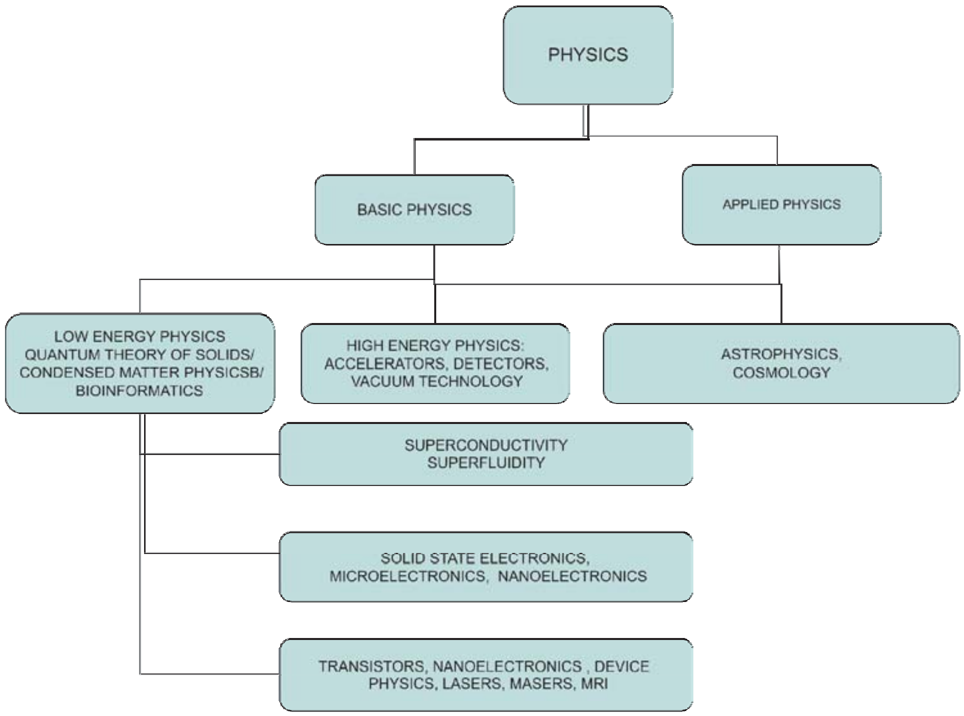

Figure - 1: Linkages of Physics to other Disciplines

REFERENCES

1. W. Wyatt Gibbs, "Atomic Spin-offs for the 21st Century", Scientific American, **291** (2004), 40.
2. C. H. Llewellyn Smith, "What's the Use of Basic Science", a talk in colloquium at CERN (12 June 1997), http:// public.web.cern.ch/Public/.
3. H. B. G. Casimir, (1988), "The Role of Industry: Knowledge and Skills", *Physics in a Technological World,* editor A. P. French, American Institute of Physics, N.Y. See other references in this AIP Proceedings.
4. Philip Yam, "Everyday Einstein", Scientific American, **291** (2004), 34.

PHYSICS IS LIFE — LIFE IS PHYSICS

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ABSTRACT

We know life is electrochemical, electricity is patently physics, and that the borders between chemistry and Physics are now fading. Physics came into existence the day when the Big-Bang took place, and the usefulness of physics as a science will remain for ever.

Physics is so ubiquitous, a thousand principles of physics can be identified in a single piece of equipment at our houses. The paper looks at things with a different perspective and underlines the relationship between physics and our day to day life. The paper also suggests and identifies number of ways to improve and promote education of physics.

INTRODUCTION

God Almighty created matter for this universe. People say it happened with the Big Bang. Everything that happened since then is physics. Science is basically physics, and it is ubiquitous. The best way to honour physics is to apply it better. Scientific principles are normally thought of as being applicable to inanimate objects. Actually, they provide excellent guidance on very important social and national policies. For example, the need for social, national coherence, the fallibility of human decisions, the optimal procedure to decide important national issues, the probability of a Judgment-day, etc. However, our application of physics to inanimate objects is also poor, the main reason being lack of comprehension of school-level science. Among other factors responsible for this is foreign medium of instruction. Finally, mathematics is no less important than science. Rather, there is no science without mathematics.

God Almighty created matter for this universe. People say it happened with the Big Bang. Everything that happened since then is physics.

The Theme “Physics in our Lives” could be modified. It would not be wrong to say ‘Physics is life’, rather than ‘Life is (all) Physics’.

We all agree today that biological processes are electrochemical. Electricity is patently physics; and the border between chemistry and physics vanishes, at the molecular and sub-molecular levels. Therefore, all science is basically physics. I shall use the words science and physics interchangeably.

Science (or physics) is ubiquitous everywhere, be it at any place, at a hall, office or home. As for example let us take the water-heater (geyser) in consideration, which is probably the most low-tech appliance at our houses. Yet, one can readily identify half the chapters of an average physics text-book being directly applied. For instance, look at the tiny temperature indicator on the front, costing about Rs. 20, it works on the principle of linear thermal- expansion. Now, look at the outer skin of the heater. How much technology, which is again physics, is used in manufacturing the skin? The insulation-jacket inside the skin, normally of glass-wool, draws upon laws of heat-conduction and insulation. The annular design of the water-reservoir and gas-exhaust must use all the laws of thermodynamics and heat-exchange. Heat exchange is improved by a mechanical design, which promotes convection-currents inside the reservoir. The burner, points to laws of gas-combustibility, combustion and molar heat of combustion. The tiny structure "sentenced" to suffer eternally in the heat of the pilot-flame is the thermocouple, reminding us of the 'Seebeck-Effect'. The thermocouple feeds current to an electromagnet, pointing to the vast physics' domain of electromagnetism. These two tiny parts, together stand guard for your safety. They cut out main gas-flow, if there is no pilot-flame to lit up the flame. This critical electromagnet is nothing but a few turn of good electrical conductor-wound on a high permeability core, with zero hysteresis. The gas-jets control the air / gas mixture, by drawing air due to Bernoulli Effect. There are at least two special springs in the control-unit, pointing to the chapter on elasticity.

If we look deeper into each of these components, we are reminded of more and more laws of physics.

On the high-tech side there is so much to mention. But just one phenomenon should suffice for an example. Teleportation [We humans are so happy about having achieved teleportation of one tiny particle with such elaborate arrangements. Muslims, Jews, and Christians should remember the transfer of Queen Sheba's throne to the Court of prophet king Suleiman (PBUH) in less than a wink of an eye. That was certainly not mass travel, because mass travel at high speed would certainly cause aerodynamic wake. Muslims, of course remember the fact of Israa of Prophet Muhammad (PBUH), the final prophet], even of a tiny particle is a major break through in the history of human beings, again in the domain of physics. It has the potential of drastically changing our lives. One can imagine traveling in no time, and to anywhere. Other influences of science in our life are well-documented and so common that needs no mention. It can safely be said that life is but physics (science).

And if physics (science) is so important to us, how do we honour it? The best way we an honour physics (science) is by simply applying it in a better manner and by popularizing it.

Application of Physics in a Befitting Manner

Humans have thought, and will continue to think of the new ways of applying physics for development and improving of standards of living. But all applications, hitherto, have involved only inanimate objects and processes. Many of the principles of physics have higher applications for an individual to societies, nations, and even for a larger community, i.e., global community.

For example, consider LASER. Lasers have a wide range of capabilities from saving lives to taking them. Laser derives its special strength from coherence. Coherence-gain is also important in communications and radar applications, which again are the off-shoots of physics. It can easily be proved that two equal, but coherent voltages (signals) together, produce twice as much power as two equal but non-coherent ones.

The coherence-gain for two voltages is, thus, two. If “n” voltages are involved, it will rise to “n”. (Of course “n” is the maximum possible gain. If coherence is not perfect, the coherence-gain will be less than “n”).

Coherence gain should apply where humans are working collectively. A team of people, which is more coherent will be more effective, with the same resources, than a team, which is less coherent. This is an accepted principle taught in management courses. (It is to be noted that there it is only an empirical law, whereas it is mathematically derivable via physics). Theoretically, “n” equally capable humans can have an advantage of “n” times over the same number of equally capable “n” incoherent individuals. However, the actual advantage may be less depending on the extent of coherence.

Now lets go a step further in describing and understanding things. Say given the same resources, national coherence should produce better GNP, Stronger Defense, etc. This fact seems to have been verified through the earlier history of Islam, when a small community was able to dominate a large part of the world, in a relatively short-time. When their internal coherence was disturbed they lost their power. Thus, we can conclude that: Coherence is a (force/effort) Multiplier.

The Holy Quran narrates:

“Adhere to the rope of Allah, and do not become incoherent”.

‘Heisenberg's Uncertainty Principle’ is taught to the children at educational institutions. In general terms, it says it is impossible to determine the exact momentum of a particle, even the tiniest one. What message does it have for humanity? An obvious conclusion is that human knowledge is severely limited. As a corollary, it is not scientifically correct to reject everything that cannot be verified by humans. Summary and categorical rejection of religion, miracles and of supernatural happenings is unscientific.

[Talking of miracles and yet claiming to be scientific seems to be illogical. But it is not. Ignoring established evidence is also contrary to scientific principles.

It is an established fact that Prophet Muhammad (PBUH) was observed for forty years and was found never lying. Till today nothing of what he has said has been "proved" to be wrong. If people refuse to believe valid evidence, that is unscientific. It is not scientific to reject that the stick of Moosa (AH) used to turn into a python, or that his hand could shine brightly, that Ibrahim (AH) was safe in the fire meant to burn him. If we cannot explain it away in terms of physics, it is only due to our limited knowledge, not because it didn't happen]

As a second corollary, an individual, or even the whole of humanity cannot "guarantee" the absolute correctness of a decision, and this raises a serious counter question. Then, how to decide important personal and national matters? A straight answer is: by following divine decisions, if available, (and provided you believe in divinity—i.e., *To Adhere to the Rope of Allah*). But this rather 'qualified' answer is half an answer. What should be done if Divine guidance is not available? Or if one doesn't believe in Divinity?

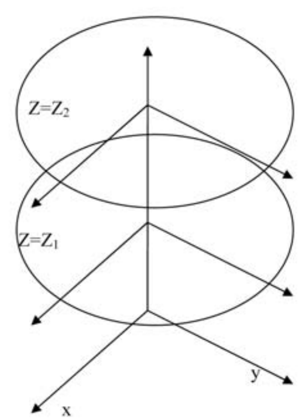
This question is easily answered by probability, which lies in the domain of physics, common with mathematics.

Probability taught at schools educate us that if among ten equally wise men, each is capable of independently making a decision with a rather large probability of error of 50 % or (0.5), the probability of all ten being wrong simultaneously will be $(0.5)^{10}$ or a mere 0.001, nearly one in a thousand. This is a phenomenal improvement!

Is there a lesson too for us here? Yes, of course. A decision arrived at by consultation has a much less probability of being in wrong. And this determines what to do when Divine guidance is not available or one doesn't want it.

The precondition is, of course, unbiased, independent opinion. Also, the probability of a correct decision increases, if the consultants are wiser on the matter under discussion. That is the correct procedure for deciding important national matters. All policy matters must be decided through, sincere and dispassionate discussion, among informed and concerned people, and not via an office memorandum.

The Holy Quran supports this conclusion by saying:
"They decide their affairs by consultation --- 'Shoora', … and also,
Once you have decided, trust in God, (do not waver)"



Message from the Fourth-Dimension:

Imagine a three-dimensional space, x, y, z. $Z= z_1$ is a two-dimensional structure spreading in x,y, only. $Z= z_2$

is another similar plane, but elsewhere.

Suppose a person (who can see down x,y but not z) travels in z. When he moves from z_1 to z_2, the structure z_1 still exists as before, although the person now at z_2, cannot see it.

In a four-dimensional universe, x,y,z,t, $t=t_1$ is a three-dimensional (universe) space, and $t=t_2$ is another one separated in time from the first one.

We are three-dimensioal beings, in the sense that we can see only along x,y,and z, but not t. So, we can only see the three-dimensional universe we are in, at a given moment. When we move from t_1 to t_2 (time passes), we are shifting from one three-dimensional universe to another one. If the difference, $t_2- t_1$, is small the two will differ slightly (Change due to time). But the important point is: our passage from t_1 to t_2 does not obliterate the universe in which we existed at t_1. That simply becomes our past and remains intact. Every moment that we live, we live in a new three-dimensional universe that goes out of sight-into the storage, we call as "past".

What does it imply? That as we move from one moment in time to another, and the present becomes past, the so-called past remains intact in full three-dimensions, even though we cannot see it.

What is the moral? Our past, good or bad, is not obliterated. It is there and will remain, (possibly) for retribution on Judgment-Day. This is a very serious prospect indeed!

All the heavenly books speak of the Judgment-Day, and that on that day all our past deeds will be visible. The Holy Quran says about that day: "We have removed the barriers on you. Today you can see well (things that were hidden)". Does physics give us a lesson in piety?

Even for those who do not believe in the Judgment-Day, there is a reason for concern. What if it does happen? We have no scientific guarantee it will not happen. What will they do then?

POPULARIZING PHYSICS

How popular is science in our society? And what is the trend? Is it becoming more popular in our society? Popularity should be judged by the extent of application of Physics. Let us define an index of application, for a given society:
A qualitative comparison can be made of the conditions today, with those half a century ago.

$$i = \frac{Extent\ of\ application}{Quantomof\ knowledge}$$

Fifty years ago, great grandma could not define the latent heat of vaporization of water. Yet, she would insist that in the afternoons of summer, mud-floors be given a coating of very thin "pocha" for cooling. Later, when cemented floors came, the wise women would insist on having the cemented floor washed, and not wiping off the water too religiously, again for cooling. During winters, they would come down hard on anyone who spilled water. "It produces a freeze", they would admonish.

Today, when grandmas have university degrees, and children have memorized all the principles of physics by heart, like: Vaporization produces cooling; Cooling is proportional to amount evaporated; Cooling can be offset by heating; Heat-energy is proportional to fuel burnt; Cost of heating is proportional to fuel burnt, etc., they do not bother to wipe off droplets left after taking shower, which produce cooling when evaporating, or indirectly, increase the heating bill in winter.

Fifty years ago, members of the household had studied little veterinary science and medicine, yet all, including women and children, were able to take care of their animals, the dog, goat, buffalo and the mare. They could even on their own treat them for minor ailments.

Today, automobiles, to the affluent families, are equivalent to mares of the past. Unfortunately, only a small percentage of our children or even adults can do a daily inspection of their automobiles. Only few can change a generator-belt in an emergency.

Our children study electricity, electromagnetism, piezoelectrics at school. Yet, very few know the difference between voltage and current. Even fewer children (or adults), actually know which hole of the 3-pin socket is live. Or for that matter, even the difference between "live" and "neutral" wire. They spend a lot of time doing "practicals/experiments" at school / college labs, but how many can correctly change a plug on a power-cord? Or how many can neatly fix a nail in a concrete wall?

Leaving aside the students, we can come to the teaching community. Very few are aware that optical surfaces need special care. Don't they place spectacles flat on table? Don't we all leave all O/H projectors uncovered in the class room?

The, reason is, one cannot consciously apply what one does not understand with ones mind and heart.

Our children study science at school /college to get good marks/scores with the goal of securing admission to a reputed professional institution. Comprehension is a secondary or even tertiary priority, both with the students and the teachers. The fault lies not with teacher and the students, but at the policy level.

The recent inclusions of multiple-choice questions (MCQs) in the paper, if applied judiciously, may help to raise the priority on comprehension. But, there are other impediments to comprehension too.

Textbooks are a serious problem. They are improved upon every so often with the pretext of modernization of the syllabi. The "improvements" seem so urgent that those cannot wait for one more academic year. As a result, textbooks are rewritten hastily almost every year, each time in a matter of a few months. Obviously, those are left with full of errors, which keep the teachers and students confused throughout the year. The books are written by the people with high qualifications, but, perhaps with little experience of teaching at that level. Such highly qualified people may know the subject very well, but teaching is something more than knowing. Teachers with experience at the relevant level are apparently not involved in the process. As a result, the books are often confusing, and at least, insipid. Also, the books on science, generally relate little to the technology around home and the farm. Little can they be expected to aid comprehension.

The well-intended system of practical examinations has also degenerated into a fruitless exercise and a waste of both time and money. It is nothing more than a business for certain people. Sale of biology samples and neatly completed practical books is a booming business just before the practical examinations. The same samples are collected by the college and kept. Those are purchased only to fulfill a regulatory/procedural requirement, to show to the examiner. These have no instructional value.

Figure - 1

Similarly, 'practical journals' are a headache for the students and financial burden for the parents. Those are carelessly printed and provide little understanding to the student. Again, just before the practical examinations one can see affluent billboards in the market-places, advertising: "Neatly completed practical journals are available here".

Little surprise, then, that Oxford and Cambridge universitys' O-level examinations do not insist on practical test/evaluations.

And now, we come to the most serious factor. Please look at the Figure-1,where the mother is trying to feed the child over the wall. Who is wiser? The mother or the child? Obviously, the child, who is talking sense in this case.

Now, consider that the food represents (science) education, and the mother represents the system. What is the wall? It is the foreign medium of instruction, acting as a barrier between the system and the student. A formal but simplified analysis of the effect of the medium of instruction on a student's comprehension is given below:

Education is basically imparting (transferring) some desirable (skills / habits) of one individual (teacher) to another person (student(s)). The teacher tries to pass the knowledge of the subject to the student(s). Hence, the teacher-student interface should be chracterizable by a transfer-function. We are basically trying to determine the transfer-function of the interface between the teacher and the student.

Assume that the teacher knows all that is needed by the student, in a particular course of study. Let us call it 'U'. Only a fraction Cet (Coefficient of Educational Performance of the **t**eacher) is available for the broadcast (or radiation) to the students. Which basically depends upon:-

a. The Teacher's own expertise;
b. His immediate plans for imparting the lesson; and
c. Minor factors like his mood, health, and environment, etc.

Here we can say that:

Cet =f (expertise, plan, mood, health, environ, etc), i.e, Cet is a function of expertise, plan, mood, health, environ, etc.

In the optimal situation, Cet will approach 1.0, but in practice Cet <1, hence, only U.Cet is available for broadcast to the students.

The broadcast to the students is, in some language called the 'medium of instruction'. If the teacher is not perfect in his command of the language, he will at most "radiate" U. Cet. C_{lt}, where C_{lt} is the '**C**oefficient of **l**anguage proficiency of the **t**eacher'. For simplicity, we note that C_{lt} will be near to unity, if the instruction is in the mother tongue of the teacher, and less otherwise, depending on his expertise in that foreign language. Due to imperfect command over language, a student will be exposed to only a fraction of what has been 'radiated' by the teacher. Let us call this fraction C_{ls} , the '**C**oefficient of **L**anguage Proficiency of the **s**tudent'. Hence a student can at most absorb:

$$U.Cet.\ Clt.Cls$$

On this basis, the student will comprehend only a fraction at the most, depending on his Coefficient of Comprehension, or, C_{cs}, Both Cls, and C_{cs} will be different for each student, being each a function of:

a. student's family background;
b. the language of instruction, i.e., The medium of instruction;
c. the student's education history i.e., past performance; and
d. the student's mother tongue.

So a given student will comprehend only:

$$U._{Cet}.\ Clt.\ Cls\ C_{cs}$$

However, in the present-day environment, mere skill / comprehension is not cognizable by itself. It must be graded and certified for the utility across a cross-section of requirements. Hence, we expand the definition of the education-system to include testing and grading.

If the teacher designs the test with a proficiency factor, C_d, in the same language, the actual test-paper will have deteriorated by the fraction C_d Clt, where Clt has already been defined.

The student will comprehend the test with a Coefficient 'Cls'. So the effective performance by the student will be:

$$U._{Cet}.\ Clt.\ Cls\ C_{cs}\ C_d.\ Clt,\ Cls,\ Cls.$$

The assessment by the teacher will be a fraction of Clt of the actual performance by the student, due to the language barrier, assuming the teacher can grade ideally.

If we do not differentiate between marking and grading (for simplicity), then the student's performance as assessed by the teacher will be:

$$U._{Cet}.\ Clt.\ Cls\ C_{cs}\ C_d.\ Clt,\ Cls,\ Cls,\ Clt.$$

So the assessment, relative to unity, will be

G= (C$_{et}$. Clt Cls) (C$_{d}$. Clt, Cls, Cls, Clt) (Ccs

= Cet. Cd . [Clt]^{3} [Cls]^{3} C$_{cs}$

The first three factors are teacher-specific, while the last two are related to the student. Further, the effect of the language is shown as [Clt]^{3} [Cls]^{3}. This brings out with some clarity, the relative role of the teacher's competence, language and the student's proficiency (C_{cs}).

Since we are interested in finding the effect of language, we fix C_{et} and C_{cs} each at unity (ideal student, ideal teacher). Now, we assume the proficiency in language of the teacher at 90% (Clt=0.9), for the present analysis, the overall throughput efficiency will be limited to nearly 70%, due to Clt alone.

In the case of children studying in English-medium schools of ordinary status, we can take Cls at = 0.8 (as a kind guess). Then $(Cls)^3 = 0.514$.

This is significant, even if we ignore all other factors. Cls alone can cause the student's results to deteriorate to nearly 50%.

In a country like ours, where teachers, having mother tongue other than English (Clt=0.9 a rather favourable estimate), are teaching to students with mother tongue other than English (Cls=0.8 a very liberal estimate), the limitation on throughput-efficiency due to language alone is phenomenal.

$$(0.9)^3 \text{ x } (0.8)^3 = 0.37$$

The ideal student, taught by an ideal teacher gets less than 40% marks of what he would otherwise get if taught and tested in his mother-tongue.

We have ignored the effect of the text books, the examination-system, etc. As is common experience in government-supported schools, the teachers are not always very competent but simply try to learn from the books, and teach the same. This could raise the effect of C_{lt} to the 4th power.

A very "strong" objection to this analysis is the fact that we have students scoring 92% marks in the board-level examinations, even though they have been taught in English medium of instructions. The reason is that the board-level examination-system, is not the ideal system for testing the comprehension. It is more a test of memory, whereby selective study, guess-papers, and availability of multiple-choices in the paper, all help to score high marks and grades. This, alongwith certain other 'enabling opportunities', the students can score close to hundred percent, without understanding even 40% of the concepts. People (like this writer) who teach and impart education at various institutions, often observe this phenomenon.

Why don't we teach our children in the local language? People often argue against this by pointing to the lack of suitable translation for scientific terms. This argument is untenable. Science is basically ideas. Terminology is a rather insignificant part of science. Nobody translates names of people like James Watt or Newton. Why translate names of things, or processes? Terminology should be translated only if it aids in the comprehension.

It is the ideas, which must be presented in our own language for better comprehension. And for that, there is no dearth of people who understand university-level science, and who can also write in their own language.

Sometimes, an argument is given that English is the language of technology. Contrarily, few Japanese know English, most of those who know have little regard for English syntax and grammar. Same is the case with the French, Germans, and citizens of Scandinavian countries.

Please note that education of science is something like the pony of Woody the Woodpecker in cartoons. Either Woody rides the pony, or the pony rides Woody. If a student doesn't comprehend science, then studying science is nothing but a load for him.

The issue of medium of instruction has been debated for far too many years now. It should be settled in accordance with the scientific principles, discussed above, through a dispassionate scientific dialogue, between experts who have taught in Pakistan for a while, and students who have recently passed out.

A National Referendum via school / college and the 'education-hierarchy' is still a better option. It will cost nothing but paper and postage. It will cost far less than a seminar, and the data obtained will be far more relevant and reliable.

Finally, we must not forget mathematics and mathematicians. Mathematics is science on the conceptual plane. It goes where physics, may reach much later, or may never reach. The prediction of electromagnetic waves came far earlier than the generation of waves themselves. Virtually, everything invented in the last century was predicted via mathematics first. On the contrary, there is no physics, or, science, without mathematics. The recently celebrated 'Year of Mathematics' was not celebrated at the same level as this 'Year of Physics-2005'. It is only appropriate to say here that, at a suitable time, the world must again honour mathematics and mathematicians, also at the same scale as it is honoring physics and physicists now.

A BIRD'S EYE VIEW OF THE 20^{TH} CENTURY PHYSICS

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ABSTRACT

This paper presents a brief description of the most important branches of modern physics, and then a year-to-year account of the most important achievements of physics during the twentieth century. One hundred years history of Nobel Prizes in physics is also explored. Finally, the Nobel Prize recipients in physics are tabulated according to their nationalities and research areas.

1. INTRODUCTION

The 20^{th} century was, without any doubt, the most thrilling and vibrant century in the entire human history. It was the time when man, truly and physically, explored the boundaries beyond its home planet, Earth. It was the century of knowledge, filled with the greatest amount, depth and diversity of discoveries, ever made. All these discoveries brought about fundamental changes in not only the way humans live, but also in how they comprehend their world. If the greatest amount of credit for all these discoveries and technological advancements is to be attributed to any single branch of knowledge, it is indeed Physics. Twentieth century showered the most shining days of sun onto physics and the physicists. All the technological and engineering achievements of the century have their firm roots in the rapidly expanding domain of physics, be it the telecommunications, aerodynamics, energy sector, computer industry, weaponry or even space exploration.

Apart from the general division into theoretical physics and the experimental physics, the modern day physics can be broadly classified into about thirty-five major branches, with several hundred sub-branches. The major branches include Acoustics, Atmospheric Physics, Astronomy, Astrophysics, Atomic & Molecular Physics, Classical Mechanics, Computational Physics, Cosmology, Dynamics, Electricity, Electrodynamics, Field Theory, Fluid Mechanics, Gas Dynamics, Gravitation, High-Energy Physics, Hydrodynamics, Laser Physics, Low-Temperature Physics, Magnetism, Mechanics, Nuclear Physics, Optics, Particle Physics, Plasma Physics, Quantum Mechanics, Quantum Electrodynamics, Relativity, Solid-State Physics, Space Physics, Statistical Mechanics, Surface Physics, Superconductivity, Thermodynamics and Wave Mechanics.

Physics entered the twentieth century with a "big bang", as Max Plank announced his "Law of Black-Body Radiation", on December 16th, 1900. This law became the foundation-stone for the emergence of "Quantum Mechanics". The science, which not only made it possible to explore the innermost secrets of the most fundamental building block of matter, the atom, but also paved the way for the ultra-modern innovations in the current day electronics, telecommunications and IT technologies. The first Nobel Prize in physics was awarded in the year 1901, to W.C. Rontgen, for the discovery of X-rays, which, in addition to a number of vastly differing applications, became the prime diagnostic tool of the interior imperfections of living and non-living objects. Within a few months of their discovery, X-rays were being used in clinics to detect foreign-bodies and to help in setting fractured bones. In 1905, Einstein, at the age of 26, shocked the world by introducing his "Special Theory of Relativity" and his explanations for the "Brownian Motion" and "Photoelectric Effect". The Special Theory of Relativity, the most beautiful and imaginative theory about the space-time mystery, ever presented, solved many riddles related to the correlation of observations carried out from the various moving frames of references.

The 20th century physics can be broadly classified into three main eras. First, the era from 1901 to 1930, mainly dominated by a series of ground breaking discoveries in "Relativity", "Atomic and Nuclear Physics", "X-Rays" and "Quantum Mechanics". The Cavendish Laboratory at Cambridge, under the leadership of Ernest Rutherford and J.J. Thompson, played a pivotal role in making new discoveries during this period.

The second era, dating from 1931 to 1950, had its major emphasis on "Nuclear Fission", "Cosmic Radiation", "Anti-matter", "Crystallography", "Artificial Radioactivity", and "Astronomy". Human vision of the universe was dramatically changed when Edwin P. Hubble announced his empirical law of cosmic expansion. According to his observations of the distant galaxies, all galaxies are moving away from that of ours, with a speed that is proportional to their distance from our galaxy. A galaxy at a distance of 3.26 million light-years from us is moving away with a speed of about 80 kilometers per second. Twice this much distant will be moving away with 160 kilometers per second, and so on. This observation expanded the size of the observable universe by a factor of a thousand billion. A whole lot of theoretical and experimental work followed these observations, beginning an entirely new era in astronomy, astrophysics and cosmology. The space in this paper does not even permit briefly mentioning the new discoveries and their impact on human comprehension of its surroundings, in which Mount Polomer's and Mount Wilson's observatories, amongst many others, played pivotal roles in the new discoveries. This is a subject that we will touch upon sometime later.

The third era, second half of the 20th century, is the era of Post World War-II which saw accelerated growth in the subject/field of Physics. It was this period, during which, man entered the "Space Age" and landed on moon. During this period, the main areas of investigation were "Fusion", "Materials Science", "Superconductivity", "Surface Science", "Fluid Dynamics", "Semiconductors", "Space Science", "Lasers", "Cosmic

Rays", "Renewable Energy", "Astrophysics", "Cosmology", "Quantum Physics" and "Unification Theories". It is neither possible, nor should it be attempted, to even briefly mention all the physics related discoveries, spread over the span of 20th century, and their corresponding applications, in any single piece of writing. In this short paper, I will only briefly cover some of the most revolutionary achievements, with the most profound impact on the human comprehension of its surroundings, and the quality of life, in a subject-wise field ordering.

2.1 Astronomy (1974, 1978, 1983, 1993)

The First Nobel Prize in the field of Astronomy was awarded in 1974 to Antony Hewish and Martin Ryle. Antony Hewish had discovered in 1964 that radio-stars (quasars) also twinkle like ordinary stars. He subsequently showed that when the radio-waves from a small-diameter source, such as a distant quasar, cross plasma-clouds in interplanetary space, they are diffracted, and fluctuations in otherwise steady intensity occur, with a period typically of about one second. This work, led him to discover pulsars - the fast rotating neutron-stars, emitting a beacon of light, like a rotating lighthouse. The radio-astronomy begun in 1932 by Jansky, providing the whole new tools for the study of the universe, but the long wavelengths of radio waves (about a million times greater than that of the visible-light waves), introduced several practical problems. The smallest detectable change in the angular position of a distant source, or the finest details in its structure, which a telescope can establish, is proportional to the wavelength, and is inversely proportional to the aperture of the telescope. This means that to acquire a resolution-power, equivalent to that of the human eye, a radio telescope should have a diameter of about one-kilometer and a surface-accuracy of a few centimeters. Martin Ryle used small computer-controlled aerial elements, moved to occupy successively the whole of a much larger aperture plane. The signals from each pair of elements are combined in the receivers and a curve-plotter draws a map of the area being observed. This way a resolution of up to 0.6 seconds of arc is attained - better than the largest ground-based optical telescopes.

Arno Penzias, when pursued at the City College of New York, by one of his professors to opt for physics as his career, asked the professor, *"Is physics something one can earn a living from?"*. The professor replied, *"Well, you can do the same things engineers can do and do them better"*. He shared half of the second Nobel Prize in Astronomy in 1978 with Robert Wilson for a beautiful, simple experiment, which provided evidence about the origin of the Universe. They used a 20-feet horn-reflector antenna (originally designed for satellite communication), to measure the intensity of the radio-waves emitted by the halo of gas, which surrounds our galaxy. They found a persistent noise coming from all directions, and whose source they concluded, was beyond the Milky-Way. The intensity of the noise corresponded to a black-body, radiating at a temperature of about 3 K^{o}. Upon discussions with Dicke and Peebles at Princeton, they concluded that what they had detected was the cosmic background-radiation, predicted to exist by the Big-Bang theory of the origin of the universe. Calculations showed that the high-temperature radiation that emerged from the big-bang, some 15-

20 billion years ago, would have cooled down to about 3 K° by now.

The third Nobel Prize awarded in the field of astronomy, came in 1983, when Subrahmanyan Chandrasekhar and William Fowler were jointly awarded for their work on the physical processes related to the structure and evolution of stars. Chandrasekhar had a unique work pattern, he would select a certain area, explore it in depth for several years, write a monograph on it, and then pass on to another area. There have been at least seven such periods in his life. His Nobel Prize related to his work on white dwarfs. He showed that electrons at the center of these stars will have velocities comparable to the velocity of light. Under the effect of these relativistic electrons, the pressure should vary as the $4/3^{rd}$ power of the density, providing a maximum limit to the mass of white dwarfs equal to 1.4 times the mass of the Sun. He concluded that stars have more mass than twice the mass of the Sun, when exhausted their source of energy, will not pass through the white-dwarf phase. William Fowler generalized the original work of Bethe on stellar energy source, into what is now called the 'proton-proton tri-chain'. In a comprehensive paper, in 1957, Fowler presented alongwith other authors (Geoffrey Burbidge, Margaret Burbidge and Fred Hoyle) a theory for the synthesis of all elements, heavier than helium, in stars, novae and supernovae over the lifetime of the galaxy. The theory suggested that the evolution of a massive star frequently ends in a supernova-explosion.

In 1993, the 4th Nobel Prize in astronomy was awarded for providing an indirect proof to one of Einstein's predictions made through his general theory of relativity. Russel Hulse and Joseph Taylor discovered a new type of pulsar - a kind of rapidly rotating cosmic beacon, with a mass somewhat greater than that of the Sun and a radius of only ten kilometers. The pulsar's beacon-light is often within the radio-wave region. Hulse was the research student of Taylor. They discovered that what they had found was a binary-pulsar system - two pulsars revolving around each other with respect to a common center. The system provided a "space laboratory" for testing Einstein's theory, which predicted that non-symmetrical, rotating, massive objects emit gravitational waves in about the same way that a system of moving electrical charges emits electromagnetic waves. Through an observation, spread over a period of 11 years, it was established that the orbital period of the pulsar was decreasing at a rate of 75 microseconds per year. The change was due to the emission of energy by the system in the form of gravitational waves. The magnitude of decrease in the orbital period was found to hold within half a percent of the value predicted by Einstein.

2.2 Atomic & Molecular Physics (1922, 1955, 1961, 1966, 1989)

The first reasonably successful attempt to use spectroscopic data, to discover the internal structure of an atom, was made by Neils Bohr. He sought to combine Rutherford's notion of a nuclear atom with the quantum-theory, in order to explain how atoms absorb and emit radiant energy. He postulated that electrons in a hydrogen-atom, radiate energy only when dropped from one allowed state to the other. They absorb energy only in quanta, which corresponds to the difference of energy between the allowed states. Through his model, Bohr was able to arrive at orbital energies, which accounted for the definite frequencies of the line-spectrum, emitted by hydrogen-atoms, when excited by electrical or other means to energies, higher than the ground-state. The Nobel Prize for 1922 went to him. However, this model did not permit the orbiting electrons around the nucleus to radiate - contrary to the classical view that an accelerated charged particle must radiate.

The study of the interaction between matter and electromagnetic radiation is called 'Quantum Eelectrodynamics' (QED). When the spectrum of a hydrogen-atom is observed through the spectrographs of very high resolution, the spectrum shows splitting of the spectral lines, indicating the existence of the so-called *hyperfine structure*. Willis Lamb discovered the reason behind this splitting, showing through very precise measurements, using radio-waves, that those energy levels of the atom which were previously proposed by Dirac to have equal energies, were actually different by about one part in a million. This difference is now called *'Lamb Shift'*. Polykarp Kusch constructed equipment of exquisite precision, to determine energy changes induced by high-frequency radio-waves in atoms of gallium and sodium. He found that the magnetic dipole-moment of the electron was slightly different (about 1/1000) from what was previously known and predicted by Dirac and others. Lamb and Kusch shard the 1955 Nobel Prize.

The first reasonably consistent picture of the nuclear-structure of atoms, was presented by Robert Hofstadter, who discovered that the neutrons and protons have similar sizes and shapes, and have a diameter of 10^{-14} cm. To explore the nuclear structure, he adopted the technique of high-energy (1 BeV) electron-scattering by the nuclei. The electrons penetrated the nuclei and the particles comprising the nucleus deflected the electrons by their magnetic fields. By measuring the angles of deflection, etc., he was able to distinguish the charge distributions of nuclear-particles, and obtained an idea of the nuclear-structure. The 1961 Nobel prize was evenly distributed between Hofstadter and Rudolf Mossbauer, who discovered the so-called 'Mossbauer effect', which found tremendous scientific and technological applications. When an atom emits a gamma-ray photon, it also receives a recoil, thereby decreasing the energy and the frequency of the emitted photon. This photon, therefore, cannot cause resonance in another similar nucleus by absorption. By locking the iridium-nuclei, into the lattice of a crystal, Mossbauer was able to prevent this recoil. The gamma-rays, thus, produced are invariable in wavelength to one part in a billion. The resonance-process they can trigger is so sensitive that it can be used to detect the difference in the gravity between the top and the bottom floors of a building.

The 1966 Nobel Prize went to Alfred Kastler for the discovery and development of optical methods for studying Hertzian-resonances in atoms. The work was described by the New York Times as 'Incomprehensible Science', and by a spokesman of the Royal Academy of Sciences as 'Impossible to understand for people other than scientists'. Yet there were many practical instruments to come out of that work - frequency-standards, atomic clocks accurate to one second in 10,000 years, and highly sensitive magnetometers. Kastler's work was aimed at studying the sub-levels of the atomic energy levels. For this, he used "*double" resonance* method, utilizing one light-beam to irradiate atoms and a radio-frequency electromagnetic wave. Irradiating by the polarized light in the presence of the radio-frequency field, and studying the re-emitted radiation, he was able to detect, the radio-frequency transitions, in the induced states.

1989-Prize was shared by Wolfgang Paul, Norman Ramsey and Hans Dehmelt. The work of these Laureates led to a dramatic development in the field of atomic-precision spectroscopy. This formed the basis of the "Cesium Atomic-Clock - The most precise time measuring device", and "Ion Trap Technique", which made it possible to study a single electron or a single ion with extreme precision. They also developed the "Hydrogen Masers", which are the most stable sources of electromagnetic radiation, used in the testing of the predictions of "Quantum Electrodynamics" (QED), the "General Theory of Relativity" and the "Continental drift".

2.3 Cosmic Ray Physics (1936, 1954)

Dirac's prediction for the existence of positrons was unacceptable for most physicists, due to many novel and unphysical ideas included in the theory. Carl Anderson was trying to directly measure the energy-spectrum of the secondary electrons, produced by the incoming cosmic radiation, which were thought to be the highly energetic photons. The photographs of the Wilson's cloud-chamber, that he was using in a strong magnetic field, showed the trajectories of a particle whose mass was equal to that of an electron but the charge was opposite. He also discovered muon, another elementary particle. The cosmic rays themselves, were discovered by Victor Franz Hess. He was motivated by the experiments, conducted by Theodor Wulf at Eiffel Tower, collected ionization data, using balloons up to a height of 5,350 meters. His striking results showed that ionization decreases from the Earth, to a height of some 150 meters, but thereafter increases markedly with increasing altitude. Cosmic rays were important not only for what information they might give concerning astrophysical processes and the history of the universe, but also as an especially concentrated form of energy. Anderson and Hess shared the 1936 Nobel prize in physics.

In 1924, de Broglie had suggested that the electron was associated with a group of waves, while Heisenberg had demonstrated that the position and momentum of an electron could not be simultaneously determined accurately. Max Born formulated a system in which de Broglie's electron-wave became a wave of probability for the presence of the electron. For his fundamental work in quantum mechanics and especially for his statistical interpretation of the wave-function, Max Born was awarded the 1954 Nobel Prize along with Walther Bothe. Bothe had combined two Geiger-counters, in such a way that they could register the passage of ionizing particles only when the passage occurred simultaneously in both the counters. Bothe used this apparatus to determine whether in the Compton-effect the energy and momentum remains conserved during each and every collision between an electron and a photon, or merely as statistical average of many collisions. He found the conservation to hold in all individual cases.

2.4 Electron Physics (1905, 1923, 1927, 1929, 1937, 1945, 1955, 1961, 1981, 1986)

1905 Nobel prize went to Philip Lenard for his work on cathode-rays, his work consisted on studies of electrons. He discovered that high-energy cathode-rays can pass through atoms, showing that the atom is relatively empty, thus, paving the way for the atomic model. 1906 Nobel prize was awarded to Sir J. J. Thompson, in continuation, for the study of the passage of electricity through gases. He, at the Cavendish laboratory, discovered the ionization phenomena and measured the charge to mass ratio for cathode-rays. Further experiments established that all sort of matters contain electrons as common constituents, and that the number of electrons in an atom is about one half the atomic weight. Seven of the J.J. Thompson's students received Nobel Prizes in their turn. He was most instrumental in the built up of the Cavendish laboratory to its prominent status in the early 20^{th} century physics.

To establish electron as the fundamental unit of charge, Robert Millikan sprayed a mist of charged oil-droplets between the horizontal plates of a capacitor. By suitably controlling the potential difference across the capacitor plates, he was able to prevent them from falling under the action of gravity. The experimental data led him to conclude that the charge contained by the oil-droplet was always an integral multiple of 1.6×10^{-19} coulomb, nature's unit of charge. He also made the first direct evaluation of the planck's constant 'h' and experimentally verified Einstein's theory of photoelectric effect. He also traveled to far off places to carry out research on cosmic rays. He was awarded the 1923 Nobel Prize for physics.

Arthur Compton, a brilliant student of his college, wanted to become an engineer, but did a Ph.D. in physics. Compton measured and interpreted the wavelength change, which occurs when x-rays are scattered by materials of low atomic numbers. He showed that x-rays are scattered by the loosely bound electrons in the material, in accordance with the principles of conservation of energy and momentum. While Planck and Einstein had already assigned energy 'h ’ to photons, Compton's experiments provided first clear demonstration that x-ray photons carried quantized amounts of momentum. This was the most convincing proof of the particle nature of photons. Other contributions of Compton include the determination of x-ray wavelengths, through their diffraction by ruled gratings and the nature and origin of cosmic rays. The 1927 Nobel Prize was shared by Compton and Charles Wilson, for their work on two entirely different subjects. Wilson is famous for his ‘cloud-chamber’, an instrument, which renders discernible the paths of charged particles by the condensation of vapors on them. He devised this instrument in his attempt to form clouds under the controlled laboratory conditions. He found that the clouds can be best formed in the presence of charged nuclei. To his cloud chamber, J.J. Thompson remarked; 'It is to Wilson that we owe the creation of a method, which has been of inestimable value to the progress of science'. Another colleague wrote about him; *"Of the great scientists of his age, he was perhaps the most gentle and serene, and the most indifferent to prestige and honor; his absorption in his work arose from his intense love of the natural world and from his delight in its beauties"*.

The settlement of the particle nature of light, quanta, through Compton's experiments, led Louis-Victor de Broglie to search for a theory that would unify the wave and particle aspects. In reverse terms, he thought of generalizing the wave-particle generality to include material particles also, particularly electrons. In his doctoral thesis, he proposed that a moving electron is also associated with a number of waves that travel with a velocity different from that of the electron itself. The superposition of many such waves makes a wave-packet that travels with a group velocity, equal to that of the electron. He precisely predicted the wavelength of these wave-packets, which were confirmed through the experiments of Davisson and Germer with slow electrons and G.P. Thomson with fast electrons, to observe their diffraction-patterns in crystal lattices. De Broglie won the 1929 prize for this remarkable leap in science.

Clinton Davisson was investigating the scattering of electrons from nickel, to explore the outer regions of atoms, when his target was heavily oxidized by an accidental explosion of a liquid-air bottle. He cleaned the target by prolonged heating, and then observed that distribution angle of the secondary electrons had completely changed, showing a strong dependence on the crystal direction, reaching a maximum at a particular angle. He attributed this as the conversion of the target to larger crystals. Further experiments in single crystal of nickel confirmed that this was due to the diffraction of the electron's 'matter-waves', in accordance with the de Broglie's predictions. Sir George Paget Thompson, the son of J.J. Thompson, observed that a pattern of circular fringes resulted when a beam of electrons is passed through a thin metal foil, in vacuum. Although not undertaken for that purpose, Thompson's demonstration of electron-interference provided another convincing proof of de Broglie's theory of matter-waves. Davisson and Thompson shared the 1937 Nobel Prize.

1945 Nobel Prize was awarded to Wolfgang Pauli, for his 'exclusion-principle', presented in 1924. The principle states that "No two electrons in an atom can have the same set of four quantum numbers". The principle brought much of the then existing knowledge of atomic structure into order. It led to an understanding of the formation of electron-shells in an atom and the periodicity of chemical properties observed when the elements are arranged in order of increasing atomic number. To an article that he wrote on relativity at the age 21, Einstein greatly admired for the development of ideas, deep physical insight, sureness of mathematical deduction, mastery of exposition, familiarity with the literature and the trustworthiness of the critical faculty. Pauli believed that *progress in physics can take place in an atmosphere of free investigation and unhampered exchange of scientific results between nations*.

Half of the 1981 Nobel Prize was awarded to Kai Siegbahn for his contributions to the development of high-resolution electron spectroscopy. This was the fourth time when father (Mann Siegbahn 1924) and son both received Nobel Prizes in physics. When electrons emerge from a specimen, they lose various amounts of energy, due to scattering, making it very difficult to isolate the zero-energy-loss electrons, thereby preventing the probing of the electronic structure of the elements. Siegbahn constructed a spectrometer with a resolving power of one out of ten thousand, sufficient to isolate the x-ray produced zero-energy-loss lines. The electron spectrometers for chemical analysis (ESCA), thus, developed have acquired annual sales worth several billion dollars. The second half of the Nobel Prize was equally shared by Nicolaas Bloembergen and Arthur Schawlow for their contributions to the development of laser spectroscopy. Bloembergen used laser beams to study the properties of matter at very high light-intensities. The familiar laws of optics had to be modified to develop the laws of non-linear optics. The techniques developed were used in new applications like Doppler-free two-photon, saturation spectroscopy and three- and four-wave light- mixing spectroscopy, study of combustion inside automobiles and jet-engines and the probing of biological materials.

The wave nature of light and the phenomenon of interference puts a limit on the resolution power of an instrument the minimum distance between two objects, which can be distinguished as separate. This limit is about one third of the wavelength of the light used for illumination (~550 micrometer for visible light). The first electron-microscope was designed by Ernst Ruska, who applied de Broglie's matter-wave idea to an electron-beam accelerated through a potential difference of 50,000 volts. The associated de Broglie's wave had a wavelength of 0.55 micrometer. Using this electron beam to “illuminate” objects, Ruska attained a resolution 1000 times better than the one attained from the visible light. Half of the 1986 Nobel Prize was awarded to him for this breakthrough. The remaining half was shared by Heinrich Rohrer and Gerd Binnig for their design of the Scanning Tunneling Microscope (STM), which also exploits the wave properties of electrons. In a vacuum, one positions a probe so close to the surface of the sample that the wave functions of electrons in the probe and those in the sample overlap. Then a small voltage applied between the probe and the sample causes electrons to tunnel through the vacuum. This tunneling current is so sensitive to the separation between the tip and the sample surface, that a change in this distance equal to the diameter of a single atom causes a 1000 fold change in the current. This sensitivity can yield measurements precise to 0.01 A° or 10^{-12} meters in the vertical direction. Sweeping the tip through a pattern of parallel lines produces a three-dimensional image of the sample. A single atom can now be distinguished on a surface. The STM technique can not only delineate the atomic topography of a surface but also reveal the atomic composition, as the tunneling current also depend on the electronic structure unique to each atomic element.

2.5 Electricity & Magnetism (1902, 1906, 1919, 1928, 1955)

Peter Zeeman, while examining the spectrum of a sodium flame situated in a strong magnetic field, using a 20 feet diameter concave grating, discovered that the spectrum gets split under the effect of the magnetic field, thus, showing that it was the electron that radiated light when sodium was heated. He also measured the charge to mass ratio of the electron. He was awarded the 1902 Nobel Prize for physics, along with Hendrik Lorentz, who for the first time put forward the concept of electron and explained the effect Zeeman had observed.

In continuation to the work by Philip Lenard and J.J. Thompson (1905 and 1906 prize-winners), Johannes Stark further advanced the investigation of the cathode rays. By introducing holes in the cathode, he found canal rays - the rays consisting of positively charged particles that travel opposite to the cathode rays in the gas filled tube. He found a Doppler effect and the splitting of spectral lines in the presence of applied electric field, in these rays, by introducing a third electrode behind the cathode at a potential difference of 20,000 volts/cm. He earned the 1919 Nobel Prize.

The rapid development of radio, telephony, television and x-ray technology was made possible due to the work of Sir Owen Richardson on thermionics - emission of electrons from a heated filament. He applied the kinetic theory to the hypothesis that freely moving electrons in the interior of a hot conductor escape when they reach the surface, provided that their kinetic energy is great enough to overcome the attraction of the positive charges in the metal. He devised a law that relates the emission current to the temperature of the metal and its work function, for which he won the 1928 Nobel Prize.

2.6 Electromagnetic Waves (1909, 1911)

Guglielmo Marconi was neither a physicist not an engineer by training, yet he combined remarkable physical intuition, engineering skill, and business acumen. He shared the 1909 Nobel Prize with Carl Braun for the development of wireless telegraphy. While Marconi did most of the work in a cut-and-try manner, Braun handled it as a scientist, producing transmission-waves that were more powerful and less damped, and how to separate signals from different sending stations at a receiver. Braun also developed directional antennae by beaming the signal in the desired direction, and invented the cathode ray tube, that is most commonly used in television receivers and cathode ray oscilloscopes.

The Planck's law of black body radiation had its roots in the work performed by Wilhelm Wien, who made the first practical black body to study the distribution of radiant energy in the spectrum and the effect of a change in temperature on this distribution. He showed that the product of the temperature of a black body and the wavelength of the greatest intensity in its spectrum remains constant. 1911 prize went to him for this great discovery.

2.7 Gas Dynamics (1904, 1910)

Rayleigh, the Cavendish laboratory professor, who was awarded the 1904 prize, not only discovered the inert gas 'Argon', but also deeply investigated the densities of mixed gases, paving the way for the later discovery of the Helium gas and many other properties of gas. He also discovered the reason as to why the sky appears blue - showing that the scattering of sun light by particles in the atmosphere is inversely proportional to the fourth power of the wavelength. He published 445 papers, covering almost every major branch of physics. He, together with Kelvin, Maxwell and Stokes, formed the great group of the nineteenth-century physicists.

The relationship between the pressure, volume and temperature of ideal gases is expressed by the equation of state. The real gases behave differently than the ideal gases at low temperatures. The difference was explained by Johannes van der Waals, by considering the mutual attraction between the gas molecules of real gases and their finite volume. This enabled him to predict the necessary conditions for the liquefaction of real gases. He received the 1910 Nobel Prize for this important breakthrough.

2.8 High Energy / Particle Physics (1936, 1957, 1963, 1969, 1976, 1979, 1980, 1984, 1988, 1990, 1992, 1995, 1999)

Tsung Lee and Chen Yang were the first Chinese physicists to receive the Nobel Prize in 1957, and Lee became the second youngest Nobel Laureate (31 years, W.L. Bragg was the youngest at 25). When Lee and Yang demonstrated an unexpected limitation in the conservation of parity principle, they were tampering with a large and established structure in physics - symmetry principles and the conservation laws they generate. The principle of parity conservation states that nature is indifferent to right and left hand - the laws of physics are the same in a right-handed system of coordinates as they are in a left-handed system. Challenging this principle Lee and Yang in separate experiments demonstrated that this principle is violated in many nuclear reactions, showing strong tendencies of either being right-handed or left-handed.

Eugene Wigner acquired his Ph.D. in engineering, but then decided to turn to theoretical physics. He was the brother in law of Paul Dirac. He worked deeply in the philosophical implications of quantum mechanics. With von Neumann, he developed the theory of energy levels in atoms on the basis of group theory, and with Seitz he provided a basis for the solid state physics by their method of treating electron wave functions in a solid. He received half of the 1963 Nobel Prize for his discovery and applications of the fundamental principles of symmetry. The remaining half of the prize was shared by Maria Geoppert (second of the only two women to earn a Nobel Prize in physics) and Hans Jensen for their discoveries regarding the shell structure of nuclear particles. The experiments had shown that elements with 2, 8, 20 and 28 neutrons (or protons) in the nucleus were extraordinarily stable - some thing that could not be explained on the basis of the liquid drop model. Maria and Jensen independently developed a model in which spinning nucleons were assumed to move in orbits arranged in shells. The shell model, plus the concept of spin-orbit coupling, predicted correctly that the 'magic numbers (2, 8, 20, 28, 50 and 126)' corresponded to nuclei of greatest stability.

Murray Gell-Mann, who became regarded by some as Einstein's scientific successor, was appointed as full professor of physics at CalTech at the age of 26. Gell-Mann's 1969 Nobel Prize relates to his discoveries regarding the classification of elementary particles and their interactions. It was him, who predicted that all matter could be built using three entities, which he named quarks. He applied the Norwegian mathematician Sophus Lie's geometrical patterns to develop a table of the elementary particles somewhat similar to the Mendeleev's periodic table of the elements. Using this table he was able to explain the properties of the particles in the geometrical families (called multiplets) and to predict the existence of new particles, many of which have been subsequently discovered.

In November 1974, a new type of elementary particle called 'psi-J' was simultaneous and independently discovered by Samuel Ting and Burton Richter, who shared the 1976 Nobel Prize. The discovery was mentioned by a member of the Nobel Prize awarding committee as "one of the greatest in the field of elementary particles". Mass of the new particle was about three times that of a proton and it was detected as one particle in the background of some 100 million. 10,000 tons of concrete and 10,000 pounds of Borax soap were used to reduce the unwanted particle background. It was totally unexpected, as the new particle did not show any kinship with any of the previously known particles, its lifetime was found to be 5000 times longer than it reasonably should have been, and it could not be constructed from any combination of the known three quarks. The particle called for the existence of a fourth quark named 'charm'. Chinese by origin, Samuel Ting has visited Pakistan several times and contributed to the policy making for higher education in physics.

1979 was the year when someone with a Pakistani origin, was for the first time, honored with a Nobel Prize. Abdus Salam, along with Steven Weinberg and Sheldon Glashow shared the prize for their independent contributions to the theory of unified weak and electromagnetic interaction between elementary particles, including the prediction of the weak neutral current. Two, out of the four fundamental forces of nature (gravitation, electromagnetism, weak nuclear & strong nuclear forces) were therefore unified to be the manifestations of a single electro-weak force. The theory is considered to be the one of the major breakthroughs of modern physics and is frequently linked to Maxwell's unification of electricity and magnetism in the nineteenth century. The theory involved a hitherto unobserved kind of weak interaction, called a neutral current interaction, and gave definite predictions for the rates of processes caused by this interaction. It predicted that owing to the weak nuclear force, when electrons are hurled at atomic nuclei and examined as they rebound, there would be a significant difference in the number of electrons with right-handed spin and with left-handed spin. These 'parity violation' interactions were discovered in neutrino experiments in 1973, and subsequent experiments with beams of neutrinos and electrons have verified many of the predictions of the theory. The theory developed by Salam and Weinberg was initially limited to only one class of elementary particles. It was subsequently extended by Glashow to incorporate all elementary particles. Salam was the chief scientific advisor to the president of Pakistan from 1961 to 1974. Weinberg was the most referred physicist in the world from 1961 to 1976. Salam is famous for his Salam International Center for Theoretical Physics (Salam-ICTP) that he established in Trieste, Italy in 1964, and to which he served as director, until his death some five years ago.

Second consecutive Nobel Prize went to particle physics in 1980. One of the fundamental principles of the elementary particle physics was the so-called CPT symmetry balance in positive and negative charges (C), left-handed and right handed-processes (parity P) and time reversal (T). Matter moving forward in time is equivalent to anti-matter moving backward in time. It was subsequently proposed that C and P symmetries could be violated in the individual capacities, but the two together, CP, were invariant. James Cronin and Val Fitch discovered in 1964, that in the decay process of the neutral K-meson (another elementary particle) CP symmetry is violated once in every 500 decays. This violation is still a mystery waiting interpretation. It means that the left-right asymmetry (P) is not perfectly compensated by transforming matter to anti-matter (C). This violation is balanced by the violation in time reversal (T). The three together are still invariant. The work of Cronin and Fitch provides a mechanism whereby in the early universe the production of ordinary matter could exceeded anti-matter (which are supposed to have been created in exactly equal quantities), by about one part in a billion, justifying the existence of the present day universe.

The 1979 Nobel Prize, that Abdus Salam shared with two others, was awarded for the electroweak theory. This complex theory requires the existence of three particles called 'weakons' (W^+, W^- and Z^o) roughly 100 times heavier than that of a proton. Carlo Rubbia and Simor Meer proposed to achieve energies high enough to create these particles by hurling a beam of protons against a beam of antiprotons as they travel in opposite directions around a circular track. The Super Proton Synchrotron at CERN, in a circular four-mile tunnel, was modified for this search. A team of 126 physicists from eleven institutions reported the evidence of these particles in 1984, with 540 Gev center-of-mass energies of the colliding particles. Carlo Rubbia also detected the sixth and final 'top' quark in 1984. 1984's Nobel Prize was shared by the two for this outstanding contribution. Carlo Rubbia has visited Pakistan several times and gave suggestions for the improvement of higher education in physics in the country.

The 1988 Nobel Prize went to Leon Lederman, Melvin Schwartz and Jack Steinberger, for their work carried out during 1960's on the discovery of muon neutrino. It led to discoveries that opened entirely new opportunities for research into the innermost structure and dynamics of matter. One of the two great obstacles to further progress into the understanding of weak forces - search for at least a second kind of neutrino - was overcame. These neutrinos are associated with muons, which were discovered during 1930's in the cosmic rays. Neutrino beams can reveal the hard inner parts of a proton, in a way not dissimilar in which X-rays reveal a person's skeleton. During the conversion of the atomic nuclei at the center of the Sun, enormous quantities of neutrinos (which belong to the electron family) are produced. These neutrinos moving virtually unhindered, at or nearly the speed of light, penetrate through each human being at a rate of several billion per square centimeter per second, day and night, without leaving any noticeable trace.

In 1990, the Physics Nobel Prize was awarded to Richard Taylor, Jerome Friedman and Henry Kendall, for their pioneering investigations concerning deep inelastic scattering of electrons on protons and bound neutrons, which have been of essential importance for the development of the quark model in particle physics. This had been a breakthrough in our understanding of the structure of matter. The work carried out during 1960's and 1970's, clearly demonstrated that even the protons and neutrons are composite particles, consisting of the so called "Quarks". The discovery was made when protons and neutrons were illuminated with beams from a "giant electron microscope" - a three kilometer long accelerator at Stanford Linear Accelerator Center (SLAC) in California. High energy (4-21 GeV) electrons were bombarded onto liquid hydrogen or deuterium, and the energies and the scattering angles of the scattered electrons were measured. Now three different types of quarks and their anti-quarks along with the gluons are known to constitute more than 99% of the matter in the universe.

Next year's prize (1992) also went to a French - Georges Charpak. Charpak invented and developed particle detectors at CERN. His multi-wire proportional chamber detector was a breakthrough in the techniques for exploring the innermost parts of matter. The invention made it possible to increase the data collection speed and spatial resolution of particles interaction with a factor of thousand compared to previous methods for registering charged particle trajectories. Various types of particle detectors based on Charpak's original invention have been of decisive importance for many discoveries in particle physics.

In 1995, the Nobel Prize was awarded to two scientists for their experimental discovery of two of nature's most remarkable subatomic particles. Martin Perl discovered the tau-lepton (a relative of electron about 3500 times heavier than it), while Frederick Reines detected the antineutrino of the electron. The discovery of the tau-lepton was the first sign that a third 'family' of fundamental building blocks of matter existed. The 'family' also contains a neutrino (tau-neutrino) and two quarks named 'top' and 'bottom'. Previously known first family consists of 'electron', 'electron-neutrino', 'up-quark' and 'down-quark', while the second family consists of 'meon', 'meon-neutrino', 'charm-quark' and the 'strangeness-quark'. Each of the above twelve particles has an anti particle. The existence of the third family is very important for physicist's confidence in the present theoretical model for understanding the properties of nature's smallest constituents. This is called the standard model. Without the third family, the model would have been incomplete and unable to admit what is termed as Charge and Parity violation a violation of a fundamental principle of symmetry, which among other things, regulates particle decay. "Is there a fundamental principle to justify the existence of just three families?" is one of the yet unanswered questions of physics.

According to the "standard model" of particle physics, matter's fundamental particles are six leptons and six quarks. The forces between these particles are described by quantum field theories. The electro-weak force is mediated by four exchange particles. These are the mass-less photon (gamma) and three field particles W^+, W^- and Z^o. the strong force is conveyed by eight mass-less gluons g. Apart from these twelve exchange particles, the theory predicts a very heavy particle, the Higgs particle H^o. The field of Higgs particle generates all particle masses. The Large Hadron Collider (LHC) under construction at CERN will be powerful enough for more detailed study of this particle. The theoretical foundation of the "standard model" of particle physics was at first incomplete mathematically and in particular it was unclear whether the theory could be used at all for detailed calculations of physical quantities. Gerardus 't Hooft and Martinus Veltman were awarded the 1999 Nobel Prize in physics for having placed the standard model on a firmer mathematical foundation, in particular for elucidating the quantum structure of electro-weak interactions in physics. Their work gave researchers a well functioning "theoretical machinery" which can be used for, among other things, predicting the properties of new particles.

2.9 Laser Physics (1981, 1997)

At room temperature, molecules of air move randomly with speeds of around 1 km/sec. It is hard to study them, since they disappear very quickly from the area being observed. Even at a temperature of 3 K^o, the velocities are about 100 m/second. Steven Chu, Claude Cohen-Tannoudji and William Phillips developed methods of using laser beams to cool gases to temperatures of a few micro Kelvin (K^o) from absolute zero, and keeping the chilled atoms floating or captured in different kinds of "atom traps". Individual atoms in this configuration can be studied with great accuracy and their inner structure can be determined. In their methods, individual atoms are frequently bombarded with laser beams. During each collision with a photon coming from a direction opposite to that of the moving atom, the photon momentum is transferred to the atom, slowing it down. In a configuration of six laser beams opposed in pairs and arranged in three directions at right angles to each other, the sodium atoms were confined at the point of intersection of the light beams, achieving a temperature of 240 K^o. The methods may lead to the development of more precise atomic clocks, atomic interferometers and atomic lasers, which may be used in the future to manufacture very small electronic components. 1997 Nobel Prize went for this discovery.

2.10 Light & Optics (1907, 1908, 1930, 1953, 1958, 1971)

Albert Michelson, who was awarded the 1907 prize, was described by Einstein, as "the artist in science". Having devised interferometers sensitive to one part in 4 x 10^9 (four billion), he taught the world to "measure". One of the Nobel Prize selection committee members said: "For my part, I must consider the work of Michelson as most fundamental and far more delicate compared to those of the past recipients". Michelson tried to measure the 'absolute motion' of Earth relative to a hypothetical medium 'ether', through which, it was supposed, light propagates, in otherwise empty space. The experiments gave a null result, showing that ether does not exist. Michelson died in 1931 after several strokes suffered during preparations to measure the velocity of light in a mile long three-foot diameter, evacuated pipe.

Prize for 1908 went to Gabriel Lippmann for his method of photographic reproduction of colors, based upon the phenomenon of interference of light waves. He also contributed to the design of instruments for seismology and astronomy.

The first Asian to receive a Nobel Prize in 1930, Sir Chandrasekhara Venkata Raman, published his first scientific paper at the age of 18. He discovered that when light is made to pass through a transparent medium, some of it is scattered in other directions, with changed wavelengths. This is due to the loss or gain of energy experienced by the photons as a result of their interaction with the vibrating molecules of the medium. This is now called the Raman effect, and is a valuable tool in the study of molecular energy levels. Raman was instrumental at the Calcutta University in making significant contributions in the fields of vibration and sound, musical instruments, ultrasonics, diffraction, meteorological and colloid optics, photo-electricity, x-ray diffraction, magnetism, dielectrics and Raman spectroscopy. He founded the Indian Academy of Sciences and an institute of his own.

Examination of the detailed structure of transparent substances was made possible when Frits Zernike invented his phase-contrast microscope. As the light passes through a transparent substance, it is slowed down, but not absorbed or reflected. This introduces a phase difference between the original light beam and the one that has passed through the substance. Phase-contrast microscope makes these 'phase differences' visible. Zernike, described as a 'classical physicist', in the best sense of the word - quite unperturbed by the 'then modern' excitements with which most Nobel Prizes of that era are concerned, was awarded the 1953 Nobel prize for his contributions, which found tremendous applications in the metallurgical and biological sciences.

The first Russians to receive a Nobel Prize in physics were Pavel Cherenkov, Ilya Frank and Igor Tamm, who shared the 1958 prize for their discovery and interpretation of the so-called Cherenkov effect. The discovery is an example of how a relatively simple physical observation investigated in the right way can lead to deeper understandings of the secrets of nature. Cherenkov observed a weak bluish glow that emanated from liquids exposed to radiation from a uranium source. Suspecting that it was not fluorescence, he found that the glow was polarized in the direction of the incoming radiation, and that it was being caused by the electrons (beta particles) in the uranium radiation. Frank and Tamm later interpreted the effect as a 'bow wave' which is created when a particle moves in a medium with a speed faster than the general wave speed in the medium. A Cherenkov 'bow wave' of ordinary light is found when a charged particle, such as an electron, traverses a medium at a speed greater than that of the *light in the medium*.

The 1971 prize was awarded to Dennis Gabor, whose inventions received more than a 100 patents, especially the invention and development of holography - a system of lens-less, three dimensional photography. The applications of his method include photographic storage of several hundred pictures in one emulsion, the recognition of patterns and characters, new microscope methods, production of gratings for optics, viewing through turbulent media, and three-dimensional cinematography. In 1971 airborne hologram radar was used to 'photograph' clearly, in spite of cloud cover, three million square miles of the amazon river basin.

2.11 Low Temperature Physics (1913, 1978, 1996, 1997)

Half of the 1978 Nobel Prize was awarded to Peter Kapitza for his basic inventions and discoveries in the area of low-temperature physics. Kapitza, a Russian, while working at the Cavendish Laboratory, was the first foreigner in 200 years to be appointed a member of the British Royal Society. He was afterwards forced by the Russian government to transfer his research to Russia, where he was appointed a member of the Academy of Sciences and the director of the S.I. Vavilov Institute for Physical Problems. At Cavendish, he achieved strong magnetic fields (not surpassed for 30 years) to study alpha particle deflection and magnetostriction. In Russia, he engineered a helium liquefier which facilitated research in cryophysics worldwide. Helium exhibits strange properties at temperatures below 2.17 K°. One of these properties is that it defies gravity flows upwards and out of the walls of the container. It has extraordinary low viscosity and has high thermal conductivity. Kapitza studied these effects in detail and introduced for them the term 'super-fluid'. Kapitza made tremendous contributions in many branches of physics, and became one of the most honored scientists of the world. He was awarded 'Order of Lenin' six times. He contributed to the successful completion of the first Russian satellite, but was detained from 1945 to 1953 for having refused to work on the development of atomic bomb.

When helium is cooled to temperatures close to absolute zero, a phenomenon called 'super-fluidity' occurs. All the inner friction amongst the atoms of the fluid ceases to exist; it can flow over a cup, flow out through very small holes, and exhibits a whole series of effects that can not be described in terms of classical physics. Fundamental understanding of the properties of such a liquid requires an advanced form of quantum physics, therefore these liquids are termed as 'quantum liquids'. While the super-fluidity in helium-4 (a boson) had been achieved earlier (1913 Nobel Prize) at 2.17 K°, it was thought that it would never be achievable in case of helium-3 (a fermion). David Lee, Robert Richardson and Douglas Osheroff at Cornell University in 1972, while attempting to observe a phase transition to a kind of magnetic order in frozen helium-3, discovered by chance the existence of a second phase transition to super-fluidity. The team was awarded the Nobel Prize for the year 1996. The phase transition to super-fluidity in helium-3 has been used to test a theory regarding how the 'cosmic strings' can be formed in the universe. The cosmic strings are regarded to have seeded the formation of galaxies in the universe during a fraction of a second after the big bang.

2.12 Materials Science (1920, 1982, 1991)

1920 prize goes to Charles Guillaume for his discovery of the anomalies of nickel-steel alloys and their importance in the physics of precision. Guillaume contributed to the development of international standards for the meter, the kilogram and the liter. He discovered Invar, a 35.6 % nickel alloy which had a coefficient of expansion far lower than any of the previously known for a metal; and Elinvar, a nickel-chromium-steel alloy whose elasticity remained constant over a wide range of temperatures. Both alloys were used to make standard meter bars, in addition to many other applications.

In addition to the three familiar states of matter (solid, liquid and gas), there are several other states like super-conducting, super-fluid, ferromagnetic, anti-ferromagnetic, ferroelectric, etc. Under changes in temperature, pressure, composition, magnetic fields and other variables, a given substance may undergo several phase transitions from one to other states. Kenneth Wilson provided a complete theoretical description of the behavior of a substance close to the critical point for phase changes, in two papers published in 1971. He provided methods for calculating the critical quantities numerically. The problems to which his method of re-normalization was applied were amongst the hardest problems known to the physical sciences. These problems include frost heaving, underground oil flow, crack propagation in materials and turbulence in fluids. 1982 Nobel Prize was singularly awarded to him for this outstanding contribution.

The prize of 1991 went to the French Physicist Pierre-Gilles- de Gennes for discovering that methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter, in particular to liquid crystals and polymers. He showed that phase transitions in apparently widely differing physical systems such as magnets, superconductors, liquid crystals and polymer solutions can be described in mathematical terms of surprisingly broad generality. Phase transition is described as the transition of a system from one state of order to another, or from a state of order to that of disorder. The demagnetization of a magnet when it is heated is such an example. De Gennes has been described by some as the Isaac Newton of our times.

2.13 Nuclear Physics (1927, 1935, 1938, 1939, 1943, 1944, 1948, 1949, 1950, 1951, 1952, 1959, 1960, 1961, 1963, 1968, 1975, 1994)

It was an unanswered puzzle by then, as to why the atomic masses of elements increase more rapidly than do their atomic numbers, when the elements are arranged in the periodic table. Another puzzle was encountered when Bothe and the Joliot-Curies found that when certain light elements such as beryllium were bombarded with alpha particles, some sort of radiation occurred, which showed its presence by ejecting protons from paraffin. Sir James Chadwick came up to suggest the existence of a neutral particle about the mass of a proton, that is ejected by the bombardment of alpha particles on beryllium, in turn eject protons from hydrogen rich paraffin. Energy measurements on different targets confirmed the prediction for the existence of the so called 'neutron', for which he was awarded the 1935 Nobel Prize.

The 1938 Nobel Prize went to Enrico Fermi, who was instrumental behind the making and the use of the first atomic bomb over Japan. His contributions to physics are many. He accounted for the beta-decay type of radioactivity, whereby a neutron changes into a proton with the creation of an electron and a neutral particle named 'neutrino'. Following the Joliot-Curie discovery of artificial radioactivity induced by alpha particles, he proposed that it could be induced more effectively by the bombardment of slow neutrons on the nuclei of atoms. This way he discovered more than 40 artificial radioactive isotopes within a few months. He was the first to achieve a controlled self-sustained thermonuclear reaction using thermal neutrons. Fermi also developed what became known as the Fermi-Dirac Statistics, the statistical law followed by anti-symmetrical particles, named fermions. He also contributed in the field like Raman effect, hyperfine structure, cosmic rays and virtual photon statistics.

Another big leap in the field of nuclear physics was the invention of cyclotron - a device that can accelerate charged particles to very high energies. The charged particles are forced to circulate between two D-shaped electrodes with alternating opposite charges, and enclosed in a strong magnetic field. Ernest Lawrence used his device to separate weapons grade uranium U-235 from U-238. In 1941 he announced the 'first man-made cosmic ray' - a beam of 96 million electron volt carbon ions. He produced laboratory antiparticles and mesons for the first time and about a dozen synthetic elements and investigated many new radioisotopes. He applied radiation in the field of biology and medicine and neutrons in cancer therapy. He won the 1939 Nobel Prize.

Arnold Summerfeld had predicted that certain atoms like hydrogen, alkali metals and silver, should possess a magnetic moment. If they are placed in a magnetic field they should be able to assume only two orientations, with the axis and magnetic moment either parallel or opposite to the direction of the magnetic field. Otto Stern set out to prove it experimentally, recognizing that if this was correct, a narrow beam of silver atoms when passed through a non-homogeneous magnetic field will split into two separate beams. He proved it in the famous Stern-Gerlach experiment. He was also the first to extend the de Broglie's 'matter wave' hypothesis from electrons to atoms and molecules. He earned the 1943 Nobel Prize.

The next year's prize was also awarded on a similar subject to Isidor Rabi, who invented the resonance method for recording the magnetic properties of the atomic nuclei. These properties are important for finding the nature of the nuclear forces and the appropriate nuclear model. Rabi tried to refocus the split beams of Stern's experiments by adding another weak alternating magnetic field. The frequency of oscillation of the second field was adjustable. When the atoms of the beam entered this region they were in one magnetic moment quantization state and focus on the detector. By carefully changing the frequency he was able to find the frequency at which focussing will be missed due to nuclei adopting the second quantized state. The difference of the two frequencies provided the energy difference between the two states. Once questioned about the aging of physicists, he remarked, *"Physicists are the Peter Pans of the human race. They never grow up, they keep their curiosity"*.

The use of the Wilson's cloud chamber was limited to random photography of cosmic rays in the hope of finding interesting events caused by charged particles. Baron Blackett adapted the cloud chamber to take its own photographs, by placing it between two Geiger counters. Any cosmic ray particle that passed through both counters had to pass through the cloud chamber. The circuitry was so arranged that a coincidence of signals from the two counters triggered the expansion of the cloud chamber and produced a photograph. The cloud chamber was placed in a magnetic field so that information about the charge and momentum of a particle could be obtained from the curvature of its path. This way, as many as 23 particles were found on a single photograph, diverging from a region over the chamber. Blackett made many other contributions in the fields of defense and submarine warfare and was awarded the 1948 Nobel Prize.

What force binds together the particles inside the nucleus of an atom, was still a mystery, when Hideki Yukawa recognized that it must be a very short range (about 10^{-13} cm) to account for the rapid increase in the binding energy from the deutron to the alpha particle. He proposed that the nuclear forces were related to the exchange of some particle in the same way as electromagnetic forces are related to the emission and absorption of photons. He estimated the mass of this particle, named meson, to be about 200 times the mass of an electron. In 1947, a particle, named pi-meson with mass 285 times that of an electron, was detected. Pi-meson decays into mu-meson and neutron. Yukawa received the 1949 Nobel Prize.

The meson predicted by Yukawa was detected by Cecil Frank Powell in nuclear reactions in cosmic rays. He is more famous for the development of his photographic emulsions for studying nuclear processes, and subsequent discoveries. He established the reliability and usefulness of these methods as quite equal of counters and Wilson cloud chamber. To record the tracks of cosmic ray particles, Powell sent several hydrogen filled balloons to heights of up to 17 miles, involving some 24 universities in the adventure. These efforts were instrumental behind the creation of CERN. Powell was awarded the 1950 Nobel Prize for physics.

Starting from the second half of the 20th century, began the 3rd era of physics, marked with the explosive growth of the post world war new discoveries. The world was stunned at the revelations of the some of the most guarded secrets of nature. Within the span of only half a century, the human comprehension of the world and the order of things, was dramatically revolutionized, triggering a roar of excitement and interest in exploring further the frontiers of the yet unknown. It was never imagined that the nature is so beautiful, so deep, and yet so understandable. So many individuals and institutions got involved with the new developments that most Nobel Prizes had to be awarded on a sharing basis during the next fifty years. Only few prizes went to individual physicists during this era.

Rutherford had discovered in 1919 that one element can be changed into another, by bombardment with alpha particles from a natural radium source. Sir Jon Douglas Cockraft proposed in 1928 that about one out of a billion bombarding particles, even with modest energies (300,000 electron volts), can 'tunnel' through the potential barriers of the nuclei due to the de Broglie waves associated with them. Cockraft, with the support of Rutherford and Ernest Walton bombarded 600,000 electron volt protons to a lithium target, and in turn obtained 8.6 million electron volt alpha particles. This ushered in a new era in nuclear physics. It gave impetus to the development of the cyclotron and other methods of accelerating particles to high energies to artificially transform one type of nuclei into others. Cockraft and Walton shared the 1951 Noble Prize for physics.

The 1952 prize was shared by Felix Bloch and Edward Purcell, for the development of new methods to measure nuclear magnetism exactly, and for discoveries made with the aid of these methods. Bloch conducted work in atomic physics of such originality and diversity that there are at least five laws and concepts to which his name is attached. One notes a close interplay of science and technology in his work. In 1954 he was unanimously appointed by the representatives of twelve nations, as director of the new European Nuclear Research Center (CERN) at Geneva. Purcell noticed that the proton and electron in a hydrogen atom behave like tiny magnets due to their spin. The relationship between these magnets can change only through the absorption or emission of precise amounts of energy. To measure those energy transfers, Purcell made atomic nuclei dance in rhythm with a radio wave, thereby determining the magnetic moment of hydrogen atoms with a precision that exceeded almost all other measurements in physics. This method provided the astronomers with the so-called 21-cm photons, to probe the motion of hydrogen clouds in galaxies. These photons are emitted when the hydrogen atoms flip from one spin orientation to the other.

The success of the 1928 Dirac theory and Anderson's discovery of the positron (anti-electron) in 1932, strengthened expectations that the proton, too, had a mirror-image particle, the anti-proton, having a negative charge and an oppositely directed magnetic moment. It was expected that the creation of an antiproton will necessitate the simultaneous creation of a proton or a neutron, each having a mass of about one billion electron volts (BeV). To create two particles, each having a mass of one BeV, the projectile protons were estimated to have 6 BeV of energy. 6.2 BeV Bevatron was constructed at Berkeley for this purpose, which confirmed the existence of antiprotons in 1955. The magnetically analyzed beam contained only one antiproton in every 30,000 product particles - one antiproton every 15 minutes. Owen Chamberlain and Emilio Segre were awarded the 1959 Nobel Prize for this long awaited discovery.

One of the more energetic particles found in the cosmic rays was named V-particle or 'pothook'. These particles could not be properly studied in the Wilson's cloud chamber or nuclear emulsion techniques. Donald Glaser, triggered by Carl Anderson in 1949, systematically investigated numerous amplifying processes that might be sensitive to minute amounts of energy dissipated along the path of a fast moving charged particle. He selected a process that utilized the thermodynamic instability of a liquid superheated to a temperature roughly two-thirds of the way from boiling point to critical point (the point where liquid and gaseous states coexist in equilibrium). Glaser used diethtyl ether and obtained high speed films showing well defined tracks before boiling erupted throughout the liquid. Very large bubble chambers were subsequently built at several labs including Fermilab. Glaser earned the 1960 Nobel Prize for this contribution.

Through the operation of the 6.2 BeV proton synchrotron (bevatron) in 1954, certain particles were identified to have much greater lives (10^{-10} seconds) than predicted (10^{-23} seconds) by theoretical models. To investigate such particles in detail, all types of existing devices appeared inadequate. Luis Alvarez set to solve the problem by developing the bubble chamber that uses liquid hydrogen. He and his group at Berkeley developed hydrogen bubble chambers starting from 1 inch diameter glass chamber and took it to 72 inches. It is due to this technique that the number of elementary particles discovered so far has exceeded 100. Alvarez, who was awarded the 1968 Nobel Prize for these contributions, also made other important contributions in rapid sequence in many areas of physics.

Aage Bohr, the son of Niels Bohr, who shared the 1975 Nobel Prize in physics with Ben Mottelson and Leo Rainwater, said in his Nobel lecture: "*The constant questioning of our values and achievements is a challenge without which neither science nor society can remain healthy. We live in an age with revolutionary changes, and the inadequacy of old frameworks for our thinking has led to a highly developed disrespect for authority and tradition. This even goes so far that the tradition for disrespect can also be looked upon - disrespectfully.*" Bohr, Mottelson and Rainwater attempted to bring together the two contrasting aspects of nuclear structure - the liquid drop model and the shell model. The liquid drop model described the nucleus as a charged liquid drop that could oscillate around its spherical shape, while the shell model viewed it in terms of the independent motion of the neutrons and protons moving in orbits about the center of mass. Both the models were successful in describing certain observations. Bohr, Mottelson and Rainwater investigated a model in which there was motion of individual nucleons in the nucleus, while at the same time the nucleus as a whole could change its shape and rotate in orientation. By analogy - in a swarm of bees, each bee seems to have its own rapid flight but the swarm moves slowly as a unit.

Many Nobel Prizes during early 20th century went to developing X-ray crystallographic techniques for the study of objects in detail. However, these and other microscopy methods are not always adequate. When neutrons flowing out of a nuclear reactor are bounced against atoms of a substance, their directions and velocities change. Changes in the direction give information about the location of the atoms, while those in velocity indicate their movement, e.g. their individual and collective oscillations. The 1994 Nobel Prize went to Bertram Brockhouse and Clifford Shull for their contributions to the development of neutron scattering techniques for the studies of condensed matter (both in the solid and fluid states). Neutron scattering techniques are used in such widely differing areas as the study of the new ceramic superconductors, catalytic exhaust cleaning, elastic properties of polymers and virus structures. Neutrons being tiny magnets, also exhibit magnetic scattering with the atoms of magnetic materials. This property is used to study the relative orientations of the small atomic magnets.

2.14 Plasma Physics (1967, 1970)

The achievement for which Hans Bethe is most widely known and for which he was awarded the 1967 Nobel Prize is his theory of how the Sun and stars use nuclear reactions to supply the energy they radiate. Bethe found that the carbon-12 nucleus has unique properties: it reacts with protons at a sufficient rate to explain energy production in the stars, and it undergoes a cycle of reactions that terminates in the creation of a new carbon-12 nucleus. The carbon nucleus thus acts as a catalytic agent that is regenerated. The net result of the cycle is equivalent to the fusion of four protons to produce a nucleus of helium the one percent difference in mass accounts for the energy released. Few other physicists have worked as productively as has Bethe on so many different problems. Bethe's strength was that of finding simple and general ways to deal with complicated situations.

The 1970 Nobel Prize in physics was equally divided between Hannes Alfven and Louis Neel for their different types of work. Hannes Alfven pioneered the field of magnetohydrodynamics (MHD) which is the study of electrically conducting gases in a magnetic field. Such gases are called plasma, and some 90 percent of the matter in the universe exists in this form. Alfven studied the sunspots and discovered the hydromagnetic waves (Alfven waves) in the ionized gas of the Sun. Louis Neel discovered the fourth state of magnetism called anti-ferromagnetism. The three states - dia-, para- and ferro-magnetism were already known. He presented a model for a crystal built up from two interlaced lattices with magnetic fields acting in opposite directions, all but canceling out the observable field. He showed that this ordered state should disappear at a temperature now known as Neel point. He also explained the strong magnetism found in ferrite materials, whose one example is magnetite. These materials are electrically non-conducting and have many industrial applications.

2.15 Quantum Mechanics (1918, 1921, 1925, 1927, 1929, 1932, 1933, 1945, 1954, 1985, 1986, 1998)

Max Planck gave the world, the so called Planck's constant 'h', showing that energy occurs only in discrete multiples of this constant. The fact that it took 25 years of experimental and theoretical work to build the quantum theory is one measure of the quality of Planck's contribution. He won the Nobel Prize for the year 1918. From 1918 to 1935 most of the physics prizes went to paving the foundations of the quantum mechanics.

For his attainments in mathematical physics and especially for his discovery of the law of the photoelectric effect, Albert Einstein received the Nobel Prize for the year 1921. His contributions are too many to mention here. He presented his General Theory of Relativity in 1916, which makes many predictions of large-scale gravitational phenomena. One of the predictions was that a beam of light coming from a far off star is bent towards the Sun as it passes close to it. The 1919 solar eclipse provided an opportunity to test this prediction. Einstein was so confident of his theory that he remarked: “I no longer doubt the correctness of the whole system whether the observation of the eclipse succeeds or not. The sense of the things is too evident.” The theory did survive the eclipse test and all subsequent tests. Einstein described himself as a 'lone traveler', who has never belonged to any country, home, friends, or even the immediate family whole heartedly - never losing a sense of distance and the need for solitude. He further remarked; *”The pursuit of wealth, power and happiness have never been my targets. I am rather inclined to compare such moral objectives with a pig's ambitions”*.

The first direct proof of the Niels Bohr's postulate of the quantum nature of energy transfer was provided by James Frank and Gustav Hertz. In a famous experiment, they showed that electrons could deliver energy to a mercury atom only if they had a kinetic energy exceeding 4.9 electron volts (eV, a unit of energy). Further, that the mercury atom took up exactly this quantum of energy and emitted light whose wavelength corresponded exactly to that energy. Frank worked extensively on the ionization potentials of diatomic gases and discovered the Frank-Condon principle of vibrational energy distribution in molecular spectra. The two shared the 1925 prize for their contributions.

A ground breaking discovery was made by Werner Heisenberg, when he considered that in a de Broglie wave packet it would be impossible to make an exact and simultaneous determination of both the position and momentum of an electron - or any moving object for that matter. This, implying that an inherent uncertainty is associated with the measurement of each of these two quantities - more accuracy attained in the measurement of one, will reduce the measuring accuracy of the other, is called the uncertainty principle. This principle disturbed many contemporary scientists who believed that *the entire history of the universe, past and future, could in principle be calculated if the position and velocity of every particle in it were known for any one instant in time*. This notion was denied by the new principle, which had tremendous new applications. Heisenberg got the 1932 Nobel Prize for this prophetic piece of work.

Another important milestone in the history of physics was reached when Erwin

Schrodinger set about trying to apply the de Broglie's matter wave concept to bound particles, to improve upon the Bohr model of the atom. In Schrodinger's atom an electron can be in any orbit in which its matter wave fits in a whole number of wavelengths. This picture of a standing wave replaces that of an electron in accelerated circular motion. As long as electron remains in any orbit it need not radiate light. Thus the problem left out in the Bohr's model was overcome. His widely used wave equation is a masterpiece of physics. However, his treatment of the problem was non-relativistic - a problem that was overcome by Paul Dirac by taking into account the spin properties of the electron. Dirac obtained correct values for the fine structure of the hydrogen spectral lines. Dirac, the so-called 'creator of the anti-universe', also predicted the existence of positron - the positive counterpart of electron. The prediction was verified in 1932 when positrons were detected in the cosmic rays. Creation of electron-positron pair from high-energy gamma rays was also observed in the laboratory. Schrodinger, who also contributed in fields like specific heats of solids, statistical thermodynamics, atomic spectra, radium, space and time, theory of colors and science and the human temperament, shared the 1933 physics prize with Paul Dirac.

When an electric current is maintained through a metal bar there is normally no difference in potential across the bar if it is measured perpendicularly to the current. However, when a magnetic field is applied at right angle to the bar, the electrons are deflected toward one edge and the probes show a potential difference across the strip. This phenomenon, called 'Hall effect', was discovered by Edwin Hall in the 19^{th} century. When Hall effect is examined in two dimensions with temperatures near absolute zero and extremely strong magnetic fields, the random collisions amongst electrons are suppressed and electrons are forced into ordered movements. This is a quantum phenomenon energy can assume only certain definite values. The conductivity assumes values that are integral multiples of e^2/h. The discovery was used to make metal oxide semiconductor field effect transistor (MOSFET), and to standardize the electrical resistance (Hall resistance = 25813 ohms). Klaus Klitzing was awarded the 1985 Nobel Prize for the discovery of Quantum Hall Effect.

1998's prize went for another important breakthrough in our understanding of quantum physics. Robert Laughlin, Horst Stormer and Daniel Tsui discovered a new form of quantum fluid with “fractionally charged excitations”. Electrons in a powerful magnetic field can condense to form a kind of quantum fluid related to the quantum fluids that occur in superconductivity and in liquid helium. What makes these fluids particularly important for researchers is that events in a drop of quantum fluid can afford more profound insights into the general inner structure and dynamics of matter. In the discovery of the quantized Hall effect (1985 Nobel Prize), it was realized that Hall resistance does not vary in a linear fashion, but 'stepwise' with the strength of the magnetic field. The steps occur at resistance values that do not depend on the properties of the material but are given by a combination of fundamental physical constants divided by an integer. In their studies with more powerful magnetic fields and lower temperatures, the above researchers found new steps in the Hall resistance, both above and between the integers. The mystery posed by these observations was resolved by Robert Laughlin. He proposed that the low temperature and powerful magnetic field compel the electron gas to condense to form a new type of quantum fluid. Since electrons (fermions) are most reluctant to condense, they first, in a sense, combine with the "flux quanta" of the magnetic field to form a kind of composite particle, which is a boson (not hesitant to condensation).

2.16 Quantum Electrodynamics (1933, 1964, 1965)

Charles Townes was the first person to describe a workable conception to obtain the Microwave Amplification through Stimulated Emission of Radiation (MASER), by combining Einstein's photon theory of radiation, Boltzmann's law for energy distribution, and the selection rules of quantum mechanics. Discovery of MASER followed extension to higher frequencies to obtain LASER. LASER beams are very narrow and exhibit very little angular divergence. They can be very intense delivering enormous power onto very small areas. They have tremendous applications including weaponry, high precision atomic clocks and medical surgery. In a typical small ruby laser, reflecting coatings are applied to the ends of a ruby rod 2-5 cm long and about 3 mm in diameter. The rod is placed within a helical flash lamp. When this lamp is flashed a bright beam of red light emerges from the partially transmitting end of the ruby rod. Half of the 1964 Noble Prize was awarded to Townes, while the remaining half was equally shared by Nikolai Basov and Alexander Prokhorov for their work in quantum electronics.

And here comes the legend of physics teaching, Richard Feynman. The 1965 Nobel prize was equally shared by him with Sin-itiro Tomanaga and Julian Schwinger for independently improving what is termed as the most nearly perfect theory in physics - theory of quantum electrodynamics (QED). The theory was initially developed by Dirac, Heisenberg and Pauli during late 1920's. It describes electrons, positrons, photons and their interactions. All tests of the theory confirm it with remarkable precision. Its one great achievement was to explain the Lamb shift which had caused considerable distrust of physicists about the quantum field theory. Schwinger, who wrote his first scientific paper at the age of 16 and obtained his Ph.D. at 21, also corrected the then known value of the magnetic moment of electron, after huge mathematical calculations. The Feynman Diagrams and Feynman Lectures in Physics earned Feynman a worldwide reputation.

2.17 Solid State Physics (1937, 1956, 1970, 1973, 1977, 2000)

John Bardeen, basically an electrical engineer, obtained his doctorate in physics. He became the first person to share two Nobel Prizes in the same field, one in 1956 and the other in 1972. He, along with Walter Brattain and William Shockley announced the invention of transistor, while working at the Bell Telephone Laboratories in 1948. The invention, as a rectifier and amplifier, brought a revolution in the world with applications almost every where: radio, television, hearing aids, data-processing equipment, tape recorders, cameras, fuel injection and ignition systems, alarms, measuring equipment, airplanes, submarines, automobiles, just name any thing.

A bizarre consequence of the wave nature of particles is that a moving charged particle can get through an 'insurmountable' energy barrier. It is just like saying that a ball flying at a height of 10 meters can get through a 20 meter tall building. This is called the 'tunneling effect'. Leo Esaki studied this effect in semiconductor diodes. Using an extremely narrow junction and heavy impurity doping of the semiconductor, he successfully achieved the operation of a 'backward diode', so called because of having polarity opposite to that of an ordinary diode. He predicted and than discovered in 1957, a *negative resistance* associated with large tunneling currents in the forward direction. The diode has practical applications in high-speed circuits such as those used in computers. Ivar Giaever discovered tunneling in super conductors, which led to a solid state spectroscopic technique. Brian Josephson predicted the properties of a super current through a tunnel barrier. His calculations indicated that a super-conducting current can exist in the junction even when there is no voltage drop across it. This is termed as Josephson effect which has found lots of scientific and industrial applications, especially in the super-conducting quantum interference devices (SQUIDS). The 1973 Nobel Prize was shared by the above three scientists.

The tape recorder, the laser, the transistor, the modern computer, and most other gadgets in modern electronics rest on imaginative theories of solid state physics. John Vleck, Sir Nevill Mott and Philip Anderson, each developed mathematical models to explain how electrons behave in electrical conductors. They suggested that in transition metals, electrons contribute to the electrical conductivity in two ways. One group of electrons is primarily responsible for current, while a second, more sluggish group accounts for the magnetic properties. They also developed the theory of dislocations, defects and strengths of crystals. The so called 'Anderson's model' of the microscopic origin of magnetism in bulk materials, is a quantum model which can explain the basic physics of a host of problems such as super-conducting transition temperatures and the effects of impurities. The three equally shared the 1977 Nobel Prize for physics.

The last Nobel Prize of the 20th century was awarded to scientists and inventors whose work has laid the foundation of modern information technology (IT). One half of the prize was earned by Jack Kilby for his part in the invention and development of the integrated circuit, the chip. Through this invention microelectronics has grown to become the basis of all modern technology, that needs no mention. The second half of the prize was shared by Zhores Alferov and Herbert Kroemer for developing semiconductor heterostructures used in high-speed and opto-electronics. Two basic requirements put on a modern information system are 'fast speed' and 'small volume'. Alferov and Kroemer invented and developed fast opto- and microelectronic components based on layered semiconductor structures, termed semiconductor heterostructures. Fast transistors built using heterostructure technology are used in radio link satellites and the base stations of mobile telephones. Laser diodes built with the same technology drive the flow of information in the internet's fiber-optical cables. They are also found in CD players, bar-code readers and laser pointers.

2.18 Superconductivity (1972, 1973, 1987)

The second most important contribution of John Bardeen, who shared the 1956 Nobel Prize for the invention of transistor was his so-called ‘BCS theory’ of superconductivity, which he proposed along with Leon Cooper and John Schrieffer in 1957. They showed that in a metal, two or more electrons with energies near the Fermi energy (energy associated with the electrons in the highest occupied level) would form a resonant state. In this state they have a common momentum which is not affected by random scattering of individual electrons, so the effective electrical resistance is zero. The theory has been called one of the most important contributions to theoretical physics since the development of quantum theory. The fascinating study of superconductivity has already led to super-conducting magnets, sensitive devices for measuring electric currents, voltages and magnetic fields, and is on its way to find applications in computers and in power transmission lines etc. All three shared the physics Nobel Prize for 1972.

A major problem in the field of superconductivity was that as lead and mercury, which are superconductors below 4.2 K^o, tend to lose this property in the presence of a magnetic field. In 1973 niobium compounds were found to be superconductors at 23 K^o. After a systematic search that began in 1983, Karl Muller and George Bednorz discovered a certain form of barium lanthanum copper oxide in 1986, that exhibited superconductivity at 35 K^o. The discovery was so promising for revolutionary practical applications that the Nobel Prize committee voted for the 1987 prize to go for it. The same year (1987), Ching-Wu at the University of Houston, discovered another ceramic material, a certain form of yttrium barium copper oxide, that remained super conducting up to 84 K^o.

2.19 X-Ray Physics & X-Ray Chrystallography (1901, 1914, 1915, 1917, 1924)

The x-rays discovered by Rontgen, were subsequently used for understanding the internal structures of crystals. Nobel Prizes for 1914 to 1917 were awarded in succession in the subject of x-ray crystallography. Max von Laue - a student of Max Plank, established the nature of x-rays as electromagnetic waves, through the diffraction patterns of x-rays by crystals, and permitted the measurement of their wavelengths. He was awarded the 1914 prize. 1915 prize was jointly awarded to Sir William Henry Bragg and his son William Lawrence Bragg. Braggs constructed the first x-ray spectrometer to investigate their spectral distribution, and the relation ship between wavelength and the atomic mass of the emitter and absorber. They showed that crystals like sodium chloride, contain no actual molecules of NaCl, but only sodium ions and chloride ions arranged in geometric regularity, thereby revolutionizing the theoretical chemistry. They also developed the distinction between

the long range and the short-range orders in crystals.
No prize was awarded in 1916. The 1917 prize went to Charles Barkla, for his discovery of the secondary x-ray emission characteristics of elements. He found that, when x-rays are absorbed by matter, there is secondary radiation of two kinds. One consists of x-rays scattered unchanged in quality, the other is a 'fluorescent radiation' characteristic of the scattering substance. He found two types of these characteristic rays, K - more penetrating type, and L - less penetrating type, accounted for as being due to transition of the innermost electrons in the Bohr's atomic model.

In 1924, the physics prize was awarded to Karl Siegbahn for his discoveries and research in x-ray spectroscopy. The relative simplicity and the close similarities between the x-ray spectra of 92 different elements convinced Siegbahn that this radiation originates inside the atom and has no direct connection with the complicated light spectra and chemical properties governed by the outer electron structure. He developed spectrometers with accuracy of one part in 100,000. In addition to K and L lines, discovered by Barkla, Siegbahn discovered the M lines, and found that all these lines were further split up into several lines. He showed that the series of x-rays labeled K, L, M etc. in order of increasing wavelength, correspond to radiation emitted when an electron further from the nucleus drops into a vacancy in the innermost K, L, or M shells, at increasing distances from the nucleus.

2.20 Miscellaneous (Radioactivity-1903, Mechanics-1912, Brownian Motion-1926, High Pressure Physics-1946, Atmospheric Physics-1947, Condensed Matter Physics-1962)

1903 Nobel Prize was shared by Antoine Becquerel, Pierre Curie and Marie Curie, for their discovery of spontaneous radioactivity. The discovery had tremendous medical and industrial applications, in addition to its forthcoming disastrous use in nuclear weaponry. Mary Curie, who received a second Nobel Prize in chemistry in 1911 for her discovery of radium and polonium, has been the most honored scientist on the postage stamps of several countries.

1912 prize was awarded to Nils Dalen, a mechanical engineer, for inventing the automatic regulators that can be used in conjunction with gas accumulators for lighting beacons and light buoys. Heike Onnes, who won the 1913 prize, had developed low temperature physics, leading to the production of liquid helium. His intimate fellows used to call him 'the gentleman of absolute zero', for his careful exploration of the optical and magnetic properties of substances at low temperatures. He also discovered 'superconductivity' and helium-II.

It was Jean Perrin, who for the first time, showed that cathode rays were actually negatively charged particles, and not a form of wave radiation. His experiments led J.J.Thompson to determine the charge to mass ratio of these particles. He is most famous for his work on Brownian motion. He suspended the small particles of gum resin in a tube filled with water, and counted their number for equal intervals of height, finding that the number decreased exponentially with increasing height. From these observations he calculated the Avogadro's number and the size of water molecules. He fetched the 1926 Nobel Prize for the discovery of the equilibrium of sedimentation.

Attainment of high pressures was of great concern in the liquefaction of gases. The greatest attainable pressure by 1880's was 3000 times the atmospheric pressure at sea level. Percy Bridgman developed a method for giving external support to the pressure vessel, in such a way that the support increased with increase in the internal pressure, making the attainment of over 400,000 times the atmospheric pressure at sea level. Using his apparatus he made many discoveries including 'hot ice' that is produced at a pressure of 40,000 times the atmospheric pressure, and has a melting point at 200 degree Celsius. He also created synthetic diamonds. The method of dimensional analysis for the derivation of many important equations in physics is also due to him. 1946 Nobel Prize went to these discoveries.

It was proposed by Oliver Heaviside and A.E. Kennely, in 1902 that an electric layer in the upper atmosphere acts to reflect the electromagnetic waves and accounts for Marconi's success in transmitting wireless signals around the curved surface of the Earth. Sir Edward Appleton decided to test this hypothesis by arranging with the BBC to vary the frequency of the transmitter in Bournemouth while the strength of the received signal was recorded at Cambridge. Looking for the strengthening of the signal through constructive interference between the signal traveling along the Earth and the one reflected from the proposed electric layer, he concluded that the layer was some 60 miles high. In the process he discovered another layer at a height of some 150 miles, later named as Appleton layer. After these discoveries he developed the magneto-ionic theory of the ionosphere, through which it became possible to forecast several months ahead, the most suitable frequencies at any time of day in any part of the world for radio transmissions for any distance. He was awarded the 1947 Nobel Prize.

Lev Landau is known for his remarkable contributions in almost all fields of theoretical physics. He was awarded the 1962 Nobel Prize for his pioneering theories of condensed matter, especially liquid helium. He explained as to why helium becomes frictionless (super fluid), at temperatures below 2 K^{o}, and acquires a thermal conductivity 800 times greater than that of copper at room temperature. Further, he predicted that in super fluid helium sound would travel with two different speeds. He exhibited versatility and a talent for solving difficult theoretical problems by ingenious mathematical analysis. At the age of 19, he presented a paper on damping in wave mechanics, describing for the first time the quantum states of systems, using density matrices.

3. CONCLUSIONS

Altogether, 94 Nobel Prizes were awarded in physics during the century to 162 recipients, spread over 21 countries. Country wise distributions of these recipients are

Table - 1(a): Nationality Wise Distribution of the 20th Century Nobel Prize Recipients in

COB / NAT	ALG	USA	AUS	UK	CAN	CHI	DEN	FRA	GER	HUN	IND	IRE	ITL	JAP	LUX	NED	NOR	PAK	POL	RUS	SWE
ALG																					
USA		52	2			3			9	1			2				1				1
AUS			2																		
UK				18					1	1											
CAN					2																
CHI																					
DEN		1					2														
FRA	1							8							1				2		
GER									18	1											
HUN																					
IND											2										
IRE												1									
ITL													2								
JAP														3							
LUX																					
NED																9					
NOR																					
PAK																		1			
POL																					
RUS																				8	
SWE									1												6

USA	- 71	Netherlands	- 9	Denmark	- 3	India	- 2
UK	- 20	Russia	- 8	Japan	- 3	Italy	- 2
Germany	- 19	Sweden	- 7	Australia	- 2	Ireland	- 1
France	- 12	Canada	- 2	Pakistan	- 1		

Table - 1(b): Country Codes

Algeria	ALG	Denmark	DEN	Italy	ITL	Poland	POL
America	USA	France	FRA	Japan	JAP	Russia	RUS
Austria	AUS	Germany	GER	Luxembourg	LUX	Sweden	SWE
Britain	UK	Hungary	HUN	Netherlands	NED		
Canada	CAN	India	IND	Norway	NOR		
China	CHI	Ireland	IRE	Pakistan	PAK		

COB ≈ Country of Birth
NAT ≈ Nationality

provided in the Table-I. In some cases, one prize is included into more than one category.

REFERENCES

1. Nobel-e-Museum, 2002, The Nobel Foundation.
2. D. Allan, Bromley, 2002, A Century of Physics, Amazon.com
3. Robert L. Weber, 1988, Pioneers of Science, Adam Hilger, Bristol and Philadelphia
4. Charles E. Gillespie, 1974, Dictionary of Scientific Biography, Scribner, New York
5. Niels Hugh de Vaudray, 1953, Nobel Prize Winners in Physics, Schuman, New York
6. Robert L. Weber, 1973, A Random Walk in Science, The Institute of Physics, London and Bristol
7. Harriet Zuckerman, 1977, Scientific Elite: Nobel Laureates in the United States, Free Press, New York
8. Curt Suplee, 1999, Physics in the 20th Century, Reed Business Information Inc., American Physical Society
9. Joel Genuth, 1999, History of the 20th Century Physics, University of Maryland, College Park
10. Peter Galison & Bruce Hevly 1992, Big Science: The Growth of Large Scale Research, Stanford University Press
11. Daniel J. Kelves, 1995, The Physicists: The History of a Scientific Community in Modern America, Cambridge, Harward University Press

PHYSICS IN MY LIFE

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ABSTRACT

Physics is ubiquitous in all aspects of our lives. Its principals underlie our understanding of all natural phenomena, and most of the technologies that surround us. These include, household-appliances, sports and entertainment, medical diagnosis, transport, computer, communication and manufacturing, advanced tools for scientific research and most of the defense-technologies. Tomes have been written on these topics and there are full fledged-degree programs related to some of these technologies. In this paper, therefore, I propose to confine myself to physics that I personally encountered at different stages of my life as a child, a student, a researcher and a teacher, as well as some recent excitements in my field of interest.

PHYSICS DURING MY CHILDHOOD

As any other child of my generation, I spent a great deal of my time playing different sports and games. These included playing marbles, making and playing with slingshots, bows and arrows and toy-guns and rolling stones down mounds to see whose stone will first reach the bottom or move the farthest. I used to play these games with my childhood friends, prior to and during my early school-years and I had no clue about their underlying physics. I learnt much later that principals of physics underlie all of these games; the physics of collisions in the case of marbles, storing my muscular energy in the form of the elastic-energy of the bent-bow and stretched rubber-band of the sling-shot or the toy-gun that was eventually converted into the kinetic energy of the arrows or the shots. The sharper the arrow, the greater the degree of their penetration into the target, due to the concentration of the force into exceedingly large pressures caused by the rapid change of their momentum, etc.

We used to roll stones down the mounds of the ruins of ancient Peshawar that were not too far from my house. Alas, these ruins have since disappeared and have been replaced by poorly planned and badly constructed buildings. We chose the stones on purely empirical basis, through trial and error and found that round spherical rather than disk-shaped stones were the likely winners in this game. My subsequent education in physics helped me appreciate its underlying physics, in that the motion of extended rigid objects is influenced by the way their mass is distributed in their bodies, something that the concept of 'moment of inertia' embodies.

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* Text of a talk at COMSATS Seminar of 'Physics in Our Lives' in connection with the 'World Year of Physics 2005', on 23-24 February 2005, Islamabad, Pakistan

This childhood pastime must have stayed in my subconscious, when I asked students of the National Physics Talent Contest (NPTC) to design such an experiment, a few years ago, to help them get a clearer concept of moment of inertia. These students had great fun doing these experiments, playing present day Galileo, rolling discs, spheres and right circular and other cylinders, of different sizes and densities, down inclined planes. Whether or not these experiments helped NPTC, the students gained a clearer understanding of the somewhat difficult concept of moment of inertia by comparing their predictions with observations. One was able to get a more clear understanding of tumbling, rolling and sliding motions and the role of moment of inertia in these motions.

The "Physics of Sports" offers us a glimpse into a fascinating world of motion, collisions, projectiles and forces. From gymnastics to Ice-hockey, physics plays a dominant role in the way athletes perform and the way sport is played! We use physics every time we participate in a sport. It helps us kick or hit a ball, make a catch, or jump the farthest or the highest, etc. A typical "Physics of Sports", Google Search, is likely to yield 5 million or more hits.

MY EDUCATION OF PHYSICS

I don't have much recollection of the physics that I leant in my school-years, although I do recall some mathematics and chemistry from those days. I do, however, have vivid recollection, though, of some exciting experiments in physics that I did during my college and university education. Experiments that fascinated me included, polarization of light and Zeeman Effect; light interference using Michaelson and Fabri-Parrot interferometers; measuring charge of electron, using oil-drop experiment and its e/m ratio using motion of electrons in a discharge-tube in between Helmholtz Coils. Another vivid recollection of my education at university is that of measuring the force between bar-magnets by studying their motion on glass-rollers on a glass-plate.

Reflecting back on these days, it appears that doing these experiments were a natural extension of my childhood pastime. I used to be so much absorbed in these experiments that I didn't pay much attention to, or perhaps was not aware of, the ongoing excitements and earlier achievements in physics. After joining the Atomic Energy Center, Lahore, I learnt about the unprecedented accuracy with which the fine structure-constant of electron was measured and its value predicted, using quantum electrodynamics. At about that time, I also began to appreciate the fact that the careful experiments of Faraday had led to the unification .of the subjects of my favorite experiments, electricity and magnetism, and that Maxwell's equations of electrodynamics and Hertz experiments of electromagnetic radiation had also led to the unification of light, a tiny portion of the electromagnetic spectrum, with electromagnetism. At about that time, I also learnt about the achievements of Salam in particle-physics, but I didn't realize that his work had already paved the way for the unification of electromagnetic and weak forces.

My studies in the United States provided me even richer opportunities to broaden my knowledge of physics and other disciplines. It was there that I learnt that some fluids lose their viscosity, below a certain well-defined temperature, thus, becoming superfluids. Similarly the resistivity of some metals vanish below a certain temperature becoming superconductors. What was even more exciting was that I learnt about these things from individuals who played a pioneering role in my understanding of these novel phenomena. At that time, some of these pioneers were also contributing to our understanding of pulsars, with the help of their model of Pulsar as a 'neutron star'. Pulsars are rotating neutron-stars and pulsars pulse because they rotate! They were first discovered in late 1967, by graduate student, Jocelyn Bell Burnell, as a radio sources that blink on and off at a constant frequency. Neutron-stars are giant nuclei, about 20 km in diameter that are composed of only neutrons and have the mass of about 1.4 times that of our Sun. This means that a neutron-star is so dense that on Earth, one teaspoonful from these stars, would weigh a billion tons! Because of its small size and high density, a neutron-star possesses a surface gravitational field about 300,000 times that of Earth. Neutron-stars can also have magnetic fields a million times stronger than the strongest magnetic fields produced on Earth.

It was also at Champaign-Urbana, Illinois, that I had a chance to briefly work at the Betatron, the world's first magnetic-induction accelerator. Technology based on this concept, led to synchrotron, X-ray sources that are now routinely used in research, medicine and industry.

The weekly colloquia there by leading physicists from around the world further broadened my knowledge of physics. It was through such colloquia that I learnt that physicists are striving to unravel the role of iron-ions in the hemoglobin of red-blood cells, in transporting oxygen from lungs to various tissues of the body.

MY PHYSICS RESEARCH

My keen interest in statistical mechanics and my exposure to work on superfluids and superconductors, led me to do research in the area of phase-transitions and critical phenomena. Condensation of vapors into a fluid and the freezing of a fluid into a solid, are examples of phase-transitions as these are of normal-fluid to superfluid and of a normal conductor, and now also of certain insulators, to superconductor. In the case of some of these transitions, the two phases become indistinguishable under certain conditions, for example a very dense vapor and a liquid after it has undergone sufficient thermal expansion. Under such conditions, the system doesn't quite know as to which phase it belongs to, and as a consequence, it undergoes very large fluctuations. Such special cases of phase-transitions are referred to critical phenomena.

My supervisor, Leo Kadanoff, suggested a problem that involved the computation of transport-coefficients of a model-system, near the critical-point using computer simulations. This was long before the time of personal-computers and I had not yet seen a computer, let alone used it. I had to learn computer-programming, simulations, phase-transitions as well as, about space and time-dependant correlation-functions from the scratch, before I could start my research. After lot of hard work and many many sleepless nights, I was able to complete this work and publish it in the physical reviews. Later on, I extended this work to percolation, spin-glass transition, long-chain polymers and phase-transitions in absorbed monolayer, etc. These days, if and when I get time, I would like to apply some of these ideas to model traffic flow and to understand the distinction, if any, between different types of irrational numbers.

MY TEACHING EXPERIENCE IN PHYSICS

Teaching is my passion and these days I am involved in teaching at all levels from kindergarten to master level. In fact, I started my career as a teacher right after my M.Sc. just before joining PAEC. I love teaching because, first and foremost, it helps clarify my own concepts, then there is nothing comparable with the gleam in the eyes of children and not-so-young students, when you help them understand a difficult concept. Teaching has also helped me appreciate the fact that physics, and more broadly science and mathematics, is an integral and important part of human-culture, and that it demands utmost honesty from its practitioners. Progress of science ultimately depends on the credibility of its practitioners, which is perhaps the most important aspect of human-culture. Training of physics not only inculcates clarity of thought and precision in communication, but also need for credibility, something that a teacher should strive to pass onto students. In fact, science constantly develops tools to check credibility so that any act of omission and commission can be identified and rectified.

RECENT EXCITEMENTS IN MY FIELD OF INTEREST: SUPERSOLID PHASE OF MATTER

In our day to day life, we commonly encounter phase-transitions such as, freezing and melting and vaporization and condensation. Mixing and un-mixing transitions in binary liquids, such as oil and water, order-order transitions from one crystal-structure to another and order-disorder transitions in binary alloys and magnets are other examples of phase transitions. Phase-transition from normal conductor to superconductor and from normal fluid to superfluid are examples of Einstein's legacy in low-temperature physics. Suprconductivity was first discovered in mercury, by the Dutch physicist, Heike Kamerlingh annes, in 1911, and Superfluidity in helimn-4 was discovered in 1938, by the Soviet physicist, Pyotr Leonidovich Kapitsa. These phenomena and the more recently discovered ‘Bose condensates’ are physical realizations of Bose-Einstein statistics.

Solids and liquids could hardly seem more different, one maintaining a rigid shape and the other flowing to fit the contours of whatever contains it. And of all the things that slosh and pour superfluids seem to capture the quintessence of the liquid state--running through tiny channels with no resistance and even dribbling uphill to escape from a bowl.

A superfluid-solid sounds like a contradiction, but it is precisely what researchers at Pennsylvania State University witnessed in January 2004[1]. Physicist Moses Chan and his graduate student Eun-Seong Kim saw the behavior in helium 4 that was compressed into solidity and chilled to near absolute zero. Although the supersolid behavior had been suggested as a theoretical possibility as long ago as 1969, its demonstration poses deep mysteries.

"We discovered that solid helium-4 appears to behave like a superfluid, when it is so cold that the laws of quantum mechanics govern its behavior," wrote Moses H. W. Chan, Evan Pugh Professor of Physics at Penn State. "We apparently have observed, for the first time, a solid material with the characteristics of a superfluid".

The possible discovery of a new phase of matter, a supersolid, is exciting and, if confirmed, would be a significant advance", comments John Beamish, professor of physics at the University of Alberta and the author of a review of Chan's discovery, published in the "News and Views" section of the Nature. "If the behavior is confirmed, there are enough questions to be answered about the nature and properties of supersolid helium to keep both experimentalists and theorists busy for a long time".

Chan and graduate student Eun-Seong Kim made this discovery by using an apparatus that allowed them to compress helium-4 gas into a sponge-like glass-disk with miniature atomic-scale pores, while cooling it to almost absolute zero. The porous glass was inside a leak-tight capsule, and the helium-gas became a solid when the pressure inside the capsule reached 40 times the normal atmospheric pressure. Chan and Kim continued to increase the pressure to 62 atmospheres. They also rotated the experimental capsule back and forth, monitoring the capsule's rate of oscillation, while cooling it to the lowest temperature.

"Something very unusual occurred when the temperature dropped to one-tenth of a degree above absolute zero", Chan says. "The oscillation rate suddenly became slightly more rapid, as if some of the helium had disappeared", he further added. However, Chan and Kim were able to confirm that the helium-atoms had not leaked out of the experimental capsule, because its rate of oscillation returned to normal after they warmed the capsule above one-tenth of a degree, above absolute zero. So they concluded that the solid helium-4 probably had acquired the properties of a superfluid, when the conditions were more extreme.

Chan offers an analogy for understanding the results of this experiment. "Imagine there is a pan holding a collection of marbles and this pan with the marbles is suspended by a spring. The pan is then made to oscillate up and down. The rate of oscillation is determined by the combined weight of the pan and the marbles. But if a few of the marbles suddenly become able to hover above the other marbles and the pan, the overall weight become lighter and the pan would oscillate at a faster rate", he explains. The researchers conclude that what happened inside their experimental capsule is that the tightly packed helium-4 particles became so slippery that they were no longer coupled to the walls of the glass sponge's micropores; in other words, it became a supersolid. One way to observe superfluidity in solid helium is to measure the resonant-period of a sample of the material, in a piece of apparatus called a torsional oscillator. This period depends on the moment of inertia of the sample, and this moment changes when helium enters the superfluid state.

Beamish notes that, although superfluids are rare, they "play a fundamental role in fields as diverse as statistical mechanics and fluid-dynamics and they provide a valuable test-bed for applications ranging from turbulence to cosmology". To understand how a supersolid could exist, you have to imagine the realm of quantum-mechanics, the modem theory that explains many of the properties of matter. In this realm, there are different rules for the two categories of particles: fermions and bosons. Fermions include particles like electrons and atoms with an odd mass-number, like helium-3. Bosons include atoms with an even mass-number, like helium-4. The quantum-mechanical rule for fermions is that they cannot share a quantum state with other particles of their kind, but for bosons there is no limit to the number that can be in the identical quantum-state. This talent that bosons have for coherent motion led to the remarkable properties that Chan and Kim discovered in supercooled helium-4.

"When we go to a low-enough temperature, thermal energy is no longer important and this quantum-mechanical effect becomes very apparent", Chan explains. "In a supersolid of helium-4, its identical helium-4 atoms are flowing around without any friction, rapidly changing places, but because all its particles are in the identical quantum-state, it remains a solid even though its component particles are continually flowing".

Chan and Kim tested their conclusion by performing the experiment again, but this time with the fermion helium-3, which theoretically is incapable of forming a supersolid. In this experiment, they found that there was no change in the oscillation-period, even when the helium-3 was cooled to just 0.02 degrees above absolute zero--in stark contrast to the results with helium-4. "This control experiment with helium-3 gives more weight to our conclusion that the helium-4 in our experiment appears to have become a supersolid", Chan says.

The existence of superfluid and "supervapor" had previously been proven, but theorists had continued to debate about whether a supersolid was even possible. "One of the most intriguing predictions of the theory of quantum-mechanics is the possibility of superfluid behavior in a solid-phase material, and now we may have observed this behavior for the first time.

Nobel Laureate Anthony J. Leggett of the University of Illinois, at Urbana, first doubted that Chan and Kim uncovered the supersolidity that he and other theorists had envisioned. After all, he notes, helium frozen within glass-pores differs markedly from the bulk crystals to which the theories apply. Instead, he speculated that the scientists detected some other type of superfluid behavior. Subsequent experiments by Kim and Chan measuring a total of 17 samples of solid helium-4, at pressures between 26 and 66 bars, confirmed that they all became superfluid at temperatures below 230 milli-kelvin. "Our experiment shows that the superfluid-like behaviour is a general and intrinsic property of solid helium", they write, "and not the result of confinement in any particular medium". This seems to have convinced Leggett, who subsequently wrote that the experiment "will force theorists to revise dramatically the generally accepted picture of crystalline solid helium-4".

So how can a solid behave like a superfluid? All bulk liquid superfluids are caused by Bose-Einstein condensation, which is the quantum process, whereby a large number of particles enter the same quantum-state. Chan and Kim's result, therefore, suggests that one percent of the atoms in the solid helium somehow form a Bose-Einstein condensate, even while they remain at fixed lattice-positions. That seems like a contradiction in terms, but the exchange of atoms between lattice-sites might allow it a characteristic of helium would tend to promote such an exchange--namely, its large zero-point motion, which is the inherent jiggling of atoms that represents a minimum amount of movement required by quantum uncertainty. (It is the reason helium ordinarily only occurs as a gas or a liquid: the extremely lightweight atoms jiggle about too much to form a solid.) Supporting the idea of condensation, the two researchers did not see superfluidity in solid helium 3, an isotope of helium that as a liquid undergoes a kind of condensation and becomes superfluid only at temperatures far below that needed by liquid helium 4.

Another possibility is that the crystal of helium contains numerous defects and lattice vacancies (yet another effect of the zero-point motion). These defects and vacancies could be what, in effect, undergo Bose-Einstein condensation.

But all these theories seem to imply that the superfluidity would vary with the pressure, yet Chan and Kim see roughly the same effect all the way from 26 to 66 atmospheres. Nobel Laureate Douglas D. Osheroff of Stanford University, the co-discoverer of superfluidity in helium 3, calls the lack of pressure dependence "more than a bit bewildering". He says that Chan and Kim have done "all the obvious experiments to search for some artifact". If they are correct, Osheroff adds, then "I don't understand how supersolids become super. I hope the theorists are thinking about it seriously.

REFERENCE

1. 'A Glimpse of Supersolid', News Scan, Scientific American, January 2005 and Google Search on "Supersolid Helium".

MY EXPERIENCE OF ATTENDING THE MEETING OF NOBEL LAUREATES, HELD IN LINDAU, GERMANY, 2004

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The Meeting of Nobel Laureates is now an the annual event, having significant impact on the developments in science throughout the world. One of the subjects from Chemistry, Physics and Medicine is chosen for each year to be discussed. Last year was the turn of physics. It was the 54th meeting in general and 18th meeting in physics, in particular. Now I would like to give you the brief account of my selection to attend this meeting.

It was bright day of March 2004. I was sitting in a small room of my college, where I used to sit in my free time to read and think about Physics. That day, one of my colleague from department of English was also sitting with me. He was busy reading his newspaper; suddenly he asked me "why don't you go to Germany?" I just smiled without looking at him, but he continued, "to meet the Nobel laureates". I, then on his insistence, wrote my application to Dr. N M Butt and after few days, I received the call for an interview and in the process of just two months, we were ready to go to Germany.

I was part of the group of eight people. We attended the orientation camp before going to Germany. This was organized in COMSATS for three days. It was very fruitful; renowned scientists of the country delivered their lectures. These lectures were very helpful in organizing our thoughts for the forthcoming meeting. We left for Germany on the 25th of June 2004.

About five hundred students from 32 countries, including Pakistan, also attended the meeting. A brief overview of the proceedings of the six-day meeting is given below:

FIRST DAY OF THE MEETING

The meeting started on the 27th June with opening ceremony in the afternoon. The formal proceedings of the meeting started the next day. The format of the meeting was as follows:

1. Roundtable discussions among the laureates,
2. Lectures by laureates,
3. Open discussions between Laureates and students,
4. Social get to gathers, and
5. Boat trips.

Eighteen Nobel Laureates from all over the world attended the meeting, most of the names of the laureates that attended are given below:

1. Prof. Dr. Martinus Veltman
2. Prof. Dr. T'hooft
3. Prof. Dr. Kossiba
4. Prof. Dr. Robert Huber
5. Prof. Dr. Leo Esaki
6. Prof. Dr. Ivar Giaever
7. Prof. Dr. Klaus von Klitzing
8. Prof. Dr. Douglas Osheroff
9. Pro. Dr. Brian D. Josephson
10. Prof. Dr. K.A. Muller
11. Prof. Dr. Walter Kohn
12. Prof. Dr. Klaus von Klitzing
13. Prof. Dr. Arno Penzias
14. Prof Dr. Nicolas Bloembergen
15. Prof. Dr. Richordson
16. Prof. Dr. Riccardo Giacconi

SECOND DAY OF THE MEETING (28th JUNE)

The meeting started with first roundtable discussion, with the following six laureates participating in it:

- Prof. Dr. Martinus Veltman
- Prof. Dr. T'hooft
- Prof. Dr. Ivar Giaever
- Prof. Dr. Herbert Kroemer
- Prof. Dr. Douglas Osheroff
- Prof. Dr. Arno Penzias

The topic of discussion was Astrophysics. The laureates discussed the different aspects of the subject in detail. Since Astrophysics is an emerging branch of physics, the discussion was very fruitful and thought-provoking.

After the discussion, the following laureates delivered their lectures. Abstracts of the lectures are also given at the end, as Appendix-I.

Lecture No 1: Negative Optical Refraction
Speaker: Prof. Dr. Herbert Kroemer
Lecture No 2: A Classical View of the Universe
Speaker: Prof. Dr. Arno Penzias
Lecture No 3: Understanding the Columbia Shuttle Accident
Speaker: Prof. Dr. Douglas Osheroff

Lecture No 4: How to Start a High-Tech Business
Speaker: Prof. Dr. Ivar Giaever

The next session started in afternoon, it was all about open discussions between students and laureates. The following laureates attended this session:

- Prof Dr. Nicolas Bloembergen
- Prof. Dr. Richordson
- Prof. Dr. Riccardo Giacconi
- Prof. Dr. Ivar Giaever
- Prof. Dr. Klaus von Klitzing
- Prof. Dr. Douglas Osheroff

Pakistani students asked several good questions, which were food for thought for me and for other students as well. Apart from our discussions with laureates, we also interacted with students from all the participating countries. In the evening, American students hosted the dinner party.

THIRD DAY OF THE MEETING(29th JUNE)

The third day started with lectures from following laureates:

Lecture No 1: How to Start a High-Tech Business
Speaker: Prof. Dr. Robert Huber
Lecture No 2: The Development of Particle Physics
Speaker: Prof. Dr. Martinus Veltman
Lecture No 3: Pesudo Science, Marvelous Gadgets and Public Policy
Speaker: Prof. Dr. Robert.C.Richardson
Lecture No 4: Some Remarks on the Symmetry of the Superconducting Wavefunction in the Cuperates
Speaker: Prof. Dr. Karl Muller

With these lectures, the first session of the day ended.

The afternoon session of informal discussions with the laureates was attended by the following laureates:

- Prof. Dr. Martinus Veltman
- Prof. Dr. T'hooft
- Prof. Dr. Kossiba
- Prof. Dr. Arno Penzias
- Prof. Dr. Leo Esaki
- Prof. Dr. Ivar Giaever

Later we were taken to the museum of the city.

FORTH DAY OF THE MEETING(30th JUNE)

Forth day also started on a similar pattern. First session was of lectures from the following laureates:

Lecture No 1: Pathological Disbelief
Speaker: Prof. Dr. Brian Josephoson
Lecture No 2: The Birth of Neutrino Astrophysics
Speaker: Prof. Dr. Masatoshi Koshiba
Lecture No 3: X- Ray Astronomy
Speaker: Prof Dr. Riccardo Giacconi
Lecture No 4: Laser Technology in Peace and War
Speaker: Prof. Dr. Nicolas Bloembergen

The afternoon session was held with the participation of the following laureates:

- Prof. Dr. Robert Huber
- Prof. Dr. Leo Esaki
- Prof. Dr. Ivar Giaever
- Prof. Dr. Klaus von Klitzing
- Prof. Dr. Douglas Osheroff

In the evening there was a dance party in the main hall.

FIFTH DAY OF THE MEETING(1st JULY)

This was the last day of the Meeting. It stared with Second Roundtable discussion about the "Fundamental and Applied Research", with the following Laureates participating in the discussion:

- Prof. Dr. Kossiba
- Prof. Dr. Klaus von Klitzing
- Prof. Dr. K.A. Muller
- Prof. Dr. Nicolas Bloembergen
- Pro. Dr. Brian D. Josephson

This discussion was again very interesting and fruitful. Many laureates were in the favor of basic research. So many laureates narrated good stories of their work.

This was fallowed by the lectures by the following laureates:

Lecture No 1: Perspectives on van Der Waals Interactions between Systems of Arbitrary Size, Shape and Atomic Compositions
Speaker: Prof. Dr. Walter Kohn
Lecture No 2: Spin Phenomena in the Electronic Transport of the Semiconductor Quantum Structures
Speaker: Prof. Dr.Klaus Von Klitzing
Lecture No 3: The Birth of a Superlattice and its Evolution
Speaker: Prof.Dr. Leo Eski
Lecture No 4: Supertheories
Speaker: Prof. Dr. Gerard T'hooft

This session ended with these lectures and routine informal discussions were held in the afternoon, that were participated by:

- Prof. Dr. T'hooft
- Prof. Dr. Kossiba
- Prof. Dr. Douglas Osheroff
- Prof. Dr. Brian D. Josephson
- Prof. Dr. K.A. Muller

SIXTH DAY OF THE MEETING (2nd JULY)

It was the concluding day of the meeting, we went to the island of Minau by boat. The concluding ceremony was held there.

Abstracts of some lectures laureates are given at APPENDIX - I.

THE ROLE OF BIOPHYSICS IN MEDICINE

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ABSTRACT

Biomedical disorders are the leading cause of death among both men and women, in Pakistan. It is important to know about the state of our body to help prevent these disorders. Among the common diseases prevalent in Pakistan are neuro-degenerative disorders, such as Alzheimer's disease and metabolic and infectious diseases, such as cardiac ischemia, renal nephropathy, type-II diabetes mellitus, many forms of cancer, different kinds of hepatitis. The scientific and clinical studies include vaccine-development and investigations for the early diagnosis and treatment of these diseases. Various biophysical techniques are used for these studies. These include Nuclear-Magnetic Resonance (NMR) spectroscopy, Magnetic-Resonance Imaging (MRI), Computed Tomography (CT), Fourier Transform Infra Red (FTIR) spectroscopy and both Matrix Assisted Laser Desorption Ionization (MALDI) and Electro Spray Ionization (ESI) Mass spectroscopy. These biophysical tools along with modeling techniques, provide both scientists and clinicians with the tools and understanding for the treatment and early diagnosis of various diseases present in the country.

INTRODUCTION

Biophysics is an interdisciplinary field that applies the techniques from physical sciences to understand biological structure and function. Biophysics uses techniques of biology, physics, chemistry, mathematics, engineering, genetics, physiology and medicine, to solve various problems of biomedical research. These techniques include, Nuclear-Magnetic Resonance (NMR) spectroscopy, Fourier-Transform Infra Red (FTIR) spectroscopy, Circular-Dichroism (CD) spectroscopy, Magnetic-Resonance Imaging (MRI) and Computed Tomography (CT). These biophysical tools along with molecular modeling provide both scientists and clinicians with the ability and understanding to solve the biomedical problems that have perplexed mankind for centuries.

HISTORICAL BACKGROUND

At the end of World-War-II, when the Manhattan Project ended, many physicists had become disillusioned about the role of physics after the aftermath of Hiroshima and Nagasaki. Some of them turned their attention towards biology and medicine. The discipline of biophysics was founded during this time. One of the earliest developments in biophysics was the discovery of the double helical structure of B-DNA by James Watson, Francis Crick and Maurice Wilkins, for which they were awarded the 'Nobel Prize for Physiology and Medicine'. Another important development was the development of the field of 'Structural Biology' when Max Perutz and John Kendrew reported the X-ray crystal structure of Apo-Myoglobin.

Nuclear-Magnetic Resonance (NMR) was discovered by two physicists, Felix Blöch and E. M. Purcell in 1946. It is based on the principle of the Nuclear Zeeman Effect. The methodology for Fourier-Transform NMR (FT-NMR) was developed by Richard Ernst, for which he received a Nobel Prize in 1991. The field of Structural NMR was later developed by Kurt Wütrich, for which he was given a Nobel Prize in 2001. The current size-limit for biological macro-molecules for structure determination is 20 kDa. Other important biophysical techniques used today for the analysis of bio-molecules are Circular Dichroism (CD) spectroscopy and Fourier-Transform Infra-Red (FTIR) spectroscopy. CD has been used to study cytosolic proteins, but problems with light-scattering limit its use for membrane-proteins. FTIR can provide information about the secondary structure-elements (% a-helical and % b-strand content) of membrane-proteins. When FTIR and NMR studies are applied to the area of Vaccine Development, they can be used to predict the regions of the vaccine (antigen-protein) that are involved in antigen-anti-body interactions. The application of biophysics in medical research has resulted in numerous discoveries. Among them is Computer-Assisted Tomography (CT). It was discovered independently by a British engineer, named Sir Godfrey Hounsfield (Hounsfield, 1980) and Alan Cormack. For their work, Hounsfield and Cormack were jointly awarded the Nobel Prize in 1979 (Bautz & Kalender, 2005). Another type of imaging, introduced in medicine by biophysicists, is Magnetic-Resonance Imaging (MRI). MRI is an application of NMR. It was jointly developed by Paul Lauterbur and Sir Peter Mansfield (Slavkovsky & Uhliar, 2004). It studies the signal from the water-molecule in different tissues and uses K-space formalism to create cross-sectional images of the human-body. It can be used to obtain information about almost any body-organ (such as the liver, pancreas, intestines, kidneys, adrenal glands, lungs, and heart), blood-vessels, the abdominal cavity, bones, and the spinal cord.

Another important development in the application of Biophysics in medical research was the introduction of Contrast Agents. These are substances that are used to make specific organs, blood-vessels or types of tissue (such as tumors) more visible during a CT scan or an MRI scan. The commonly used contrast agents are iodine, barium, gadolinium and thallium-based compounds. 101Thallium and 99mTc-based contrast-agents are used in SPECT imaging modality of Nuclear Medicine. 18F-deoxyglucose is used as a contrast agent in PET imaging.

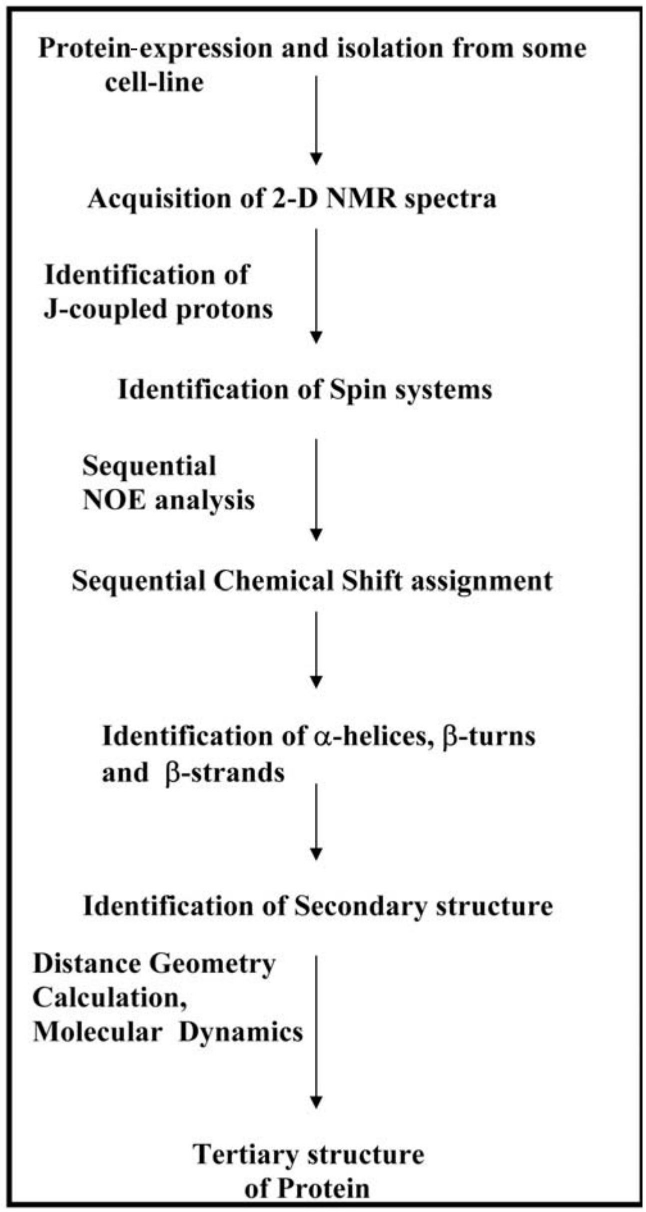

Figure - 1: Schematic Showing the Protocol Used for Protein-Structure Determination

APPLICATIONS OF BIOPHYSICS IN MEDICAL DIAGNOSIS AND RESEARCH

Nuclear Magnetic Resonance (NMR) Spectroscopy

Three dimensional protein-structures are useful for predicting structure-function relationships. They also have application in Proteomics. NMR is used to solve protein-structures by the use of experimental data, based on the Nuclear-Overhauser Effect (NOE), Distance-Geometry calculations and Molecular-Dynamics simulations. A typical protocol for protein-structure determination by NMR (Wütrich, 1986) is shown in the schematic of Figure-1. It consists of a series of NMR experiments on a protein-sample and subsequent data-analysis to determine the secondary and then tertiary structure of the protein. The determination of the high-resolution solution-structure of a protein, using nuclear-magnetic resonance (NMR) spectroscopy, requires that resonances observed in the NMR-spectra be assigned to individual nuclei of the protein (Leopold et al., 1994). Numerous methodologies exist for assigning the chemical shifts to individual 1H, using two-dimensional NMR techniques. These include the sequential assignment strategy and the main chain-directed strategy. These basic strategies have been extended to include newer 3-D homo-nuclear experiments and 2-D and 3-D hetero-nuclear methods. The increase in dimensionality due to the introduction of 3-D NMR has greatly increased the spectral resolution in comparison to 2-D NMR. It has solved the problem of resonance-overlap and has extended the range of molecules, amenable to structure-determination by high-resolution NMR-spectroscopy. It has thus, become possible to identify spin-systems by tracing cross-peak patterns in cross-sections, perpendicular to the three frequency-axes (Vuister et al., 1990). To solve the protein-structure, the 1H NMR-spectrum is first assigned using correlation and Nuclear-Overhauser Effect (NOE) experiments to demonstrate through-bond (scalar) and through-space connectivities, respectively. Since the NOE cross-peak intensity is proportional to r-6, it can provide distance information. However, multiple spin ("spin diffusion") effects have to be taken into account (Liu et al., 1995).

Fourier-Transform Infra-Red (FTIR) Spectroscopy

Fourier-Transform Infra-Red (FTIR) Spectroscopy studies molecular vibrations induced by infra-red light (Byler et al., 1986). This vibrational spectral method involves the use of much lower energies than absorbance-based spectroscopy. The most useful region of FTIR-spectrum is the so-called amide I band (1600-1700 cm^{-1}) which corresponds to carbonyl-stretching vibrations. The amide III band at 1200-1400 cm^{-1}, corresponding to NH vibrational modes, has also been used but it is not useful for quantitative measurements. The amide II band (1500-1600 cm^{-1}) corresponds to the NH stretching vibrations. It shifts down a 100 wave-numbers, when hydrogen is replaced by deuterium. There are a number of technical problems associated with the FTIR-spectra of proteins. However, modern FTIR instruments and software have overcome these to a large extent. A major problem is that liquid-water

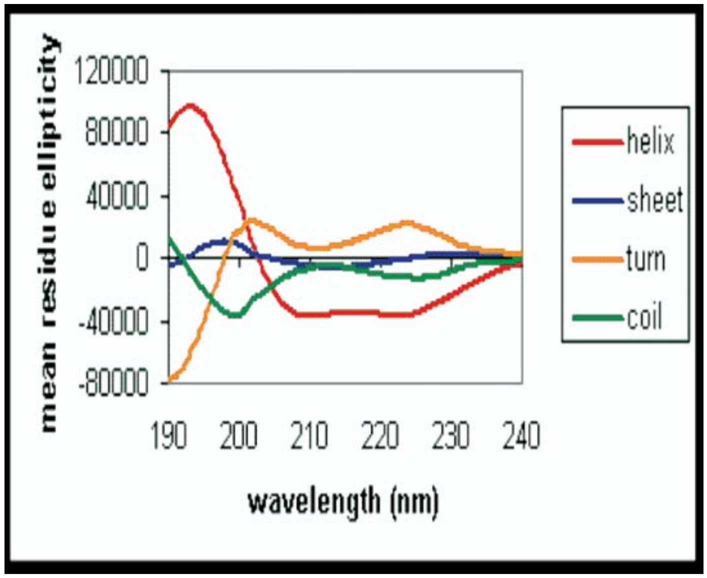

Figure-2: Far-UV CD-Spectrum Showing the Different Signals Produced By α-helix, -β-sheet, β-turn and Random Coil

has a major absorbance-band at 1640 cm^{-1}. Thus, one is actually dealing with a very weak signal from the protein on top of a major signal from the solvent. In D_2O, the band is slightly shifted in position leading, to a significant improvement of the signal-to-noise ratio.

Circular Dichroism (CD) Spectroscopy

The physical basis of circular dichroism is the differential absorbance of left and right circularly polarized light by the protein-sample. When circularly polarized light is passed through a chiral-sample, the emerging light is elliptically polarized. This is referred to as the ellipticity (θ). It is a measure of the chirality of the protein-sample. Far-UV CD is the most commonly used method, to determine the secondary structure of the protein (Choi et al., 2005). Near-UV CD is used to determine the tertiary-structure of the protein.

The circular-dichroism spectrum of proteins consists of two regions: the near-UV region (300-250 nm) and the far-UV (250-175 nm) region. The signal is usually much stronger in the far-UV region than in the near-UV region. An important consideration is the absorbance by the buffer and other components in the far-UV region (including oxygen at very low wavelengths). Usually one uses very short path-lengths such as 0.1 mm. The far-UV CD signal arises from the amide absorbance. Whereas, the near-UV CD signal arises from the aromatic side-chains. The far-UV signal contains relatively quantitative information about the secondary structure of the protein. The near-UV

CD signal contains information about the tertiary structure of the protein. Superimposed CD spectra of α-helix, β-sheet and "random coil" are shown in Figure- 2. They all show minima at 222 nm (θ222). This is a measure of the secondary structure of the protein. At this wavelength, the major contribution to the signal is from α-helix, although β-sheet also makes a significant contribution. Recently, many far-UV CD studies have also been reported that show significant contribution from the aromatic side-chains in the protein. In some cases, the positive contributions from the aromatic groups offset completely the negative ellipticity from the protein, so that only a very weak signal is obtained.

Magnetic-Resonance Imaging (MRI)

Magnetic-Resonance Imaging (MRI) is based on the principles of NMR. Both NMR and MRI rely on the fact that some atomic nuclei have a magnetic moment associated with them as they spin in an external magnetic field. MRI studies the signals of the water-molecules, as they diffuse through different tissues of the body, to obtain images of the inner parts of the body, without the use of an ionizing-radiation source, such as X-rays. Unlike conventional X-rays, MRI uses a combination of static and varying magnetic fields to produce images of the body. Tissue contrast is based on the chemical and physical state of the tissue, rather than the electron-density. An MRI exam lasts 30 to 60 minutes. No special preparations are required for the exam. However, metallic implants such as a pacemaker, surgical clips, joint or bone pins, metal plates, un-removed bullets, shrapnel, BB shots, cochlear implants, neuro-stimulators or permanent tattoos may interfere with the procedure.

Computed Tomography (CT)

Computed Tomography (CT) is also called Computerized-Axial Tomography (CAT). CT is another diagnostic procedure (Hsieh, 1996) like Magnetic-Resonance Imaging (MRI). It uses special X-ray equipment to obtain cross-sectional images of the body. The ionizing X-ray radiation is used to scan the body in a spiral manner. The acquired raw data, called a Sinogram, is used for image-reconstruction by the use of a mathematical technique, called ‘Radon Transform’.

CONCLUSIONS

At the end of the Human-Genome Project, about 35,000 human-genes have been sequenced. However, the “one-gene one-protein” hypothesis that was originally proposed in the beginning of this project, has not turned out to be true. As a result, the role played by biophysical methods in biomedical research, has become more important than ever before. The Nobel Prize committee also seems to agree with this verdict. For the last two consecutive years: 2001 and 2002, it has honored scientists who have made contributions in the field of Biophysics. As a result, the role played by biophysics will continue to remain important. It will be applied in areas such as, Proteomics and Vaccine-Development, to name just a few. Another important application of biophysics will be in medical diagnosis, where the use of Contrast Agents has improved the quality of imaging and can lead to the early diagnosis and treatment of disease.

REFERENCES

- Bautz, W. & Kalender, W. (2005) Radiologe 45(4):350-5.
- Boelens, R., Padilla, A., Kleywegt, G. J. & Kaptein, R. (1990) Biochemistry 29(7): 1829-1839 Wüthrich, K. (1986) NMR of Proteins and Nucleic Acids, Wiley, New York.
- Byler, D.M. & Susi, H. (1986) Biopolymers 25: 469-487.
- Choi, J.H., Kim, J.S. & Cho, M. (2005) Journal of Chemical Physics 122(17):174903.
- Hounsfield GN. Medical Physics (1980) 7:283-290.
- Hsieh J. Medical Physics (1996) 23:221-229.
- Leopold, M. F., Urbauer, J. L. & Wand, A. J. (1994) Molecular Biotechnology 2(1): 61- Liu, H., Spielmann, H. P., Ulyanov, N. B., Wemmer, D. E. & James, T. L. (1995) Journal of Biomolecular NMR 6(4): 390-402.
- Slavkovsky, P. & Uhliar, R. (2004) Bratisl. Lek. Listy 105(7-8):245-9. Vuister, G. W.,

ATOMIC ABSORPTION SPECTROMETRY IN OUR LIVES

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ABSTRACT

This article is concerned with Atomic Absorption Spectrometry (AAS), the most widely used atomic spectrometric technique and its applications related to various fields. The different modes of operation of AAS are included in the paper, with the basic advantages and drawbacks of each. The recent developments of AAS techniques that may lead to future improvements are also mentioned.

1 INTRODUCTION

The science of atomic spectroscopy has yielded three main techniques having analytical applications, namely: atomic absorption, atomic emission and atomic fluorescence techniques. Most of the atomic spectrometric techniques commercially available are atomic absorption or emission techniques [1].

If enough energy is absorbed by a ground-state atom, an outer electron will be promoted to a less stable configuration called excited state. As this state is unstable, the atom will immediately and spontaneously return to its ground-state energy-configuration. The electron will return to its initial, stable orbital position and radiant energy equivalent to the amount of energy initially absorbed in the excitation process will be emitted. The wavelength of the emitted radiant energy is directly related to the electronic transition which has occurred. Since every element has a unique electronic structure, the wavelength of the light emitted is a unique property of each individual element.

The process of excitation and de-excitation (decay to the ground state) is involved in all three-atomic absorption, atomic emission and atomic fluorescence-techniques. Either the energy absorbed in excitation process or the energy emitted in the decay process is measured and used for analytical proposes.

In atomic emission, excited-state atoms capable of emitting light of the analyte element are produced by subjecting the sample to high-energy, thermal environment. This high-energy source can be an electric arc (AC or DC arcs), a flame or more recently a plasma. The emission spectrum of an element consists of a collection of the allowable emission-lines because of the discreet nature of the emitted wavelengths. The emission-spectrum can be used as a unique characteristic for qualitative identification of the element, as well as the quantitative determination of the element. For quantitative analysis, the intensity of light emitted at the wavelength of the element to be determined is found to be proportional to the number of analyte element atoms.

If light of just the right wavelength impinges on a free, ground-state atom, the atom may, absorb the light as it enters an exiting state in a process known as atomic absorption. The capability of an atom to absorb specific wavelength of light is utilized in atomic absorption spectrometry [1-2].

In this paper, atomic absorption spectrometry (AAS), as an example of atomic spectrometric techniques, is reviewed with some of its recent applications. The most popular and commercially widely used AAS techniques are reviewed. The recent trends and future aspects of AAS techniques will also be focused on.

2 ATOMIC ABSORPTION SPECTROMETRY (AAS)

The flame (F), graphite furnace (GF), hydride generation (HG) and cold vapor (CV) techniques of AAS are the most popular techniques for trace-element determination. Thousands of research papers are annually published applying these AAS techniques. In all AAS techniques, the linear range, which is the concentration-range giving linear relationship with absorbance, is limited to more or less 100 times of the minimum measurable concentration for the technique. However, out of the AAS techniques, the flame AAS is the most applied technique in routine analysis. This might be attributed to its simplicity and applicability in different fields and types of samples. The main drawback of flame AAS is related to the relatively high-detection limits (in the range of μg/mL) for many elements. Some trace elements, such as *As*, *Te* and *Se*, have poor detection-limits in flame mode when conventional *nebulization* is applied. Fortunately, this group of elements can produce volatile hydrides of the element. The introduction of these volatile hydrides into the absorption volume, as gases instead of liquid-aerosols, helps in its separation from its matrix, as well as, produces low (good) detection limits. This technique is called 'hydride-generation AAS'. The cold vapor-generation technique is based on the fact that Hg can be easily reduced to its metallic form and a marked vapor-pressure can be exhibited at room temperature. This vapor is in the atomic form and can be directly introduced into the absorption-volume, to absorb its specific light beam at room temperature [1, 2].

When the investigated element-concentration is less than the detection-limit of the flame AAS technique, the graphite-furnace AAS can perform the analytical task. This is true since the latter technique has detection-limits lower 100 to 1000 times than that of the flame one. It also could use micro-liter volumes of the sample to perform the trace analysis [2].

2.1 Flame AAS (F-AAS)

The Flame-AAS technique is the oldest of the different AAS techniques. Nowadays, it is difficult to imagine a routine analytical laboratory without F-AAS. In F-AAS, the solution samples are nebulized and only the fine droplets of the spray are introduced into the flame. The task of the flame is to vaporize and convert the entire sample as far as possible, into gaseous atoms. At the same time it serves as the absorption-volume. The air/acetylene flame offers an environment and temperature suitable for atomization for many elements. This flame is completely transparent over a wide spectral range, to absorb radiation below 230 nm. The nitrous-oxide flame is operated with a slight excess of fuel gas. Many research works had been carried out to develop the flame atomization system, including the design of burner head and its safe operation [3] and the nebulization systems including spray-chamber designs [4].

Flame-AAS is a rapid and precise technique. It permits the determination of more than 40 elements in the mg/L concentration range. However, the need for trace metal analysis at μg/L, and even lower, calls for a more sensitive method. The main weakness of F-AAS may be the nebulization-system, in which 90-95% of the nebulized solution is sorted out and only 5-10% nebulization-efficiency can be achieved. In some cases, such as biological fluids, this sample volume is not available [2].

During the last three decades, many attempts have been made to eliminate problems related to pneumatic nebulization in F-AAS. Manual micro-injection techniques [5-8] have been connected to the nebulization-system of the F-AAS to produce transient-absorption signals. The main advantage of this manual injection is concerned with the lower limits for the volume of the measurement solution (down to 50 μL), at which relatively good sensitivity and signal-to-noise ratios were attained. This is a good improvement since conventional continuous nebulization of samples require about 1-5 mL to perform 3-5 replicates. In some cases, this is also accompanied with improved absolute-sensitivities and limits of detection [9]. It has also been reported that this micro-sampling technique produces long-term stability for the measured signals [8].

Flow injection (FI)-F-AAS has also been extensively applied to perform transient-signals in automated and semi-automated procedures [2, 7]. In FI, the injected aliquot of the sample forms a zone sandwiched between two segments of a suitable liquid, which is then transported towards the flame of AAS. Also, micro-liter volumes down to 65 μL could produce similar sensitivity to that of the continuous conventional aspiration [10].

Although the technique of AAS is concerned with the determination of trace-elements in the sample, regardless of their oxidation-state, several trials had been carried out to apply AAS to get more information about the investigated elements. Bermejo-Barrera et al. [11] investigated the possibility of determining total and labile Cu and Fe in river-surface water by F-AAS after batch pre-concentration. They applied a separation-technique based on solvent-extraction for the separation of Cu (II) and Fe (III) from samples into isobutyl-methyl ketone (IBMK), prior to their determination by F-AAS. The extraction procedure included a ten times pre-concentration step. They optimized the best compromised conditions for the simultaneous solvent-extraction, including sample pH, solvent-volume and extraction time. Normal aqueous standard solutions were subjected to the optimized solvent-extraction procedure, then used as calibration standards. In order to assess the total Cu and Fe contents, a microwave-assisted oxidation step was applied to break down the metal-organic matter complexes in samples. The preoxydisulfate weight used for sample-digestion, microwave power and its irradiation-times were investigated. They concluded that the solvent extraction and microwave-assisted oxidation procedures showed adequate capability to study the total Cu and Fe levels, as well as the labile Cu (II) and Fe (III) concentrations in real river surface-water. The authors stated that this procedure can be easily subjected to automation.

Cadmium, as well as some other ultra-trace elements, could not be directly measured in biological tissues using conventional F-AAS, since the minimum measurable concentration of the technique is higher than that of the sample. In order to overcome this difficulty, a direct solid-sampling F-AAS procedure for trace-determination of Cd in biological samples has been developed [12]. In this technique, a small portion of the tissue-sample (0.052.00 mg) was ground and weighed into a small polyethylene vial, which was connected to the device for solid sample introduction into the conventional air/acetylene flame. This system includes a flow-meter to control air flow into two valves towards a glass chamber. The sampling system ends at quartz-cell positioned 48 mm above the burner-head of the air-acetylene flame. When air flows through the sampling chamber, the test sample is blown out to the quartz-cell and burnt in the flame. The optical beam of Cd lamp passes about 10 mm above the quartz-cell. The atomic vapor generated in the flame produces a transient-signal. The produced transient-signals were completely recorded within one second. The effect of flame-composition on the observed signal was investigated and presented in histograms, as affecting the characteristic mass. The distance between the quartz-cell and the optical path was also optimized. The influence of particle-size on the transient observed signal has also been investigated.

The obtained results [12] revealed that the absorption-signal is apparently non-dependent on the particle-size from 30 to 80 μm. The integrated absorption-signal shape was found to be sharp, while the background signal was low. The calibration curve was obtained using different masses of solid-certified reference material. Results obtained for certified and in-house reference materials were typically within 95 % confidence-interval at the certified and / or reference value. The precision was between 3.8 and 6.7 %. The characteristic mass measured for the investigated technique was 0.29 ng Cd. Sample-measurement frequency was found to be 80 tests per hour. The authors stated that the proposed system is simple and requires adaptation to conventional F-AAS [12].

2.2 Hydride-Generation AAS:

In HG-AAS, samples are reacted in an external system with a reducing agent (typically sodium borohydride). Gaseous reaction-products are then carried to a sampling cell (normally connected to the flame) in the light-path of the AAS system. These gases (hydrides of the elements) are molecules to be atomized with the heat-energy of the flame. This trend is not valid for many elements. The elements that readily produce volatile hydride-compounds are Sb, As, Bi, Ge, Pb, Se, Te and Sn. Generation of volatile hydrides can be performed either in batch or in flow (continuous and flow injection) systems. Batch procedures consist of normal laboratory apparatus, such as flasks, and dropping funnels connected with glass or inert polymers. Reagents, such as $NaBH_4$ are used to produce the element-hydrides and the gaseous analyte-species is transferred in an inert-gas stream to the absorption-cell [2]. A common feature of flow-systems used to produce gaseous hydrides is that the reaction takes place within tubes and, thus, a separator is required to separate the gaseous analyte from the aqueous phase. Another common feature of flow-systems is that both continuous and flow-injection systems can be easily automated. A major advantage of flow-injection systems used in HG-AAS is that they can easily be use as continuous-flow systems, if this technique is performed for a practical technique [1, 2, 13].

The achievable detection-limits of the HG-AAS technique are well below the μg/L range. This excellent detection-limit results from a much higher sampling-efficiency compared with pneumatic nebulization. In addition, separation of the analyte-element from the sample matrix by HG-AAS is commonly used to eliminate matrix-related interferences [1]. The major limitation of HG-AAS is that it is restricted primarily to some elements. Also, the results depend heavily on some practical parameters, including valence-state of the analyte element, reaction time with reagents, carrier gas pressure, reagent concentrations and absorption-cell temperature. The formation of the analyte hydride is also suppressed by a number of common matrix components, leaving the HG-AAS technique subject to chemical interference.

D'Ulivo et al [14] investigated several masking agents to be used in the determination of As by HG-AAS. They introduced the samples into a miniatureargon-hydrogen diffusion-flame as an atomizer, applying continuous hydride-generation procedure. The effect of KI, NaSCN, Thiourea, L-cyteine, 1,1,3,3, tetramethyl-2-thiourea as masking agents were investigated, both in the absence and presence of selected interfering species (Cu, Ag, Au, Ni, Co, Pb, Pt and Fe). This study was performed using real samples or $NaBH_4$ reducing solutions, in online mode, to the sample either before or after the HG-step. The combined effect of some masking agents was also investigated. It was found that the addition-mode of the masking agent to the reaction-system could play a decisive role in the control of interfering process, both in absence and presence of concomitants. Also the addition of NaSCN to the reducing solution of $NaBH_4$ produced a moderate catalytic effect similar to that obtained in the presence of KI and improved the tolerance-limits for Cu, NI, Co and Pd. Linearity of the calibration-graphs was unaffected by the on-line addition of 1,1,3,3 tetramethyl-2-thioria to sample solution. On the other hand, the addition of thiourea produced dramatic curvature in the calibration graphs. The addition of KI to reducing solution and 1,1,3,3, tetramethyl-2-thioria (on-line to the sample) exhibited masking properties comparable to those of thiourea, except for Pt and Pd, for which good tolerance-limits were achieved. In the absence of KI in the reduction-solution, the masking efficiency of 1,1,3,3, tetramethyl-2-thiourea was considerably lowered. The addition of some masking agents such as thiourea, L-cyteine and 1,1,3,3, tetramethyl-2-thiourea on-line to reaction-solution after the $NaBH_4$ + KI reduction step, could be highly effective in the control of Cu and Ag interferences. The method had been successfully applied to determine traces of selenium (˜ 18 and 100 μg/g) [14].

2.3 Cold-Vapor AAS:

Mercury determination in the cold gaseous state can be carried out, using a procedure similar to that used in HG-AAS. The formation of hydrides is not required in this case. Mercury is chemically reduced to the free atomic state by reacting the sample with a strong reducing agent, like stannous chloride or sodium borohydride in a closed reaction-system. The volatile free mercury is then driven from the reaction-flask by bubbling air or argon, through the solution. Mercury atoms are carried in the gas-stream towards the absorption-volume, which is placed on the light-path of the AAS system. In most cases, there is no need to heat the absorption cell (volume), since mercury atoms are free. In isolated cases, the absorption-cell is slightly heated to avoid water condensation [2].

The sensitivity of the cold-vapor technique is far greater than what can be achieved by F-AAS. This improved sensitivity is achieved through 100% sampling-efficiency. The sensitivity can be further improved by using very large sample volumes. The detection-limit for mercury by CV-AAS is approximately 0.02μg/L. The only stated limitation is that the CV-AAS system is limited for mercury only, since no other elements offer the possibility of chemical reduction to a volatile free atomic state at room temperature [2, 15].

Rio-Sigade and Tyson [16] described a fast, simple, precise and accurate method to determined mercury in biological and environmental samples. This method is based on an optimized flow-injection mercury system that permits the separate determination of inorganic and total mercury, using sodium boro-hydride as reducing agent. Inorganic mercury was selectively determined after reaction with 10^{-4} % W/V sodium boro-hydride, while total mercury was determined after reduction with 0.75 % W/V sodium boro-hydride. The calibration-graphs were linear up to 30 ng/mL. The detection-limits of the method, based on three times the standard deviation of the blank, were 24 and 39 ng/ml for total mercury and inorganic mercury determination, respectively. The relative standard-deviation was less than 1.5 % for a 10 ng/ml mercury-standard. In order to check performance of the proposed method deionized water and pond-water samples were spiked with methyl and inorganic mercury, and quantitative recovery for the two spikes were obtained. The accuracy of the method was verified by analyzing alkaline and acidic extracts of five biological and sediment reference materials.

2.4 Graphite-Furnace AAS:

The GF-atomizer's function is to generate a population of free atoms, so that atomic absorption can be measured. This process is performed in three main steps, namely: drying, ashing and atomization. In the drying stage, solvent is removed from the sample, while in the ashing stage organic molecules or other inorganic materials are removed from the sample. In the atomization stage, free analyte-atoms are generated within a confined zone coincident with the optical path of the spectrometer. The absorption signal produced in the atomization-stage is a well defined peak. The height and area of this peak are related to the amount of the analyte present in the sample [1, 15].

Although Welz and Sperling [2] stated that the potential of FI has not been fully exploited for its applications in AAS, the use of FI on-line pre-concentration and separation procedure is frequently needed to solve real analytical problems [17, 18]. This procedure relies on sorbent-extraction in packed micro-columns and /or precipitation and collection on knotted reactors. The combination between FI and GF-AAS offers ideal conditions for fully automated ultra-trace determination at low ng/l range in complex matrices under normal routine laboratory conditions. This approach produces detection-limits lower, 2-3 orders of magnitude in difficult samples, such as sea water [19, 20] and high-purity reagents [21], with relatively minor instrumental requirements. This permits one to avoid the necessity to clean-room facilities. These detection-limits are close to those normally encountered using the relatively expensive and complicated technique of inductively coupled plasma mass-spectrometry, with one order of magnitude lower in cost.

Wizemann and Haas [22] discussed the applicability of isotope selective Doppler-limited (DL)-GF-AAS to the rare earth elements (REEs). They presented a schematic experimental set up for Doppler-free saturation spectrometry. The same set up could easily be changed to Doppler-limited applications by blocking the probe-beam and positioning the band-pass filter and the photodiode behind the low-pressure GF. The criteria for the selection of the transitions suitable for isotope selective GF-AAS with diode-laser were the magnitude of the isotope shift, the hyperfine splitting, the line-strength, energetically poor lower-level and, specially also, the feasibility of matching the transition-wavelength, either with the fundamental or frequency-doubled radiation of single-mode diode laser or with commercial external cavity diode-laser systems. The line-strength data were taken from NIST atomic spectra database [23]. For all transitions suitable to isotope selective GF-AAS, a spectrum was calculated by adding the Voigt, profiles [24] of all contributing isotope and hyperfine structure components. The width of a Voigt-profile is determined by a temperature and frequency-dependent inhomogeneous (Doppler) broadened Gaussian line-width $_G$ as well by a homogeneous broadened Lorentzian line width $_L$. The spectra of most of the transitions which were viewed as suitable for isotope selective GF-AAS were subsequently verified by measurements. Finally Wizemman and Haas [22] stated that the isotope shift and hyperfine-structure data available in the literature were inspected for nine REEs, in order to expand the list of elements acceptable for isotope-selective investigations in low-pressure DL-GF-AAS at a few kPa. It has been found that the isotope-dilution method for calibration can be applied for the five lanthanides Sm, Eu, Gd, Er and Lu, where appropriate transitions are currently matchable with single-mode diode-lasers. Doppler-limited absorption spectroscopy is appropriate for Eu and Lu, whereas for Sm, Gd and Er Doppler-free saturation spectroscopy must be performed. Eu and Lu are also accessible to isotope-ratio measurements and join the elements Li, Rb and Pb [22].

Characteristic mass and limit of detection were determined for the isotopes ^{154}Sm, ^{151,153}Eu and ^{170}Er. The values were about three orders of magnitude beyond the ones obtained for the elements at atmospheric pressure with conventional GF-AAS. The difference is attributed to the much weaker transitions in the isotope-selective measurements, the relative abundance of the isotopes, the faster analyte-diffusion and also to the linear polarization of the exciting laser-light. There is also a hope for improved detection-sensitivity for Er and Eu. With the availability of powerful blue laser-diodes for isotope-shift and hyperfine-structure measurements, the currently missed data for the strong Er transitions should be obtained in the near future. Furthermore, if laser-diodes with wavelength of approximately 460 nm will be available, the strong Eu transition at 466 nm should be usable for isotope-selective applications and, probably also for Nd with the two lines at approximately 465 nm. However, for the latter there is still a lack of some isotope-shift and hyperfine-structure data [22].

2.5 Other Developments and Recent Approaches in AAS

Because AAS seems to be such a simple technique at the first glance, its forthcoming end and replacement by more exciting techniques has been forecast, more than once, over the last five decades. However, AAS has received strong inputs again and again, e.g., by the introduction of GFAAS as a routine spectro-chemical technique. Another positive push came from the flow-injection technique, a technique the output of which can be considered revolutionary in almost all aspects of AAS analysis [25]. Flow-injection permits the automation of the AAS technique, either for new instruments by the use of auto-samplers or the coupling of a suitable flow-injection procedure to the already working instruments. Also Welz [26] believed that AAS is about to give birth to new offspring, in the near future, similar to what was done in the seventies of the last century by L'Vov [27] who suggested GFAAS to work as an absolute measurement-technique.

They hoped that bright future of AAS might be referred to the expected improvements in both the instrumental side and the application one. The introduction of solid samples into the absorption-volume, without the need to convert it into a liquid form ,is an example related to AAS promising applications. Despite the fact that the technique of AAS itself can not distinguish between the different oxidation states of the element, it is possible to be coupled with a speciation-procedure, either on-line or off-line. This trend could present very useful information about the investigated element, as well as its chemical composition and toxicity. The introduction of continuous-sources AAS and the use of diode-lasers as radiation-sources are promising instrumental approaches [26].

In the following sections, the most important recent approaches and developments in the technique of AAS are presented. Future trends in the AAS technique can be expected.

2.5.1 Simultaneous-Determination

Chiu et al [28] developed a simple GF-AAS method for the simultaneous determination of trace-concentrations of Mn, Fe, and Co in copper-chip reference material, with added impurity solutions. They used a multi-element GF-AAS spectrometer equipped with transversely headed graphite atomizer. A microwave digestion-system has been used for sample digestion in nitric acid. A solution of Pd $(NO_3)_2$ was prepared, to be used as a chemical modifier, as well as a mixture of gases (5 % H_2 and Ar). The authors investigated the effect of pyrolysis-temperature and the atomization-temperature on the absorption-signal of the investigated elements, as well as the background signals, both in presence and absence of matrix chemical modifier. At the optimum temperature program, the effects of masses of Pd as the chemical modifier on the absorption-signals were studied and it was found that 10 μg of Pd is optimum for multi-element analysis. The accuracy of the method was confirmed by the analysis of certified material (CRM # 075). The interferences were removed effectively, so that a calibration-curve method based on simple aqueous standard could be used. The measured values of the three investigated elements were better than 95 % of the certified values. The relative standard-deviation for the simultaneous determination of Mn (6.5 μg/L), Fe (18 μg/L) and Co (5 μg/L) in Cu solution are 2.4 to 3.5 % and the detection-limits were 0.17, 0.50 and 0.30 μg/g for the investigated elements, respectively.

2.5.2 Solid Sampling GF-AAS

The direct analysis of solid samples, using all kinds of furnaces and devices for sample-introduction had been continued throughout the past three decades, as reviewed in a recent book [29]. In fact, the direct solid-analysis was typically supported by isolated researcher-groups only. This is surprising because GF-AAS is an ideal technique for direct solid-sample analysis and solid-sampling for GF-AAS. It is a very flexible technique, with respect to the form in which the sample is presented and also with respect to the sample size, which can range from approximately 0.01 mg up to almost 100 mg. This is, among other things, due to the way the sample is introduced, e.g. on a platform, the thermal pretreatment in the graphite furnace, and the long residence-time of the atoms in the atomizer. The introduction of the commercial system for automatic slurry-sampling [30] could have been the turning point, but the acceptance was not as expected.

More recently, however, there appears to be an increasing market for solid-sample analysis, coming predominantly from the producers of modern high-tech materials, such as hard materials, super-alloys and ceramic super-conductors, etc. All these materials have two things in common; their quality depends extremely on their purity with respect to a number of critical trace-elements, and they are very difficult to bring into solution. Friese and Krivan [31] did excellent pioneering work in that field, demonstrating that detection-limits of solid-sampling GF-AAS are superior to all other techniques available for this kind of analysis, including ICP-MS. This is simply because the risk of contamination associated with any acid digestion technique, is avoided [31]. It has been shown that modern furnace-technology, using platform atomization in a transversely headed graphite-tube, and integrated absorbance for signal evaluation, has increased the accuracy dramatically, making solid-sample analysis possible with calibration against simple aqueous standards [31].

Sokolnikova et al [32] compared solid sampling GF-AAS with flame atomic-emission spectrometry in the determination of trace-alkaline metals in quartz-samples. Levels less than 10 μg/g of K and Na were determined using the two spectroscopic techniques. In the GF-AAS technique, the graphite tube atomizer must be burnt at 1900 K^o then the determination of the K or Na in quartz was performed for sample-weight of 20 to 100 mg. Quartz samples were placed as a thin layer in the center of the graphite furnace-tube groove. Absorption-area signals were recorded and used to construct the calibration graphs for Na and K. The solid-sampling GF-AAS procedure is less time-consuming and avoids the extensive sample-preparation. Detection-limits are equal to 1 μg/g for both K and Na in quartz using GF-AAS. The use of flame-atomic emission spectrometry to determine Na and K required a tedious digestion procedure, which allowed one order of magnitude improvement in the detection-limit. Comparison of the data obtained for K and Na determination, using solid-sampling GF-AAS and flame atomic-emission spectrometry, showed good agreement [32].

2.5.3 Speciation Analysis

It is well established that the total content of an element does not give sufficient needed information, as several elements may be essential for humans or animals, and may be toxic at the same time, depending not only on their concentration, but even more importantly on their oxidation-state or the chemical form in which they are present. A typical example is Cr, which is essential in its trivalent form, but carcinogenic in its hexavalent compounds. Another example is arsenic, the inorganic forms of which are well known to be highly toxic, whereas organic compounds, such as arsenobetain, which are found in high concentration in some seafood, are non-toxic, and may even be essential.

A simple method had been proposed to distinguish between 'toxic', i.e. inorganic mono- and di-methylated arsenic, and non-toxic arsenobetaine using HG-AAS [33]. Flow-injection on-line column concentration and separation is typically selective for one oxidation-state of an element only, and may hence be used for the separation of redox species, as was demonstrated for the differential determination of Cr (VI) and total chromium in water [34]. Another example of speciation-analysis by on-line separation and pre-concentration for an activated alumina micro-column, which at pH 2 selectively pre-concentrates Cr(VI), whereas Cr(VI) is retained selectively at pH 7 [35]. There is no question that this field of routine speciation-analysis is far from being completely explored.

In another recent investigation [36], a technique was developed that showed the presence of trace amounts of hexavalent Cr in certain steps of the tanning process in leather industry and, consequently, in the drainage-water of some tanneries in Cairo. Regarding the high toxicity of hexavalent Cr, it was recommended that the waste water of the re-tanning step should be collected separately and treated before flowing to the main drain.

2.5.4 Flow-Injection Gradient Ratio Calibration

It has been demonstrated that the repeatability of all events over time can be used successfully to correct a number of limitations of conventional AAS, including the limited linear working range, and the influence of concomitants on the analyte-signal in F-AAS [37]. With this gradient 'ratio calibration' the entire transient signal produced by the sample bolus is stored in a computer and used for calibration. The ratio of the absorbance of the calibration-solution and the test sample-solution is formed at the reading frequency of the spectrometer. If no interference is present, and the measurement solutions are all in the linear range, the ratio will not change during the entire measurement. If the maximum absorbance of a test sample solution is outside the linear range, however, the absorbance ratio changes as soon as the linear range is exceeded. This is recognized and corrected by the computer. The same situation occurs if an interference is present that decreases with increasing dilution (dispersion). If the computer program is used to extrapolate the signal-ratio over the entire absorbance-profile against absorbance $A = 0$, the interference can be eliminated by calculation.

2.5.5 Developments in Line Sources

The most commonly used light-sources in AAS are hollow-cathode lamps (HCLs). They are excellent stable light-sources for most elements. However, for some elements, HCLs have problems, such as short operational life. For some other elements they are not available at all, due to technological problems, which means that there is still a need in AAS for other light-sources with high-intensity, stability and long-operating life for a range of elements [2, 38].

High-frequency electrodeless discharge-lamps (HFEDLs) are widely used as high-intensity source from the vacuum ultraviolet to the infrared [39]. Early work showed that intensities of HFEDLs emission lines are higher than those from other sources, such as HCLs [40]._However, the use of HFEDLs in AAS devices has been limited mainly because of the large size and weight of high-frequency (HF) generator. For example, some early commercial AAS devices used a small-induction coil assembly with the lamp inside, connected with the generator by means of a few meters long cable [41, 42]. The use of electrodeless discharge lamps in AAS has been discussed [43, 44].

Ganeev et al [38] described a design of HFEDLs for AAS. It consists of a glass or quartz vessel filled with a filler gas (a noble gas) and having a short side-arm containing the working elements. The lamp-bulb is located in a HF generator-coil to induce an inductively coupled electrodeless discharge. The side-arm can be thermostatted to control the pressure of the metal vapor in the lamp. The lamp is thermally insulated with glass or ceramic, to maintain a higher temperature around the lamp vessel.

It had been stated that both the spectral line-width and the spectral line-profile depend strongly on isotopic composition of the element. The use of one isotope provides better sensitivity in AAS [45]. Most elements consist of more than one isotope. For example, Hg has seven isotopes. For this reason Ganeev et al [38] investigated the spectral line-shapes for isotope and natural abundance HFEDLs, and estimated the full width at half- maximum for main analytical lines of different filler elements. They confirmed that single (main) isotope HFEDLs provides sharper lines, compared with natural abundance element. An increase in AAS sensitivity by factors between 1.5 and 3.2 is also found with the use of HFEDLs with enriched isotopes. This enabled them to assess the best lamp-working mode, in respect to the line-width and to self-absorption. The theoretical descriptions of the main physical processes in HFEDLs were also discussed. The essential characteristics of the lamps designed for AAS, such as intensity, stability and operating-life, are also considered. They found that the intensities and detection-limits are comparable with the corresponding characteristics of HCLs. The temporal behavior of an As HFEDL is compared with that of a commercially available electrodeless discharge-lamp. Detection limits in graphite- furnace AAS with HFEDLs were better by a factor of 1.5 to 8 times, depending on the elements.

This technology allowed the production of HFEDLs for single elements of Sn, Cd, Zn, Pb, As, Sb, Bi, Tl, Rb, and Cs. Multi-element lamps for Hg-Cd, Hg-Zn, Hg-Cd-Zn and Se-Te were also prepared in a similar way. The design of the HFEDLs optimized for AAS, includes an integral compact HF generator (100 MHz) and a simple external power supply (32 V, 1A). The HFEDL set-up has the same dimensions as a normal HCL. These lamps were installed in a commercial-type Zeeman background-correction AAS.

2.5.6 Continuum Source AAS

The fact that the use of line sources (LSs), in essence, makes AAS a one-element-at-a-time technique has stimulated researchers again and again to investigate the feasibility of continuum source (CS) AAS [46]. Recently, with the availability of high-resolution echelle-spectrometers [47] solid-state array detectors [48, 49], we have continuum sources that have sufficiently high emission-intensity within the small spectral interval under consideration, over the entire wavelength-range of AAS. Heitmann et al [50] depicts such a system with a Xenon short-arc lamp, a douple-echelle monochromator and a CCD detector, providing a spectral resolution of approximately 2 pm/pixel. The resolving power of this setup shows the integrated absorbance-spectrum around the cadmium resonance line at 228.802 nm.

Obviously, instruments for CS-AAS can be designed in several different ways, and their features depend on their particular design. This setup is still of the monochromator type, i.e. designed for the determination of one element at a time. However, it provides a variety of advantages over conventional LS-AAS.

Firstly, the atomic absorption can not only be measured at the center of the absorption line (with maximum sensitivity), but also at its wings (with reduced sensitivity), thus greatly increasing the dynamic range to approximately 5-6 orders of magnitude in concentration or mass. This, together with detection limits that, according to recent reports [46], tend to be even better than those obtained with LS-AAS, and with the expectation of further improvement, eliminates one of the classical disadvantages of AAS- its limited dynamic range.

Secondly, the setup equipped with a CCD detector provides a lot of information about the spectral neighborhood around the analytical line, which eventually results in a much more reliable and accurate background-correction, as essentially any pixel or set of pixels may be used for that purpose, depending on the nature of the background. In addition, as this wavelength-resolved absorbance is measured over time with each pixel, a three-dimensional absorbance pattern is obtained eventually. The structured background makes a correction with a deuterium lamp impossible, and presents a problem even for Zeeman-effect background correction [51]. In the case of the CS-AAS, however, it was possible to eliminate the background almost completely by a least-squares background correction with the normalized spectra of PO and Na [51]. To extend the capabilities of CS-AAS to its full capability, that is simultaneous multi-element AAS, requires the replacement of the one-dimensional array detector by a two-dimensional multi-array detector. This would obviously have a significant impact on the cost and the complexity of the whole instrument, if all the above described features are to be retained. A sacrifice in information obtained by significantly reducing the number of pixels per array could be a compromise which, however, has yet to be investigated. However, as also pointed out by Harnly [46], the advantages of CS-AAS over LS-AAS, even for the determination of one element at a time, with respect to detection-limit, dynamic range, spectral information, and background-correction capabilities, are so convenient that it is about time for CS-AAS to replace conventional LS-AAS, step by step. The simultaneous multi-element version will then follow, with the increasing acceptance of CS-AAS, as prices for two-dimensional array detectors drop.

2.5.6 Diode Laser AAS

Tunable dye-lasers have been proposed as radiation-sources for AAS already more than 20 years ago. They have not found their way into common use with AAS, because of a number of particle and economic reasons: these laser-systems are expensive, frequently unreliable and difficult to operate. In contrast to dye lasers, diode lasers (DL) appear to be more likely, one day, to replace hollow-cathode lamps (HCL) and electrodeless discharge lamps (EDL). Semiconductor laser diodes are nowadays mass- produced for compact-disc players, laser printers, optical data-storage systems, and telecommunication equipment, and hence they are cheap, reliable, easy to operate and they have long lifetimes. A number of these diodes have excellent spectroscopic properties, which make them attractive sources for spectrochemical analysis [52]. This can be referred to different parameters. Firstly, the power of presently available commercial DLs is between one and several orders of magnitude higher than what is provided by the best HCLs. In addition, DLs show exceptional stability, both in terms of wavelength and intensity. These two factors together make it possible to measure extremely low absorbance, if optimal experimental conditions are realized and the fundamental shot-noise limit is achieved. But even in conventional 'routine' atomizers, such as flames and furnaces, detection limits were achieved that were 1-2 orders of magnitude lower than those obtained with HCLs [52, 53].

Secondly, the typical line-width of a commercial DL is approximately two orders of magnitude less than the width of absorption-lines in flames and furnaces. This makes possible the expansion of the dynamic range of calibration to high analyte concentrations by measuring the absorption on the wings of the absorption line, where optically thin conditions prevail [53]. In addition, a DL, under normal operating conditions, emits one single narrow line, which dramatically simplifies the spectral isolation of the absorption signal. One does not need the monochromator, which is necessary with HCLs for the isolation of analytical line from the other spectral lines emitted by the HCL, and the photomultiplier could be replaced by a simple semiconductor photodiode [52, 53].

Thirdly, the wavelength of DLs can be easily modulated at frequencies up to GHz by modulation of the diode current. Wavelength modulation of the DL with detection of the absorption at the second harmonic of the modulation frequency, 2f, greatly reduces low-frequency (flicker) noise in the baseline, providing improved detection-limits [52, 53]. In addition, wavelength-modulation of the radiation-source provides an ideal correction of non-specific absorption and significantly improves the selectivity of the AAS technique.

The major limitation of DL AAS at this point in time is that, although a commercial blue laser diode was introduced, the lower wavelength-limit for mass-produced DLs is approximately 630 nm, which means that even with frequency-doubling in non-linear crystals, the important wavelength range for AAS of 190-315 nm can not be attained yet with this technique. However, this need not necessarily be a major limitation for the successful introduction of DL AAS into routine application, as this technique is ideally suited for dedicated instruments for special purposes and as low-cost detectors for gas chromatography (GC) or high-performance liquid chromatography (HPLC). One example for such an application is the HPLC-DL AAS system for speciation analysis of Cr(III)/Cr(VI) proposed by Groll et al., [54]. Another example is the tungsten coil atomizer DL AAS system for the determination of aluminum and chromium, described by Krivan et al., [55].

Another very interesting aspect is that, with DLs as radiation sources, the determination of non-metals such as halogens, sulfur, or even noble gases comes within reach of AAS. All these elements have long-lived excited states from which strong absorption transition can be induced by the red and near-IR radiation of LDs [53]. Zybin et al., [56], for example, reported about determination of chlorine by GC-microwave-induced plasma-DL AAS with a detection-limit some two orders of magnitude lower than the best values obtained by optical emission spectrometry.

Franzke et al [57] studied the applicability of diode laser AAS in low-pressure plasmas for sulfur determination in CO_2. Two simple methods for the measurement of sulfur compounds were investigated in a direct-current discharge. In the first method, the CO_2 sample gas is mixed with the plasma gas (Ar and He). The second one is based on reproducible measurements of the sulfur released from the walls in a helium discharge, after being deposited as a result of operating the discharge in pure CO_2 sample gas. For the measurement of metastable sulfur atoms, the extended cavity (EC) DL was tuned to the S absorption line at 921.539 nm, having a large oscillator-strength ($f = 0.53$).

CONCLUSIONS

From the discussions above, it is clear that AAS-techniques are in use all over the world in every research group and analytical laboratory, since it permits the analysis at different levels of concentration, as well as in different sample-types. In the near future, it is expected that the AAS will have more and more support from different methodologies, such as solid-sampling GF-AAS. Diode-Laser AAS is expect to be the most rewarding field of application. The development in line-sources is also expected to replace different HC-Lamps with one continuum-source lamp. In the field of analytical applications, the need will give new bright spots for developments in the future.

REFERENCES

1. R. D. Beaty and J. D. Kerber, Concepts, Instrumentation and Techniques in Atomic Absorption Spectrometry, PerkinElmer, Inc. Shelton, (2002).

2. B. Welz and M. Sperling, Atomic Absorption Spectrometry, Wiley-VCH, Weinheim, (1999).
3. R.F. Suddendorf and M.B. Denton, Appl. Spectrosc., 28 (1974) 8.
4. R. F. Browner, Microchem. J., 40 (1989) 4.
5. H. Berndt and W. Slavin, At. Absorpt. Newsletter, 17 (1979) 109.
6. E. Sebastiani, K. Ohls and G. Reiner, F. J. Anal. Chem., 264 (1973) 105.
7. E. A. Al-Ashkar, Investigation of spectrometric techniques for the determination of trace elements in small volume samples, Ph. D. Thesies, Fac. Science, Al-Azhar Univ., Cairo, 1998.
8. M. A. H. Ramadan and E. A. Al-Ashkar, Egypt. J. Soil Sci., 41 (2001) 501.
9. F. F. Fu, Z. Z. Zhang J. D. Zheng and M. W. Zhang, Fenxi Huaxue, 21 (1993) 123.
10. Z. L. Fang, B. Welz, and M. Sperling, J. Anal At. Spectrom., 6 (1991) 179.
11. P. Bermejo-Barrere, A. Moreda-Pineiro, R. Gonzalez-Iglesias and A. Bermejo-Berrera, Spectrochim. Acta Part B, 57 (2002) 1951.
12. E. M. M. Flores, J. N. G. Paniz, A. F. Martins, V. L. Dressler, E. I. Muller and A. B. Costa, Spectrochim. Acta Part B, 57 (2002) 2187.
13. E. Manuf, T. Takeuchi, D. Ishii and H. Harguchi, Anal. Sci., 7 (1991) 605.
14. A. D'Ulivo, L. Gianfranceschi, L. Lampugnani, and R. Zamboni, Spectrochim. Acta Part B, 57 (2002) 2081.
15. P.A. Bemett and E. Rothery, Introducing Atomic Absorption Analysis, Varian Techtarm Pty. Ltd., Mulgave, (1983).
16. S. R. Segade and J. F. Tyson, Specrtrochem. Acta Part B, 58 (2003) 797.
17. Z.-L. Fang, M. Sperling and B. Welz, J. Anal At. Spectrom., 5 (1990) 639.
18. Z.-L. Fang and L.-P. Dong, J. Anal At. Spectrom., 7 (1992) 439.
19. M. Sperling, X.-F. Yin and B. Welz, J. Anal At. Spectrom., 6 (1991) 615.
20. M. Sperling, X.-F. Yin and B. Welz, J. Anal At. Spectrom., 6 (1991) 295.
21. M. Sperling, X.-F. Yan and B. Welz, Spectrochim. Acta Part B, 51 (1996) 1875.
22. H. D. Wizemann and U. Haas, Spectrochim. Acta Part B, 58 (2003) 931.
23. W. C. Martin, J. R. Fuhr, D. E. Kelleher, A. Musgrove, L. Podobedova, J. Reader, E. B. Saloman, C. J. Sansonetti, W. L. Wiese, P. J. Mohr and K. Olsen, NIST Atomic Spectra Database (version 2.0), National Institute of Standards and Technology, Gaithersburg, MD, 2002.
24. A. Unsold, Physik der Sternatmospharen, Springer, Heidelberg, Berlin, 1968.
25. B. Welz and M. Sperling, Pure Appl. Chem., 65 (1993) 2465.
26. B. Welz, Spectrochim. Acta Part B, 54 (1999) 2081.
27. B.V. L'Vov, Spectrochim. Acta Part, B 33 (1978) 153.
28. C. H. Chiu, Y.-H Sung and S. D. Huang, Spectrochim. Acta Part B, 58 (2003) 575.
29. U. Kurfurst (Ed), Solid Sample Analysis, Springer-Verlag, Berlin, Heidelberg, New York (1998).
30. G. R. Carnrick and G. Daley, At. Spectrosc., 10 (1989) 170.
31. K.-Ch. Friese and V. Krivan, Spectrochim. Acta Part B, 53 (1998) 1069.
32. J. V. Sokolnikova, I. E. Vasilyeva and V.I. Menshikov, Spectrochim. Acta Part B, 58 (2003) 387.
33. T. Guo, J. Baasner and D.L. Tsalev, Anal. Chem. Acta, 349 (1997) 313.
34. M. Sperling, X.-F. Yin and B. Welz, Analyst, 117 (1992) 629.

35. M. Sperling, S.-K. Xu and B. Welz, Anal. Chem., 64 (1992) 3101.
36. M. A. Eid, E. A. Nashy, E. A. Al-Ashkar, K. A. Eid and E. H. Borai, JALCA, 97 (2002) 431.
37. M. Sperling, Z.-L. Fang and B. Welz, Anal. Chem., 63 (1991) 151.
38. A. Ganeev, Z. Gavare, V. I. Khutorshikov, S. V. Khutorshikov, G. Revalde, A Skudra, G. M. Smirnova, and N. R. Stankov, Spectrochim. Acta Part B, 58 (2003) 879.
39. S. A. Kazantsev, V. I. Khutorschikove, G. H. Guthohrlein and L. Windholz, Practical Spectroscopy of High-Frequency Discharges, Plenum Press, NY, 1998.
40. W. Bell and A. L. Bloom, Electrodeless Discarges methode and apparatus, US Patent 2975330, 1961.
41. Y. S. Chidson, A semiconductor generator for excitation of a spectral lamp, in V. S. Edelman (Ed) Instruments and Experimental Technique, Academy of Science of the USSR, 1973, pp. 129-130.
42. B. I. Smirnov and V. L. Kontorovich, Geophys. Equip., 59 (1973) 31.
43. K. A. Wagner, K. E. Levine and B. T. Jones, Spectrochim. Acta Part B, 53 (1998) 1507.
44. C. Blake and B. Bourqui, Atom. Spectrosc., 19 (1998) 207.
45. N. R. Stankove, Proc. of the 5th Intern. Sympos. on the Synthesis and Appl. of Isotopes, June 20-24, Strasborg, France, 1994.
46. J. M. Harnly, J. Anal. At. Spectrom., 14 (1999) 137.
47. H. Becker-Ross, S. Florek, U. Heitmann and R. Weisse, F. J. Anal. Chem., 335 (1996) 300.
48. S. Florek, H. Backer-Ross and T. Florek, F. J. Anal. Chem., 355 (1996) 269.
49. H. Backer-Ross and S. Florek, Spectrochem. Acta Part B, 52 (1997)1367.
50. U. Heitmann, M. Schuetz, H. Backer-Ross and S. Florek, Spectrochim. Acta Part B, 51 (1996) 1095.
51. H. Backer-Ross, S. Florek, U. Heitmann, and M. Schuetz, Fifth Rio Symposium on Atomic Spectrometry, Cancun, Mexico, 1998.
52. K. Niemax, A. Zybin, C. Schnurer-Patschan and H. Groll, Anal. Chem., 68 (1996) 351A.
53. A. Zybin, C. Schnurer-Patschan, M.A. Bolshov and K. Niemax, Anal. Chem., 17 (1998) 531.
54. H. Groll, G. Schaldach, H. Berndt and K. Niemax, Spectrochim. Acta Part B, 50 (1995) 1293.
55. V. Krivan, P. Barth, and C. Schnurer-Patschan, Anal. Chem., 70 (1998) 3525.
56. A. Zybin, C. Schnurer-Patschan and K. Niemax, J. Anal. At. Spectrom., 10 (1995) 563.
57. J. Franzke, D. G. Stancu and K. Niemax, Spectrochim. Acta Part B, 58 (2003) 1359.

AN OVERVIEW OF TELECOMMUNICATIONS DEVELOPMENT AND ITS IMPACT ON OUR LIVES

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ABSTRACT

The paper aims to provide an overview of the development of the Information and Communication Technologies (ICTs) and their impacts on our lives.

Internet, wireless and mobile communications are the combination of computing and communication technologies, which enable manipulation of voice, data, images and messages, round the clock and around the world. No one can be exactly sure as what the future will look like, but the phenomenon anytime, anywhere communications — is becoming a reality. There is much discussion about the impact of ICT on individuals, companies and societies. Each actor looks at the issue from his own point of view. The issues of marketability, usability, and acceptance are inexorably linked to the concept of societal and cultural needs and values. Since the beginning of human occupation of the Earth, each new technological innovation has had a hand in the development and shaping of our society. The question is, how the ICTs have changed and will change our society in the future? It is important to remember that, while technology has brought us many new and wonderful things, it has not been without a price. Certainly, for everything that technology gives us, it also takes something away.

1 INTRODUCTION

Information and Communication Technologies (ICTs) not only constitute an industry in their own right, but also these pervade all sectors of the economy, where they act as integrating and enabling technologies. ICTs have a profound impact on society; and their production and use have important consequences for development in economic, social and environmental areas. The Internet and today's global networks of mobile-communication technologies presage an era that will be dominated by complex, integrated Information Technology Systems.

The major challenge for research and development will lie in learning how to design and manage complex networked systems comprising thousands of heterogeneous components, while ensuring that these systems bring benefits to the society.

Technology has been exerting a decisive influence over the course of human history. From gunpowder to the steam engine, from electricity to nuclear power, through electronics and biotechnology, nations that have harnessed natural forces through technology have visibly prospered, leaving others behind. Over the past three decades the explosion in information-technology has demonstrated this point again. Driven by terrific advances in electronics, the revolution in information and communication technology has spread powerful computing devices across the globe, created an unprecedented information resource of the Internet and World-Wide Web; hence, transformed global communications through flexible e-mail and mobile telephone services. This explosive increase in our ability to gather, store and process information, has stimulated sweeping social changes, altering the way we do our work and linking people together more closely than ever before.

The Internet has already revolutionized the relationships between businesses and their customers, as well as the way businesses manage their supply-chains and internal communications and processes. Indeed, modern information-technology has altered the very nature of the global economy, which increasingly thrives on the creation and provision of knowledge-based products and services, rather than the production of material goods. In the coming decades, computers and communication-technology will become immeasurably more powerful, and yet cheaper.

Most significantly, however, information-technology is set to experience a massive and unprecedented increase in systems' complexity, as developers strive to integrate a vast spectrum of diverse technologies and 'intelligent devices by the billions' into connected networks. In tomorrow's world, the environment will brim with pervasive sensors and other devices. Trafficing of Communications will increase enormously, as these devices share information in order to carry out the 'housekeeping' chores of an information-centric world. The Internet will be everywhere, and will be a vastly deeper and more powerful environment than we know today, with multiple layers and inhabited by a population of intelligent software-agents aiming to support its health and efficient operations[1]. The information-society of tomorrow will be, first and foremost, a networked society, with individuals and businesses always linked into a global web of technology, and an economy founded on a seamless environment of networked information-resources. These networks will aim to provide socially beneficial functions – from monitoring individual health to supporting global enterprise – with efficiency and resilience.

ICT will also contribute to the achievement of a broad range of other social goals. In today's networked and information-centric world, individuals, businesses and governments face novel kinds of risks. With the global economy now far more integrated than it has ever been, for example, chains of economic cause and effect reach across the world with disconcerting speed, exposing individuals, firms, and governments to a new kind of "interdependence-risk" — to the possibility that events quite far away can undermine the activities on which their security and prosperity depend. While information-technology cannot provide security on its own, it will play an important part in the design of security-solutions. ICT also offers novel and potentially powerful tools for dealing with other societal risks, such as that associated with healthcare.

2 TRENDS IN INFORMATION-COMMUNICATION TECHNOLOGIES (ICT)

2.1 Mobile Next-Generation Networks (NGNs)

With the evolution from second- to third-generation (2G to 3G) mobile networks, wideband-radio access and Internet-based protocols characterize the way from a mobile-handset today to a mobile-multimedia device in the future. Providing wireless access to the wired Internet first, brings more flexibility and facilitates penetration. Secondly, new services can emerge from enabling functions, such as mobility, personalization, and localization capabilities. This motivates the industry to evolve the wired Internet to a mobile-Internet with new capabilities and applications [2]. At the turn of the last century, telecommunication's focus changed considerably, from traditional wired telephony-oriented services and infrastructures to data-based services; from homogeneous to heterogeneous networks; from non-intelligent devices to smart handhelds, personal digital assistants, and mobile computers.

A key question, rises when we discuss the evolution of hardware and software technology in the telecommunications and computing field: "what are the targets of mobile next-generation networks (NGNs)?". One target could be computing anywhere, anytime, and another could be personalized mobile communications—that is, ubiquitous computing.

We can view NGNs as a merger of the Internet and intranets with mobile-networks and with media and broadcast technologies. The Universal Mobile Telecommunication System (UMTS) is, from a radio perspective, a third-generation cellular technology, which is defined by the International Telecommunication Union (ITU) in its IMT-2000 framework. From a conceptual point of view, it represents a technological step towards mobile NGNs, facilitating ubiquitous computing.

In the 4G system, the trend is toward global information-networks, offering flexible multimedia-information services to users, on demand, anywhere and at anytime. Satellite-based mobile systems will be used in this system in a complementary mode to the terrestrial system, to better meet demands of user.

2.2 Multimedia Technologies

Currently, Multimedia-technology currently provides content-creators and consumers with a myriad of coding, access, and distribution possibilities. At the same time, communication-infrastructure is being put into place, to provide access to informational and multimedia services from almost anywhere at anytime. The appetite for content and the accessibility of information is increasing at a rapid pace.

Access-devices, with a large set of differing terminal and network capabilities, are making their way into people's lives. Additionally, these access-devices are used in different locations and environments, anywhere and anytime [3].

2.3 Ubiquitous Computing

Ubiquitous computing describes the evolution of computing toward the so-called third era of computing. Mobile computing will be a main contributor to this development. The primary goal of ubiquitous computing is to embed many small and highly specialized devices within the everyday environment, so that they operate seamlessly and become transparent to the person using them, either offline or online. Ubiquitous computing-products aim to be everywhere (for example, by being portable); small, and aware of their environments, users, and contexts. Products and devices embodying these characteristics will provide a physical entity with complete freedom of movement and freedom of interaction. Wireless connectivity is a key-contributor to this vision [2].

2.4 Sensor-Networks

The development of sensor-networks requires technologies from three different research areas: sensing, communication, and computing (including hardware, software, and algorithms). Thus, combined and separate advancements in each of these areas have driven research in sensor-networks. Recent advances in computing and communications have caused a significant shift in sensor-network research and brought it closer to achieving the original vision. Small and inexpensive sensors, wireless networking, and inexpensive low-power processors allow the deployment of wireless ad-hoc networks for various applications [4].

2.5 Ambient Intelligence

Ambient Intelligence (AmI) will not be the outcome of any single technology or application; it is an '*emergent*' property that results from the parallel development and introduction of a large number of interrelated systems, sensors, databases and interfaces [5]. Two main perspectives exist: the optimistic perspective, that sees mostly benefits instead of challenges and hopes that AmI will improve our lives and the pessimistic approach, that perceives the challenges as risks, the risk of intrusion and loss of privacy, and of the emergence of an Orwellian 'Big Brother' society.

The deployment of AmI technology opens huge possibilities, though also huge risks to society. We have to be aware of both, chances and risks, and work for a balanced realization of the vision today, the fact is that nobody knows certainly how it is going to materialize. We know that "everything will be connected to everything else," but "no one has any idea what all those connections will mean".

This uncertainty can be understood at several levels. It can be taken as a criticism of the perceived lack of focus when it comes to AmI applications, or as a lack of understanding of the consequences of its deployment in the real world: how will we use "smart things" in our everyday lives? When should we switch them on or off? What should smart things be permitted to hear, see, and feel? And whom should they be allowed to tell it ?

3 SOCIETAL IMPACTS

There is much discussion about the impact of Information Technology (IT) on individuals, companies and societies. Each actor looks at the issue from their own viewpoint. The goal of the Information Society plan is very ambitious and consists of the use and implementation of information-technology in all areas of life.

The introduction of information technology is possible when an individual user has the communications capabilities: the motivation, skills and access. In today's information society dialog, it has been very often emphasized that there is not enough content in the information-systems. If there is no content, result is that there is no motivation. The core of the problem is that the use of information technology in all its areas is not clearly outlined according to the motivation of the user [6].

A technology or technological-innovation goes through a period of diffusion, wherein "an innovation is communicated through certain channels over time among the members of a social system". Whether or not, the technology is accepted or rejected, will depend largely on the "economic, sociological, and political features" of the society in general, including determination of whether the technology is compatible with that society's values. Today, of course, diffusion is facilitated by the marketing process, which utilizes such earlier innovations as radio, television, and the printing press as the channels for communicating, both quickly and to large audiences [7].

3.1 Benefits and Burdens of Technology

The issues of marketability, usability, and acceptance are inexorably linked to the concept of societal and cultural needs and values. In order to successfully market the technological innovations, it is necessary to first understand the values of the group or society, one is trying to sell to. The better one can understand how the group's members live, what motivates them, what they care about, and what they want, the easier it will be to design and market products that they will accept and adopt into their culture. But these ideas relate to getting new technology into a society. Of even greater concern is, what happens to that society after the technology has been accepted/adopted.

Since the beginning of human occupation of Earth, each new technological innovation has had a hand in the development and shaping of our society. Just think of how profoundly inventions, such as the wheel and the telephone, have affected our everyday lives. Anytime, anywhere, communication-technology promises to be no different in that respect. The question is, how will it change our society? It is important to remember that, while technology has brought us many new and wonderful things, it has not been without a price. Certainly, for everything that technology gives us, it also takes something away.

Any technology, adopted by a society, will have “inherent and identifiable social, political, and environmental consequence. And although these consequences may be both beneficial and detrimental, the negative attributes are usually slower to appear and, even if they are known at the outset, are often concealed by the proponents of technology.

What impacts will the emerging communication-technology have on our society? What benefits will it bring, what burdens will it bestow, and upon whom? What, if anything, can be done to anticipate and minimize the negative aspects of such “anytime, anywhere technology”? A number of studies were carried out to find out how the values held by a society affect the technology, which that society produces, and how that technology, in turn, affects a society’s values?

What societal values brought on the development of “anywhere, anytime communication”? Perhaps, it is a fondness for novelty, for things that are new and exciting. Maybe it is pride in our nation’s technological superiority, or a fascination for material possessions, or just an “I want it now” sense of urgency. And if it is true that “values open apparently change to fit the world, which technology presents”, what value-changes are in store for us, as the result of all this new information-technology?

3.2 Privacy

One of the first value-conflicts on the horizon surrounds the issue of personal privacy in an information-society. Unfortunately, the desire for privacy and the ability to control the access to information about oneself is seriously, if not irrevocably, jeopardized by advances in computer-technology. Even today, merchants electronically collect, share, and sell information about the people who buy their products and services.

All of this data-collection has been made possible by advances in computer and bar-coding technology. Merchants and businesses can record the most minute data about an individual’s preferences and buying habits. This information is then stored, sorted, and sold to anyone who can afford it. For example, marketers use it to more accurately define the desired target-population for specific promotions. What effect will “anytime, anywhere technology” have on this process? If nothing else, it may make it even easier for marketers to find out personal information and preferences, thanks to the software agents that we will use to run errands for us. The key to this issue, say many, is to put measures in place now, to ensure that privacy is a consideration before all this technology gets so far advanced that it is too late!

3.3 Security

While issues of privacy are concerned with what is done with personal information by people or companies that obtained it legitimately, security-concerns relate to keeping that data out of the hands of those who have no right to it, in the first place. As information becomes more easily accessible, concern continues to grow about the ability to keep databases secure and incorruptible. As we know, just from reading the newspapers, so-called computer "hackers" specialize in defeating allegedly secure-systems, sometimes for criminal purposes, other times just for fun. What will stop them from attaching viruses to agents as they move from place to place, or impersonating another user, in order to obtain information or merchandise illegally?

3.4 The Mobile Office

One of the most highly touted uses for "anytime, anywhere" is in creating the "virtual office." This means that whether an employee is on the floor of a customer's plant, stuck in a traffic jam, or sitting in the spare bedroom at the end of the hall, he or she can also be "in the office" because the office, in essence, travels wherever the employee goes. New, devices and wireless networks will allow workers to make calls, send voice and data messages, and access important information from wherever they happen to be. This technology will change not only the way we do our work, but the nature of the work itself. The long-term success of the mobile-office is far from a sure thing. In fact, some feel that companies may have jumped too quickly on the bandwagon, purely because of the perceived short-term financial benefits, and failed to study the lasting effects on employees and productivity.

3.5 Virtual Communities

Those in virtual offices, and others who are feeling isolated from human contact and interaction, will find alternative ways to fill their needs for socialization. One way will be through electronic bulletin-boards and virtual communities that will replace the real thing. Thanks to the new services and the Internet, individuals are now able to correspond in real-time with people all over the world. These virtual communities are "bringing together people who otherwise would never meet". On-line meeting-rooms and discussion-groups are growing more and more popular, prompting one artist to state that "technology today is the campfire around which we tell our stories." Others describe it as a place where people "hold meetings or schmooze in online watering holes". These on-line environments are fast taking the place of face-to-face interaction and conversation. In fact, on-line discussion-groups are even challenging singles bars and fitness-centers as a popular spot to find romance. It is true that these on-line environments will greatly expand our access to people from all walks of life.

3.6 Disabled and the Elderly Persons

The advent of "anytime, anywhere communication" will have a significant impact on the lives of the elderly, "shut-ins", and those with disabilities. Many of these communication-technologies can be easily adapted for the handicapped and infirm, giving them the same access to information and the same ability to communicate as those without disabilities. the potential benefits of information-technology for older adults are substantial. The needs of this market, such as "social interaction, access to information, opportunities for entertainment and for learning," combined with the physical limitations of many of its population, are a perfect fit with many of the new devices and services that "anytime, anywhere technology" will offer.

3.7 Human Factors and the 24-Hour Society

Highly advanced technologies are being developed, without any real understanding of how people might interrelate with new technologies. The information that we can now get from machines, is more than human beings can absorb. It is this overabundance of data that hampers the human ability to make decisions. That is to say, that we are more focused on the optimization of technology and equipment than human alertness and performance. "Human error has become the problem of our age, because the trade-offs and compromises, made to ensure the technological achievements of the modern world, have not taken into account the design-specifications of the human body! Creating and installing a human-centered technology to redress the balance will be one of the most important challenges of the twenty-first century".

3.8 Global Politics

Even bigger than the impact that "anytime, anywhere communication" will have on individuals is the effect it will have on all societies and cultures, and, maybe, even world geography. Because it utilizes thin little wires and invisible airwaves, communication-technology pays little attention to the geographic or other types of boundaries between countries, and in some cases has played a role in literally reshaping borders. Information is power; communication-technology has continued to play a role in changing cultures and reshaping borders around the world. Thus, wireless technology will continue to play a part in the communication-revolution by enabling instant access to information in all corner of the world.

4 CONCLUSIONS

In the future, today's emerging Information and Communication Technologies will be as much a part of our everyday lives as telephones and computers are today. There are, however, numerous issues to be resolved before the complete acceptance and integration of this technology can take place. Most importantly, individuals in our society must take the responsibility for deciding how this technology will become a part of our lives. Today, instead of blindly accepting that "bigger, faster, flashier" is the best thing for us, we should be asking ourselves what we really want from ICT tomorrow. Will it be used to enhance our face-to-face communication or to replace it?

What guidelines and boundaries will we place between our work and our personal time? How will we deal with the pace of a 24-hour society and our own physical limitations? It is only through a full understanding of the possible impacts that we can make the decisions that will help us to shape the future of both our technology and our society.

REFERENCES

1. "On the evolution of Internet technologies" Cerf, V.G.; Proceedings of the IEEE , Volume: 92 , Issue: 9 , Sept. 2004 , Pages:1360 – 1370.
2. "Mobile next-generation networks" Huber, J.F.; Multimedia, IEEE ,Volume: 11 , Issue: 1 , Jan-Mar 2004 Pages:72 – 83.
3. "A perspective on the evolution of mobile communications" Tachikawa, K.; Communications Magazine, IEEE , Volume: 41 , Issue: 10 , Oct 2003 Pages:66 – 73.
4. "Sensor networks: evolution, opportunities, and challenges" Chee-Yee Chong; Kumar, S.P.; Proceedings of the IEEE ,Volume: 91 , Issue: 8 , Aug. 2003, Pages:1247 – 1256.
5. "Ambient Intelligence: from vision to reality" IST Advisory Group, September 2003 ftp://ftp.cordis.lu/pub/ist/docs/istag-ist2003_consolidated_report.pdf
6. "Mapping of Customer Needs for eEurope 2005" Marja-Liisa VIHERÄ, Leena VIUKARI, Proceedings of the eChallenges e-2004 Conference, 27- 29 October 2004, Vienna, Austria.
7. "Anytime, anywhere: the social impact of emerging communication technology" Perugini, V.; Professional Communication, IEEE Trans. on , Volume: 39 , Issue: 1 , March 1996, Pages:4 – 15.

USE OF PHYSICS IN AGRICULTURE: IMPROVING RELATIONSHIPS BETWEEN SOIL, WATER AND PLANTS, UNDER STRESS-ENVIRONMENT

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ABSTRACT

Soil and water are the two fundamental resources of nature for agriculture. The knowledge of physics played a significant role in the 'Green-Revolution' of agriculture in the 20th century. Green-revolution made tremendous contribution to food-production; however, it showed limited and unsustainable impact in the developing countries because of stress on environment. This paper reviews the research conducted at NIAB, using nuclear and other advanced techniques, to improve agricultural productivity under stressed environment. Introduction of modern techniques for the assessment of soil and water-salinity and use of environmental isotopes, proved to be very successful in, exploring the sources of water-logging and salinity; and developing and recommending remedial measures for specific areas to combat problem of land-degradation. Manipulation of salt-affected soils to improve their soil physico-chemical properties, particularly water-retention, hydraulic permeability, structural stability, bulk density/porosity, organic matter, soil salinity and alkalinity, etc., confirmed the effectiveness of growing salt-tolerant plants, with poor-quality water to improve crop-yields on sustainable basis. Now, the use of Neutron Moisture Meter (NMM) for soil-water assessment and its potential application in various fields has been well established world over. The technique is non-destructive, less time consuming and economical, compared with conventional methods. Plants' water-requirement and screening of many plants-species (grasses bushes and trees) for high water-use efficiency has been carried out with a technique established at NIAB using NMM.

Studies were also conducted to find relationship between carbon-isotope discrimination (CID) and water-use efficiency (WUE), to select plants suitable under water-limited conditions. Among grasses, Sporobolus arabicus showed higher WUE followed by Kallar grass and the results confirm that these grasses can be grown successfully in water-limited environments, by selecting an optimum soil-moisture level for maximum biomass production. In trees, Acacia ampliceps showed 4-5 times more biomass-yield than Eucalyptus camaldulensis, grown in similar soil-moisture conditions. Significant positive correlation of CID with WUE ($r = 0.99$) was observed in A. ampliceps. In contrast, CID of E. camaldulensis showed a significant negative correlation with WUE ($r = 0.82$). The CID in rice was correlated linearly and positively with WUE.

Results of these studies confirm that leaf carbon-isotope discrimination (CID) can be used as good predictor of WUE in C3 and C4 plants. Innovative approaches applying principles of physics are imperative, along with traditional agricultural approaches, to improve soil-water plant relationships and increase the productivity of the areas with given constraints under stress-environment. Earlier, the knowledge of physics has provided the foundations and has enabled the scientists to adjust to changing situation in the field. It is hoped that this process will continue in 21st century and will establish a new base for new revolution in agriculture.

INTRODUCTION

The increasing role of physics in agriculture has its deep roots in the middle of the 19th century, at the time in which development and production of the agricultural machines was taken from the hands of craftsmen by the agriculture-industry. The invention of tractors; the knowledge of plant-fertilizer; as well as discovery of the simple genetic rules, formed the basis for miraculous development of agriculture in the 20th century. Physics contributed in finding solutions of nearly all the basic technological problems. This process also continued in the 20th century and physics found its permanent position among the agricultural engineers. The second part of the 20th century was accompanied by quick increase of the role of physics in agricultural sciences. The period from 1960s to1980s was mainly the "golden era" for development of physical properties of agricultural materials.

Physics assisted in discovering and developing new technologies for use in agriculture. There were robotics, new food-technologies, new forms of biotechnology, application of new forms of information-technologies, forming of new agricultural precision-systems, production of raw materials for industrial use, sustainable agricultural systems, controling and checking of the quality of food-products and new genetic revolution. Physics in the last years of the 20th century directly penetrated into soil science and biology and brought qualitative change in the base of these sciences. Principal role of sophisticated instruments and mathematical theory transformed soil-sciences to soil-physics and biology to bio-physics. It is hoped that this process will continue also in the 21st century and it will form a new basis for new revolution in agriculture. The intensification of agriculture through the “Green-Revolution” mainly involved the development of new technologies and improved agronomic practices. These include, the use of high-yielding cultivars, mechanization, irrigation, and especially agrochemicals. However, there has been an increasing awareness over the last 20 years that the “green-revolution” has a limited impact on the farmers in developing countries, due to the following, factors:

- The rapidly mounting pressure due to population-explosion has led to the careless exploitation, and at times even to the rapid destruction of our highest quality soil and water-resources.
- Food–production in many parts of the world, particularly in arid and semi-arid regions, is severely affected due to decrease in area-under cultivation, increase in

area under salinization and decrease in overall productivity of good and fertile soils, as a result of improper irrigation and water-management practices.

- Decrease in availability of fresh-water for irrigation, because: (a) cities, industry, and farming are in competition for available water, (b) ground-water sources are gradually depleting, (c) the costs of pumping and distributing surface-water are increasing, and (d) many surface and ground-waters are being contaminated by a variety of pollutants.

Land represents a mere 29% of the world's total area, yet provides approximately 98% of its food. Most of this land is not very fertile: only 11% is of high level of fertility, 28% of moderate fertility, and 61% of low fertility. Of all the water on Earth, only 2.5 per cent is fresh-water, the rest is salty. Of this fresh-water, most is frozen in icecaps, present as soil-moisture, or inaccessible in deep underground-aquifers, leaving less than 1 per cent accessible for use. Thus, less than 1% of the total water that is present in rivers and underground resources is available to meet our present day requirements. The surface and ground-water resources are not evenly distributed on the surface of Earth and about half of the land has very little or no water at all.

Pakistan is mainly a dry country and its climate is semi-arid to arid, because average annual precipitation is 250mm. It is estimated that 66.7% of the area of the country receives rainfall less than 254mm (arid), 24.2% between 254-508mm (semi-arid), 5.4% between 508-762mm (sub-humid) and 3.7% more than 762mm (humid). About 60% of the total rainfall occurs in Monsoon period, during July-September. Major part of the summer-rains is lost because of rapid runoff, due to torrential showers and is not available for agricultural use. Salinisation of soils and ground-water is a serious land-degradation problem in arid and semi-arid areas, and is increasing steadily in many parts of the world, including Pakistan. Saline-soils cover about 380-995 Mha of the Earth's land-surface and of these, 62% are saline-sodic or sodic. In Pakistan soil-salinity is a widespread problem in the country and according to a latest report, about 6.17 million hectares (Mha) of land are affected by salinity, out of which 9.7, 19.9, 38.6 and 31.8 % area is slightly, moderately, severely and very severely saline, respectively. Irrigated plains of Indus-basin possess subsurface-aquifer under 16.2 Mha. Out of which, 5.2 Mha contain water with less than 1000 mg l^{-1} of total soluble-salts (TSS), about 2.5 Mha have ground-water of moderate salinity (TSS= 1000-3000 mg l^{-1}) and 8.5 Mha contain water of high salinity (TSS > 3000 mg l^{-1}). Therefore ground-water in most of these saline-areas is brackish and thus, not suitable for irrigation.

The foregoing may be summarized that both fundamental resources, soil and water, essential for agriculture are under stress, world over including Pakistan. The need to manage these resources efficiently and effectively on sustained basis is the most vital task related to present and future agricultural production. Therefore, it is important to use the knowledge of the principles and processes of the physics in relation to climate and plant-growth. This paper highlights the salient results obtained with application of knowledge of physics to enhance the agriculture-production under stress-environment, particularly salinity and drought.

1. ASSESSMENT OF SOIL-SALINITY USING LATEST TECHNIQUES

Almost all irrigation-water contains salts. These salts remain in the soil as the plants use water. These salts accumulate if proper leaching is not applied and reduce crop-yields. Periodic monitoring of soil-salinity is recommended where salinity is a potential problem. Measurement of salinity involves collecting soil-samples and taking saturated extracts of the soil and analysis of its chemical constituents. The most common way to assess soil-salinity is by measuring electrical conductivity of the saturated extracts of soil. This method is laborious, time consuming and expensive if salinity measurement at large areas is required. Different techniques of measuring salinity directly in field (in-situ), have been developed by using physics. a): Four-electrode salinity probe, generally known as Rhoades probe, measures soil-salinity in-situ and is useful for mapping salinity in the field (Akhter et al., 1987). b). Electromagnetic Induction Method (EM-38): The electromagnetic conductivity meter allows rapid measurements in the field over larger areas. The method is non-destructive and very quick for assessing soil-salinity in the field. Measurements can be taken almost as fast as one can walk from one location to another. Quick distinction can be made between top-soil salinity, where most of the plant-roots are located and sub-soil salinity. These methods are useful for salinity-surveys on large areas, small fields and experimental plots (Shaheen et al., 1997).

2. ISOTOPIC TECHNIQUES IN HYDROLOGICAL STUDIES

Both stable and radioactive environmental isotopes are extensively used now-a-days to trace the movements of water in the hydrological cycle. Isotopes can be used to investigate underground-sources of water to determine their source, how they are recharged, whether they are at risk of saltwater intrusion or pollution, and whether they can be used in a sustainable manner. The problem of origin of water-logging and salinity in north west of Faisalabad Division, was investigated (Akhter et al., 1986, 1990), using isotopic (O^{18}, H^2, H^3) and hydrochemical techniques. The technique was found to be useful to explore the subsurface conditions and following main conclusions were made:

- Three distinct aquifers: shallow, intermediate and deep, were recognized in the area.
- The water contained in three aquifers was of different origins and history.
- The deep aquifer was recharged more than 60 years ago and the source of recharge seems to be river and canal water. The shallow-aquifer gets its major recharge from rainfall.
- The vertical mixing between the shallow and intermediate aquifers is very clear at various sites, but recharge does not extend to the deep aquifer.
- The recharge to ground-water, from the irrigation, seems to be negligible due to high evaporation and evapotranspiration from the ground-surface.
- The salinity in the area is not of marine or sea-water origin. It may be due to the basic rock-type and alluvium, belonging to salt-range mountains of Pakistan,

which might have been brought and deposited by the rivers in ancient times.

- The drains have recharged only a few underlying sites locally and further onward transmission is restricted.
- The spatial variation of hydrochemical facies and environmental isotopic concentration proves that mixing in lateral direction is confined to certain distances, depending upon the nature of strata in shallow and intermediate aquifers. But later flow in the deep aquifer seems to be possible.
- The level of ground-water table is restricted upto shallow and intermediate aquifers and does not extend to deep aquifer. The fluctuations in the depth of ground-water table are correlated with precipitation, confirming rainfall as a major source of recharge to the shallow and intermediate aquifer.

3. AMELIORATION OF SALT-AFFECTED WASTELANDS

The threats of losing agricultural land to salinity are now well understood, and a great deal of effort is being made to combat the problem of soil and water-salinity. While reclamation of vast areas of saline-land seems difficult, because of economic and climatic constraints, use of salt-tolerant plant succession-technique (Biological approach or vegetative bioremediation) for reclamation of saline-soils, using brackish subsurface irrigation-water has been very attractive and economical (Malik et al., 1986; Qureshi and Barrett-Lennard, 1998; Qadir and Oster, 2002). The approach involves use of nuclear and other advanced techniques, based on principles of physics. The question that how the long-term use of saline irrigation-water will affect, deteriorate or ameliorate, the chemical environment of soils already degraded due to excess of salts, still remains unanswered. Studies were, therefore, conducted to monitor the changes in physical, chemical and mineralogical properties of a saline-sodic soil-profile in reclamation fields, under Kallar-grass irrigated with brackish water. Soil-salinity, sodicity and pH decreased significantly in top-soil in cropped fields as a result of leaching of salts to lower depths (Akhter et al., 1988 & 2003). Cultivation of Kallar-grass enhanced leaching and interactions among soil-chemical properties and thus, restored soil fertility. The growth of grass for three years, significantly improved soil's physical properties, viz., available water, hydraulic permeability, structural stability, bulk-density and porosity (Akhter et al., 2004). The growth of grass enhanced interactions among the soil's physical, chemical and mineralogical properties and restored soil-fertility. The improved soil characteristics were maintained with further growth of grass upto five years. The ameliorative effects on soil's physico-chemical environment, were more pronounced after three years of growing grass. Soil maintained the improved characteristics with further growth of the grass upto five years, suggesting that growing salt-tolerant plants is sustainable approach for biological amelioration of saline-wastelands.

4. WATER-MANAGEMENT

In arid and semi-arid regions or areas of low and erratic rainfall, sustainable food cannot be obtained if the agricultural practices do not address the effective use of most

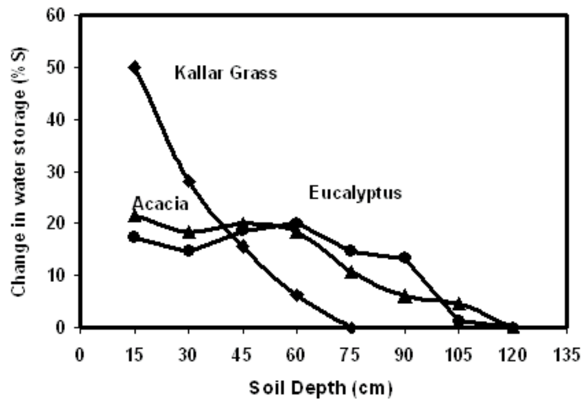

Figure - 1: Differences in Effective Rooting Depth of Kallar-Grass, Acacia Ampliceps and Eucalyptus Camaldulensis, as Estimated from Changes in Soil's Water-Storage

precious resource, i.e., water. Irrigation is one of the means available for maintaining optimum levels of soil-water in plant's root-zone. In Pakistan, due to flood-irrigation and due to inadequate water-management, much less area is often irrigated than actually planned. The efficient utilization of available water, both in irrigated and rain-fed areas, can increase the area under cultivation, as well as crop-productivity. The measurement and management of soil-water are pre-requisite for maximizing the use of soil-water available for plant-growth. Neutron-Moisture Meter (NMM) is most commonly used for measuring soil-water contents; monitoring its changes with time; and for irrigation-scheduling. NMM has shown wide field applications, including; soil-

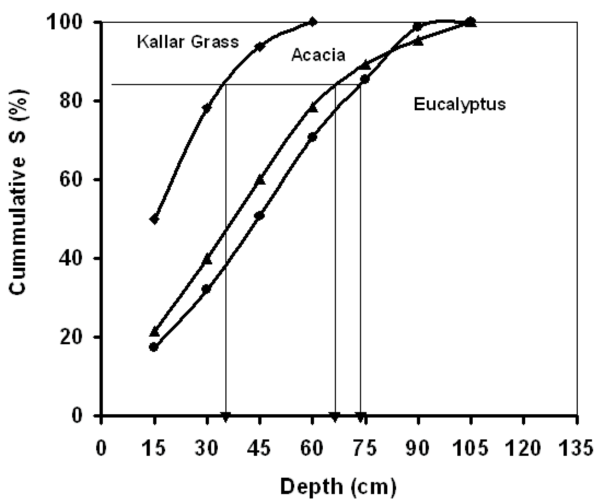

Figure - 2: Root-Distribution and Relative Root-Activity of Kallar-Grass, Acacia Ampliceps and Eucalyptus Camaldulensis, as Estimated from Changes in Soil's water-storage

water assessment; field capacity; rooting activity; irrigation requirement; hydraulic conductivity; water use efficiency; water-balance and groundwater-recharge/discharge studies. Some of these are described below:

a. In-situ Determination of Active Rooting-Zone of Plants with Neutron-Moisture Meter

Maximum soil-depth providing 80 % of water taken up by plants, is assumed effective rooting-depth or active rooting-zone. Determining active rooting-zone of plants and soil's hydraulic properties are most vital components, to assess the water-requirement for irrigation. For maximizing efficient use of water and fertilizers, the soil-water content and crop-root zone need to be evaluated in order to apply the exact irrigation-water, at different stages of plant-growth. Information of plant's rooting depth and soil-water storage in root-zone is the key data, required in water-consumption studies. Collection of such information with conventional techniques is laborious, time-consuming and expensive. Neutron-moisture meter have successfully been applied to collect such information very quickly. An example of such a data, collected with Neutron-Moisture Probe from three selected sites under vegetation of Kallar-grass, Acacia ampliceps and Eucalyptus camaldulensis have been presented in Figure-1.

Figure-1 shows that Kallar-grass roots had reached up to 75 cm depth and were getting water from there, while roots of A. ampliceps and E. camaldulensis plants had penetrated up to 120 cm of soil-layer. Differences in effective rooting-depth of three plants under study are shown in Figure-2. More than 50% of water-depletion under Kallar-grass was observed within 30 cm of soil-layer. This implies that roots of Kallar-grass were more active at shallower depths as compared to A. ampliceps and E. camaldulensis. The effective rooting-depths of Acacia and Eucalyptus were observed at 63 cm and 70 cm of soil-layer. Results indicated that rooting-length, determined with NMM, was same as noted physically by removing soil in Eucalyptus (Trees), Acacia ampliceps (Bushes) and Leptocholoa fusca (Kallar grass). The data from neutron-moisture meter predicted the effective rooting-zone with very high accuracy. Data confirmed that technique was applicable to trees, bushes and crops. The method was found to be superior to other methods due to less time consuming and non-destructive nature.

b. Technique Established for Studying Plant's Water-Requirement

The growth of plants with high water-use efficiency (WUE) is desirable under water-limited environment, to improve crop-production. Many salt-tolerant plants have already been selected (described elsewhere) and grown on saline-soils irrigated with brackish under-ground water. The biomass and grain-yield of crop-plants can easily be enhanced by selecting plants of higher water-use efficiency. The screening of plants for WUE is difficult, rather limited, because of lack of fast screening-method and difficulties in taking accurate measurements. Studies were conducted at NIAB to establish a standard technique, for determining WUE of selected plants by growing at

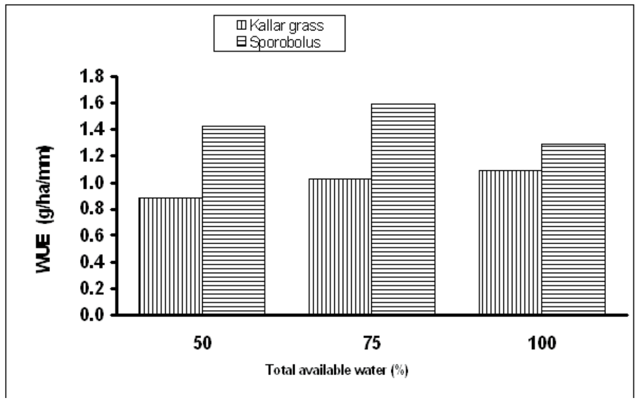

Figure-3: Water-Use Efficiency (WUE) of Kallar-Grass and Sporobolus Arabicus, as a Function of Total Available Water

different soil-moisture regimes, using neutron-moisture probe.

The plants are grown in cemented lysimeters (1m x 1m x 1m) filled with pre-selected soil (saline or normal) of required physico-chemical characteristics, with NMM access tubes installed in the center of lysimeters. Selected plants (Trees, Bushes & Grasses) are transplanted and grown till uniform biomass cover. The plant species (triplicate) are randomly subjected to three water-regimes (Well watered, Medium watered & Low watered), and three plots are kept as control without plants. Under well-watered treatment, the soil was kept at 100% of total available water (TAW), under medium water treatment at 75% of TAW and in low watered treatment at 50% of TAW. The soil-water regime is restored after alternate days on the basis of readings from the neutron-moisture meter. The water required is added through a prefixed locally prepared irrigation-system, including a water-pump, a water-meter, fixed pipes and taps, etc., The plants are harvested after suitable time-intervals. Samples of plant-leaves, straw and grain are collected for analysis of Carbon-isotope discrimination (Δ). Fresh and dry biomass and other required plant-parameters are determined. Water-use efficiency (WUE), transpiration-efficiency (TE) and required parameters are determined at each level of moisture.

Water-use efficiency based on grain (WUEG) and biomass (WUEB) is calculated as:

WUE_G ($kg\ m^2\ mm^{-1}$) = Grain yield / Total water consumed.
WUE_B ($kg\ m^2\ mm^{-1}$) = Biomass yield / Total water consumed.

The isotopic ratio ($R = {}^{13}C/{}^{12}C$) of plant-samples in sample (R_{sample}) and in standard ($R_{standard}$) is determined using a ratio-mass-spectrometer. The R values are converted to $\delta^{13}C$, using the relation:

$$\Delta^{13}C\ (‰) = [R_{sample} / R_{standard}{}^{-1}] \times 1000$$

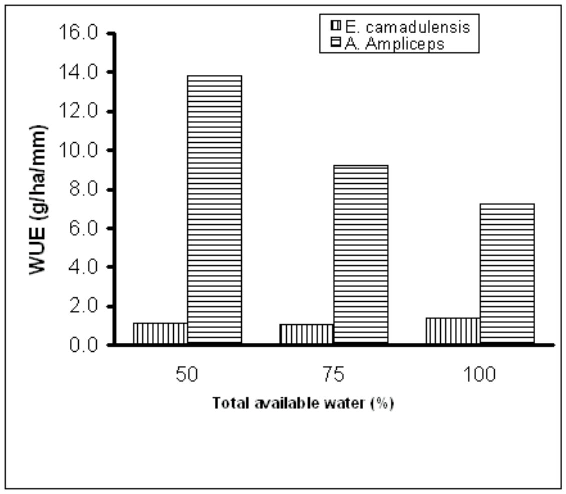

Figure-4: Water-Use Efficiency (WUE) of Eucalyptus Camaldulensis and Acacia Ampliceps, as a Function of Total Available Water

The standard is the carbon-dioxide obtained from "PDB", a limestone from Pee Dee Belmenite formation in South Carolina, USA and was provided by International Atomic Energy Agency (IAEA), Vienna, Austria. The $\delta^{13}C$ values are converted to Δvalues using the relation:

Δ (‰) = $(\delta^{13}C_a - \delta^{13}C_p) / (1 - \delta^{13}C_p/1000)$ Where, a and p represent air and plant,

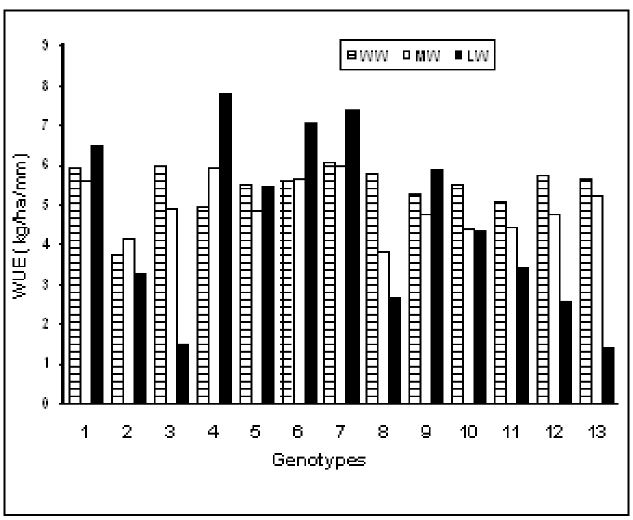

Figure-5. Water-Use Efficiency of 13 Rice Genotypes Under Well, Medium and Low Watered Levels

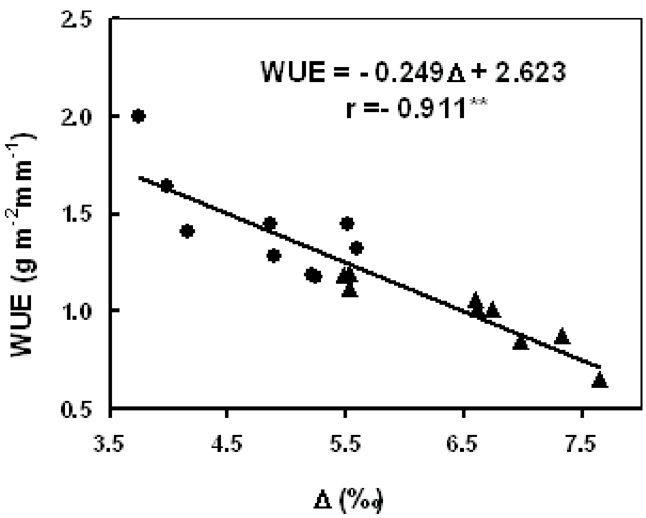

Figure-6: Relationship Between Water-Use Efficiency (WUE) and Carbon-Isotope Discrimination (Δ) for Combined Data of Kallar-Grass and Sporobolus-Arabicus

respectively. To convert $\delta^{13}C$ values to Δ values –8.00 ‰ ($\delta^{13}C_a$) for air was used in these studies.

5. SCREENING FOR HIGH WATER-USE-EFFICIENT GRASSES, TREES, AND CROP-PLANTS

The technique established (see section 4.b) is very useful and many plant-species have been screened successfully for their WUE and TE, including: 1. Leptochloa fusca (Kallar grass) 2. Sporobolus arabicus 3. Eucalyptus camaldulensis 4. Acacia ampliceps 5. Barley 6. Atriplex. 7. Rice. Some of these are described here as under:

a. Grasses (Kallar and Sporobolus)

Both the grasses exhibited significant differences in WUE at different water treatments (Figure-3). Sporobolus showed significantly higher mean WUE under all water-treatments compared with Kallar-grass. Sporobolus indicated highest WUE ($1.59 gm^{-2}mm^{-1}$) under medium-water followed by well-watered and low-watered treatments. The WUE of Kallar-grass increased with decrease in TAW and highest WUE was observed under low-water treatment. The data confirm that these grasses can be grown successfully in water-limited environments, by selecting an optimum level of soil-moisture for maximum biomass-production.

Carbon-isotope discrimination indicated that Sporobolus, with mean $\delta^{13}C$ value –12.37‰, and Kallar-grass, with mean $\delta^{13}C$ value –14.38 ‰, are C4 plant types (Akhter et al., 2003a). The carbon-isotope discrimination (D) was significantly and negatively correlated with WUE of the both species, separately and in pooled data. WUE of Kallar-grass (WUE = -0.189 D + 2.219) and Sporobolus-grass (WUE = -0.305 D + 2.912) showed significant negative correlations with D. The combined- regression between WUE and D of both the grasses is shown in Figure-6. The results of the present study confirm that $\delta^{13}C$ or D of leaves can be used as good predictor of WUE in some C4 plants.

b. Trees (Eucalyptus camaldulensis and Acacia ampliceps)

The water-use efficiency (WUE) of both the tree-species was affected by different soil-moisture levels. Overall magnitudes of WUE in E. camaldulensis were 1.40, 1.03 and 1.04 (g m^{-2} mm^{-1}) at well-, medium- and low-water treatments, respectively (Figure-4). A. ampliceps showed almost 5, 9 and 12 times higher water-use efficiency than E. Camaldulensis under low-watered, medium-watered and well-watered treatments, respectively. Higher WUE (13.86 g m^{-2} mm^{-1}) was observed in A. ampliceps for low-watered plants followed by medium-watered and well-watered plants. The well-watered E. camaldulensis plants showed highest WUE followed by low- and medium-watered plants. The results suggest that E. camaldulensis has a prodigal water-use strategy and may be useful plant for areas where water-availability is not a problem and A. ampliceps employs a conservative water-use strategy and can be grown in water-limited and high salinity conditions with more biomass yields (Akhter et al., 2005).

c. Rice

Thirteen rice-genotypes subjected to three water-regimes (see section 4.b) were

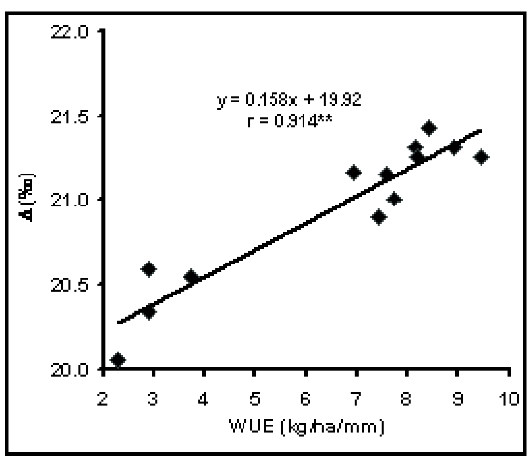

Figure-7: Relationship Between Water-Use Efficiency (WUE) and Carbon Isotope Discrimination (Δ) of Grain in 13 Rice-Genotypes

screened for high water-use efficiency. The selection history of these genotypes is described elsewhere. Three rice genotypes out of 13 genotypes showed very high grain-yields, with very high water use-efficiency (WUE). In general the WUE decreased with increase in water-stress in rice-genotypes (Figure-5), however, five genotypes showed higher WUE under low watered conditions. Under low-water condition, the highest WUE of 7.8 kg ha^{-1} mm^{-1} was obtained by genotype 4 (DM-49418) followed by 7.39 and 7.07 kg ha^{-1} mm^{-1} by genotype 7 (DM-64198) and 8 (Jhona-349xBas-370), respectively. Water-use efficiency showed significant positive correlation ($r \geq 0.884^*$) with Δ of grain under low-and medium-water conditions and non-significant positive correlation ($r \geq 0.666$) under well watered conditions. The straw Δ also showed non-significant positive correlation with WUE at different irrigation-levels. Correlation between leaf Δ and WUE (Figure-7) was positive, linear and highly significant ($r \geq 0.914$). Leaf Δ is integrative value and can be used as indirect criterion of screening for WUE in rice. Correlation between Δ and WUE were better for grain & leaves than straw and improved with water-stress. Significant correlation between Δ (grain/or leaf) and WUE showed that grain Δ can be used as a good indicator / predicator for WUE in C3 plants.

REFERENCES

- Akhter, J., Mahmood, K., Malik, K. A., Ahmad, S. and Murray, R. 2003. Amelioration of a saline sodic soil through cultivation of a salt-tolerant grass Leptochloa fusca. Environmental Conservation, 30:168-174.
- Akhter, J., Mahmood, K., Tasneem M. A., Malik, K.A., Naqvi, M.H., F. Hussain and Serraj, R. 2005. Water-use efficiency and carbon isotope discrimination of Acacia ampliceps and Eucalyptus camaldulensis at different soil moisture regimes under semi-arid conditions. Biologia Plantarum, 49: 269-272.
- Akhter, J., Mahmood, K., Tasneem M. A., Naqvi, M.H. and Malik, K.A. 2003a. Comparative water use-efficiency of Sporobolus arabicus and Leptochloa fusca and its relation with carbon-isotope discrimination under semi-arid conditions. Plant and Soil, 249:263-269.
- Akhter, J., Murray, R., Mahmood, K., Malik, K. A., Ahmad, S. 2004. Improvement of degraded physical properties of saline-sodic soil by reclamation with Kallar grass (Leptochloa fusca), Plant and Soil, 258:207-216.
- Akhter, J., Waheed, R.A., Aslam, Z. and Malik, K.A. 1987. A rapid method of appraising soil salinity. Pak. J. Agri. Sci., 24:123-128.
- Akhter, J., Waheed, R.A., Haq, M.I. Malik, K.A and Naqvi, S.H.M. 1986. Subsurface hydrology of North-west, Faisalabad using isotope techniques. 1. Water salinity investigations and mixing zones. Pak. J. Soil Sci., 1:13-20.
- Akhter, J., Waheed, R.A., Niazi, M.L.K., Malik, K.A. and Naqvi, S.H.M. 1988. Moisture properties of saline sodic soil as affected by growing Kallar grass using brackish water. Reclamation and Revegetation Research, 6:299-307.
- Akhter, J., Waheed, R.A., Sajjad, M.I., Malik, K.A. and Naqvi, S.H.M. 1990. Causes of ground water table fluctuations in north west of Faisalabad Division, Pakistan.

In: Soil physics applications under stress environment. Proc. of seminar held on 22-26 Jan. 1989, BARD, Pak. Agri. Res. Council, Islamabad. 94-110 pp.

- Malik K A, Aslam Z and Naqvi M 1986 Kallar grass. A plant for saline land. Ghulam Ali Printers, Lahore, Pakistan, 93 pp.
- Qadir M. and Oster J. D. 2002. Vegetative bioremediation of calcareous sodic soils: History, mechanisms and evaluation. Irrig. Sci., 21, 91-101.
- Qureshi R. H., and Barrett-Lnnard, E. G. 1998. Saline agriculture for irrigated lands in Pakistan. A handbook, ACIAR Monograph No. 50. Australian Center for International Agricultural Research. Canberra. 142 pp.
- Shaheen, R., Akhter, J. and Naqvi, M.H. 1997. Evaluation of electromagnetic technique for mapping soil salinity. J. Agri. Res., 35:41-48.

THE RELEVANCE OF NANO-SCIENCES TO PAKISTANI SCIENCE

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ABSTRACT

The world of science is buzzing with the term 'Nanoscience', which is the new, multi-disciplinary and highly innovative extension of the 20th century sciences and technologies. The entrepreneurs of physics, chemistry, biological and materials sciences are extending the frontiers of technology from the micro- to the nano-meter dimensions. The projected impact of the researches in Nanoscience will be small nano-scale materials and instruments, worth billions of dollars. We would discuss its relevance to Pakistani science, keeping in the view the meager human and financial resources.

1. A SUMMARY OF SOME OF THE TYPICAL ONGOING NANOTECHNOLOGY PROJECTS IN THE WORLD

Box - I: The Relationship of Nano-Sciences with the Existing Body of Sciences?

1. Nano-Sciences are the cutting edges of the existing sciences: their recognition has come in the last two decades.
2. There are different physical and chemical properties of the same material in macro/micro and nano dimensions and that is where the importance of the nano-dimensional material lies.
3. However, the same electron microscope at highest resolution, can see the nano-particles.

The following is the list of Nanotechnology projects that are shown on the official website of USA's National Science Foundation[1]. It may be mentioned here that, it was in USA that the National Nanotechnology Initiative (NNI) was launched after a large body of scientists agreed that a new dimension of scientific activity is being pursued by various labs and organizations. The top scientists of USA met the then president, Mr. Clinton, and formally launched this new and novel technological initiative - NNI - with massive governmental support. Other leading nations of the West and Japan followed and, ever since, the research and development in nano-sciences is leading to nano-technological products.

The following are some of the ongoing projects that have been shown to be within the reach of the existing knowledge and technologies:

- High-speed computing and *post-silicon* electronic devices.
- Intel plans for transistors that are 3 nm long and three atoms thick, to make a 10-GHz chip.
- High-speed genomic drug modeling (e.g., Intel, Compaq, and Celera are collaborating to build a 100-gigaflop proteomic analysis computer).
- Materials development and manufacture
- Quantity sales of Nanotubes (e.g., the goal of a new firm founded by Nobel laureate Richard E. Smalley).
- New and improved fabrics (e.g., Burlington Industries/Nano-Tex line of wrinkle-, stain-, and water-resistant clothing).
- Paints (e.g., German nano-scientists perfecting coatings and paints that can fill in cracks or release fire-retardants).
- Coatings for cosmetics, bio-sensors, and abrasion-resistant polymers; small-grained ceramic composites for stain and wear-resistance (e.g., research is under way at several National Aeronautics and Space Administration laboratories).
- Fluid membrane networks for solid-state devices for microfluidics and microelectronics (e.g., a project at Gothenburg University in Sweden).
- Environment and energy
- Nanotubes to store hydrogen for batteries and electric motors (e.g., National University of Singapore's demonstration project).

2. APPLICATIONS OF NANO-TECHNOLOGY THAT ARE SPECULATIVE

The ideas given below are logically consistent, but rely on unproven breakthroughs. They are improbable but are not disallowed by physics:

- Communicating and/or programmable molecular machines.
- Controlled genetic erection of large-scale structures.
- Artificial DNA as the programming language *and* the structural material.
- Ability to manufacture virtually anything, at practically no materials cost.
- Nanobots that operate inside cells, to cure diseases or reconstruct damaged DNA (i.e., nanobots that replace drugs).
- Artificial immune systems.
- Construction using air-pollution as the source of raw materials.

3. THE STATE OF PAKISTANI SCIENCE

To be able to visualize the state of Pakistani science one can use the yard stick of the significant achievements during the last seven years, i.e., 1998-2005. This is a period of major milestones in Pakistan's achievements and all are due to the hard work and dedication of its scientific community. Let us summarize these achievements:

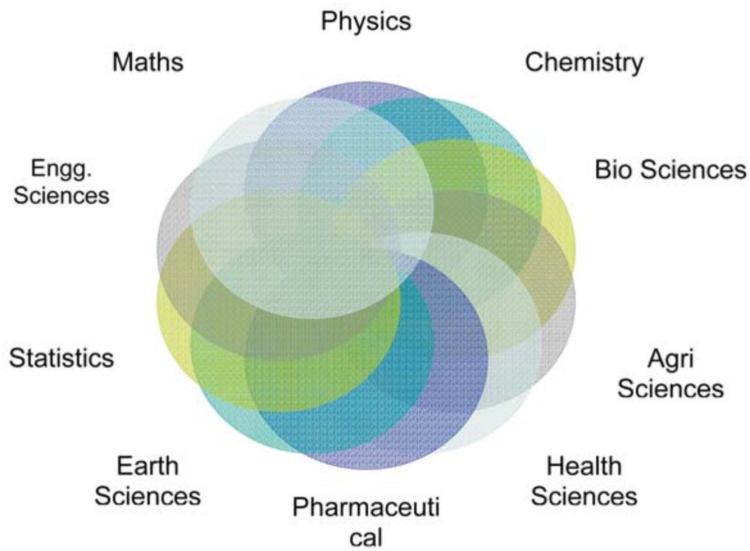

Figure - 1

i. Pakistan joined the Nuclear Club in 1998. It was a gigantic step that has redefined our place among the nations of the world. The ballistic-missile tests have added yet another important element in our defense capabilities.

ii. The ongoing IT revolution in Pakistan is unique among the developing nations, and will have its mark on the future commerce and financial management of our economy. The various scientific disciplines will certainly benefit from the IT revolution as well, but the real gain will be in the modernization of our economy.

iii. The recognition of the scientists and engineers by the State of Pakistan as a vitally important community, which is relevant for the defense as well as the civil society. A compendium of working scientists and engineers was published by the Ministry of Science and Technology-MOST in 1998, for the first time in this country. Its publication was an indication that the government was serious in recognizing science and technology as important pillars of modern Pakistan.

These developments have heralded a new era, in which science and technology were recognized and the scientists duly rewarded. During the last seven years, this recognition has come in the form of civil honors and awards by the State to the deserving scientists. A large number of Science and Technology (S&T) projects were awarded during the last one year to the working scientists and scholars in various universities and R&D organizations. The emphasis has been on the proven and established scientific credibility, rather than the rank and seniority. Three hundred doctoral fellowships were announced for the young men and women for research degrees in Pakistani and foreign universities. This again was an initiative, with a huge financial commitment by the government of Pakistan. Human-resource development is the key-area that was often neglected in the past. However, it needs to be said that the existing state of Pakistani science is not an ideal one for a developing country that has achieved the status of a nuclear power. Much more needs to be done. The following is a simplified analysis, based on the data provided by PCST in its two consecutive publications in 2000 and 2004 [2]. Pakistani Science, its magnitude and dimensions can be seen from the following:

- *There are barely ~ 700 productive scientists in all disciplines;*
- *There are < 100 research labs in the entire country; and*
- *These scientists and their labs are distributed among physics, chemistry, materials, engineering, bio and agricultural sciences.*

4 DISTRIBUTION OF PRODUCTIVE SCIENTISTS IN VARIOUS DISCIPLINES

The total number of productive Pakistani scientists are shown in the following pie-chart (Figure-2), where Chemistry is shown to be the most productive science among the Pakistani institutions, with Bio-sciences in the second and physics in the third place.

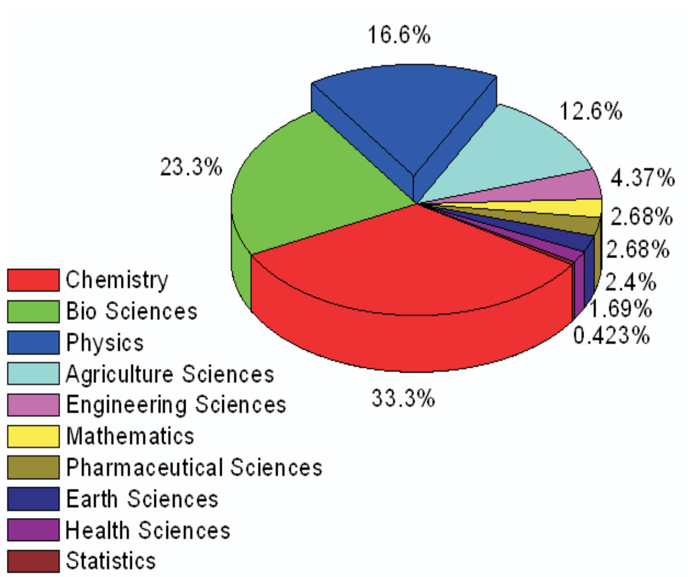

Figure - 2

5 OVERALL SCIENTIFIC ACTIVITIES IN MAJOR PAKISTANI CITIES

One major concern for some of us (i.e. those scientists, educationists and planners who worry about the state of Pakistani science and the contribution from all of our citizens) is the lack of a broader distribution of productive, higher educational institutions among all the provinces and cities of Pakistan. Science and scientific activity seems to be concentrated and centered in and around Islamabad. This is a trend that can isolate these productive scientists from the rest. The data in the two pie-diagrams (Figure 2A & 2B) shows that 90% productive scientists are working in universities and institutions in Islamabad and Rawalpindi.

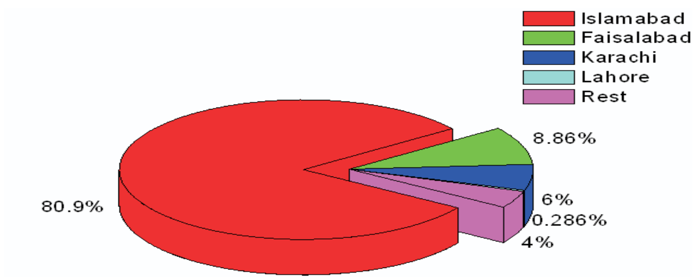

Figure - 2A: Number of Scientists

The two sets of data plotted above show the number of scientists in the first pie-chart (Figure-2A) while the measured productivity is given in the second pie chart (Figure-2B). The interesting feature is the small number of chemists (42 scientists) in Karachi, who have taken a large share of the national productivity. When compared with the Islamabad scientists (630 in all) their output is five times less per scientist compared with those of one Karachi institution i.e., HEJ RIC.

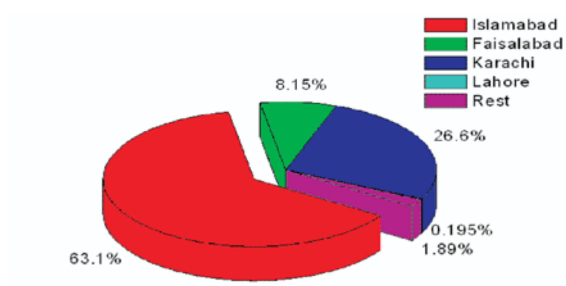

Figure - 2B: Scientists' Productivity as measured by PCST

6. RESEARCH ACTIVITIES AT UNIVERSITIES VERSUS R&D ORGANIZATIONS

There is an interesting pattern of research outputs, which shows that the universities and various R&D organizations share equal number of scientists and the productivity. This is shown in the two pie-charts shown in Figure-3 A & 3B . However, the disturbing fact is that only two of the universities, i.e., Quaid-i-Azam University (QAU) and Karachi University (KU) are the major contributors of research, while PAEC has most of the productive scientists as well as the lion's share of R&D organizations.

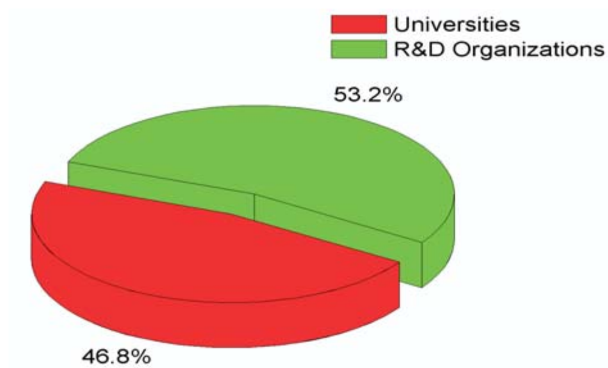

Figure-3A: Number of Productive Scientists

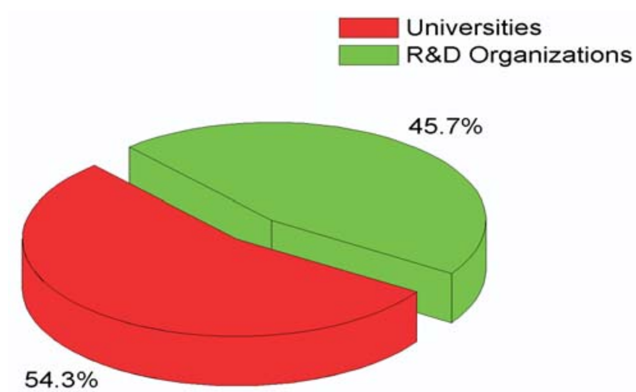

Figure - 3B: Productivity measured by PCST

a. The scenario with the new HEC initiative of "3,000 to 5,000" Ph.D.s in the next 5-8 years

Whereas the existing situation of Pakistani science is not very bright, the recent HEC initiative to get 3,000 to 5,000 Ph.D.s trained in the next 5 to 8 years looks like a silver lining on the horizon. There are two very important aspects of this initiative; one that deals with the capacity-building of the existing Pakistani higher educational infrastructure and the other part is the foreign Ph.D. training in Western and, similarly, North American universities. In the case of local doctoral research, the institutions will be strengthened and Pakistani science will get a big boost. However, this cannot bring about the fruits of new researches that are being done in the West, especially in fields like nanotechnology, etc; therefore, the foreign Ph.D. Scholars will be at an advantage and be in a position, to get training in advanced fields during their research degrees. In both of these cases, the Pakistani scientist will benefit and one hopes that, in the coming years, there will be much more activity in all disciplines of sciences and not just the nano-sciences. The figure shows the graphical representation of such a scenario.

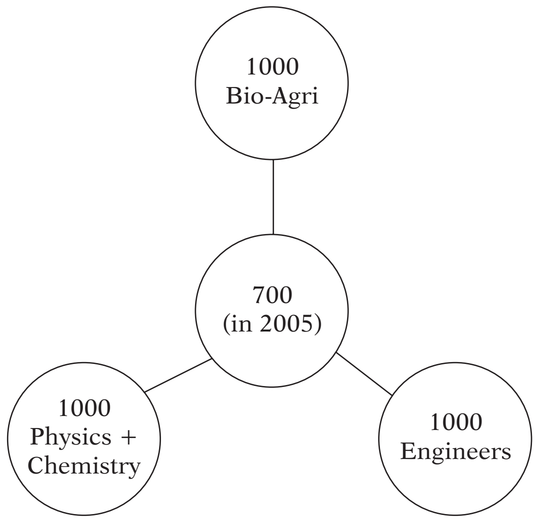

Figure - 4: Future Scenario of Pakistani Scientist

REFERENCES

1. NSF, USA's official web site: http:/www.nsf.gov
2. "Productive Scientists of Pakistan", Pakistan Council for Science and Technology, 2004., "Scientific Research in Pakistan", Pakistan Council for Science and Technology, 2000.

COMPUTER SIMULATION IN PHYSICS

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ABSTRACT

The computer, as we know it today, is hardly sixty years old. In this short period, there is hardly a branch of modern endeavors that has not been affected by it. One branch of science that has a symbiotic relationship with computers ever since their inception, is that of physics. This review-paper highlights the importance of Computer Simulation as a third branch of physics, the other two being theory and experiment. With the advent of cheap and powerful computers, it is envisaged that Computer-Simulation techniques will help more and more scientists from the developing nations to contribute to the developments at the frontiers of science and technology.

DEVELOPMENT OF THE COMPUTER

The advancements in the field of 'Computer-Simulation' are very closely and intimately linked with the advancements in the field of computer-technology. The advancements in computer-technology, over the past 60 years or so, have been breathtaking. From the ENIAC of 1945 to the whole variety of machines: main-frames, desktops, laptops, super-computers, the list is bewildering. ENIAC-the first digital machine-contained 18,000 vacuum-tubes, weighed 30 tons, and its tubes failed at an average rate of one every seven minutes. Thousands of times more computing power is now available to us in an integrated form, right on our desks. The brain of a simple desktop is contained in an integrated form, on a small chip, hardly one square inch in size. This chip contains more than a million transistors and its processing speed far exceeds 2 GHz. The applications of computers, in physics in particular, and science in general, have followed very closely these developments in the field of computer-technology.

APPLICATION OF COMPUTERS IN PHYSICS

Initially, the computer was basically meant to be a number-cruncher, a role it has been performing admirably right to this day. Broadly speaking, its applications in physics can be divided into the following four categories:

i. Numerical Analysis;
ii. Symbolic Manipulation;
iii. Simulation;
iv. Real-Time Control.

In Numerical Analysis, one computes with the help of computers-integrals, solves differential equations, manipulates large matrices and solves several other problems for which analytical solutions are not available.

A Symbolic-manipulation programme can give a solution of an equation in a symbolic form; for instance a quadratic equation of the form $ax^2+bx+c=0$ will have its solution in the form:

$$x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}$$

In addition, such a programme can give us the usual numerical solution for specific values of a, b and c.

In computer-simulation, a model of the physical system is used to teach/feed the computer the laws governing the evolution of the system.

In Real-Time Control, the computers are involved in almost all phases of a laboratory experiment, from the design of the apparatus, control of the apparatus (during experimental runs) to the collection and analysis of data. The tasks involved in control and interactive data-analysis involve real-time programming and the interface of computer-hardware to various types of instrumentation.

COMPUTER-SIMULATION

In recent years, the method of Computer Simulation (C.S.) has started something of a revolution in science: the old division of physics into an "experimental" and a "theoretical" branch is no longer really complete. Rather Computer-Simulation (C.S.) has assumed the role of a third branch of science, complementary to the two traditional approaches. It is now considered a valid scientific tool to understand the laws of nature.

Sometimes in literature, C.S. has been referred to as a "Computer Experiment". This is so, because it shares a lot of things with laboratory experiments. The following comparative table (Table - 1) shows the reasons for this:

Table - 1

Lab. Experiment	Computer Simulation
Sample	Model
Physical apparatus	Computer programme
Calibration	Testing of programme
Measurement	Computation
Data analysis	Data analysis

More often, C.S. has been referred to as 'theory'. This is so because the starting premise, both in C.S. and theoretical analysis is the model of a physical system.

It is to be emphasized that C.S. is in fact, neither of the two; rather it is to be classified as a third branch of science, which complements the other two in an attempt to study the laws of nature. The complimentary nature of the three techniques will become clear from the following flow-chart (Figure-1)which brings out the main features of the three techniques:

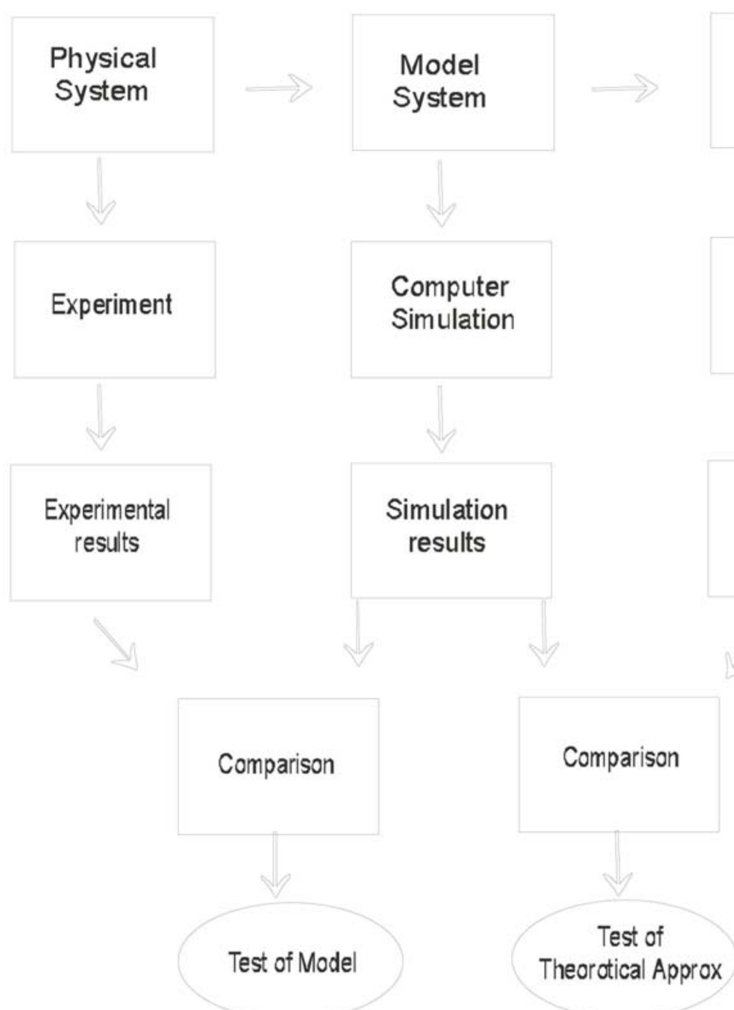

Figure - 1: Flow Chart

A comparison of the results generated through C.S. with the experimental results, sheds light on the trustworthiness of the model that was used in carrying out the simulations. It is to be noted that C.S. generates exact results only on model-systems that are precisely defined.

In both C.S. and analytical analysis, the starting premise is the same model of the system. Solving this model analytically is an impossible task except for a very limited number of cases. In almost all cases, approximations are used to carry out analysis of the model. A comparison of the results generated through C.S. with analytical results, therefore, is a good test of the validity of the approximations involved in carrying out the analytical work.

Therefore, C.S. acts as a two-edged sword. In one case, a comparison of its results with experimental results acts as a test of the model of the system and, on the other hand, a comparison with analytical results acts as a test of the approximations involved in carrying out the analytical results.

Apart from these important features of C.S., it is also employed in the following typical circumstances:

i. Where it is too dangerous or difficult to carry out an experiment e.g. extremes of temperature or pressure, as obtained in stars, high-temperature plasmas or nuclear reactors, etc;

ii. Where subtle details of molecular motion are difficult to probe experimentally, these can be followed readily by C.S.;

iii. Where the problem to be analyzed involves so much expense that any adjustments must be put into effect at the model-stage, before a commitment is made to a final version;

iv. Where the problem is totally theoretical and for which it is impossible to carry out physical experiments. Astrophysicists, for example, speculate on how stars are formed, and models are used to evaluate one cosmological theory, say "Big Bang", against another.

MODEL-MAKING IN PHYSICS

The one most important and critical aspect of C.S. is building the model of the physical system. The closer the model is to the real physical system, the better the results to be expected. But at the same time, one needs to keep in mind the fact that computers have a limited memory and speed. Therefore, the model must be such that it not only gives a simplified view of the real system but it must also preserve and retain the essential significant features of the problem, discarding minor details that will have little influence on the results of interest, the aim being to be able to solve the problem within the computer-resources available to us.

As a very simple example of a model, consider two glasses, one filled with white fluid and the other filled with red fluid. If a tea-spoon full of red fluid is added to the white fluid, thoroughly mixed and then a spoon-full of mixture is returned to the red glass, which glass has the greater impurity? There are many ways of tackling the problem. The simplest is to set up a model of the situation. In this model we assume that, instead of liquids in a glass, their volume is that of a spoon full. Now, it is very easy to see that in this case both glasses will have the same degree of impurity. Extending the model to larger quantities of fluid will show that the same is true in each case.

In order to study real systems, one formulates models where one has to limit the number of molecules or limit the interactions between them. In C.S., these models are then either solved through Stochastic (Statistical) techniques or through Deterministic methods.

SIMULATION TECHNIQUES

Since the physical systems and their models are usually classified into two families i.e. *deterministic* and *stochastic*, simulation techniques are also either deterministic or stochastic. The former technique is known by the name of *Molecular Dynamics,* while the later is called *Monte Carlo* simulation technique.

Monte Carlo Simulation

Systems that have an intrinsically stochastic behaviour, may be simulated on a computer in a straight forward way by generating this randomness on the computer. Some examples of such systems are Flipping of a coin, radioactive decay of nucleii, percolation, catalytic surface reactions, polymers, and most of the problems in statistical physics.

Take the example of flipping a coin. We would like to determine the probability of getting a head or a tail. Use is made of an algorithm that generates random number on the computer. Such an algorithm is called a Random Number Generator. In this case, successive numbers lying between 0 and 1 are randomly generated on the computer. In case, the random number generated is less than or equal to 0.5, the event is taken as a Head; for number greater than 0.5 the event is taken as a Tail. The generation of each random number is equivalent to performing a flip of the coin. The greater the flips or random numbers generated, the greater is the accuracy of the results. In fact, the error goes as 1/sq. rt(N), where N is the total number of attempts at generating a random number.

In Statistical Physics, one deals with systems with many degrees of freedom. The thermal average of any observable A(x) is defined in Canonical Ensemble as

$$\langle A(\underline{x})\rangle_T = \int d\underline{x}\ \exp\left[-H(\underline{x})/kT\right] A(\underline{x})/Z \qquad (1)$$

$$\text{where } Z = \int_\Omega d\underline{x}\ \exp\left[-H(\underline{x})/kT\right] \qquad (2)$$

T is the temperature and H the Hamiltonian of the system.

$x = (x_1,x_2,x_3,\ldots\ldots\ldots\ldots x_n)$ n being the number of degrees of freedom. The set of states constitutes the available phase-space.

Equation (1) represents a 6N dimensional integral and $N = 6\,X10^{23}$

It is impossible to solve such an integral either analytically or numerically. In C.S., one generates a characteristic sub-set of all phase-space points, which are used as a statistical sample and the integral is replaced by a summation. Various techniques are then available to study the evolution of the system in time.

Random Numbers

A very basic tool that is required in M.C. simulations is the generation of Random numbers with the help of a computer. There are various algorithms that perform this task. The random numbers that are generated through these techniques pass most of the tests of randomness. However, these random numbers are never truly random, since they employ "strict arithmetic procedures" for their generation, and this process is, therefore deterministic in the sense that their generation is ultimately repeatable. The same seed given as input will generate the same sequence of random numbers. In a way, this is helpful in simulation, as it allows one to repeat the same simulation, to look for any problems, etc. The cycle for the generation of random numbers is also repeatable. Once, a given number is repeated, the entire sequence following this number gets repeated.

Keeping these aspects in mind, two types of techniques are usually employed to generate random numbers on the computers. These are i) Linear Congruential Generators, and ii) Shift Register Methods. In Linear congruential technique, one previous number determines the generation of the successive random numbers while in Shift register method, the generation of a random number depends upon several initial numbers. Therefore, the later technique will have a very large repeatable cycle, as compared to the former. It must be emphasized that computers can never generate truly random numbers. The random numbers generated by computers are therefore, called 'pseudo random numbers'.

It is to be emphasized here that Monte Carlo techniques are also extensively employed to deterministic systems, for example in the calculation of multi-dimensional integrals. A simple example will illustrate this point:

This involves the determination of the value of Pi(π).

Consider a circle and its circumscribed square. The ratio of the area of the circle to the area of the square is Pi/4.

One good way of determining the value of Pi is to put a round cake with dia L inside a square pan of length L, and collect rain-drops over a period of time. Then ratio of the rain-drops falling on the cake to the number falling in the pan is Pi/4. An easier way of doing the experiment is to generate random-pair of coordinates lying between 0 and L/2. These represent random points in the 1st quadrant . The distance of this point from the origin is calculated. If the distance is less than or equal to one, then it is assumed that the point lies in the first quadrant of the circle. The ratio of points lying within the quadrant of the circle to the total number of points generated gives the value Pi/4. The accuracy in the calculation of Pi can be improved by increasing the number of tries (Figure-2).

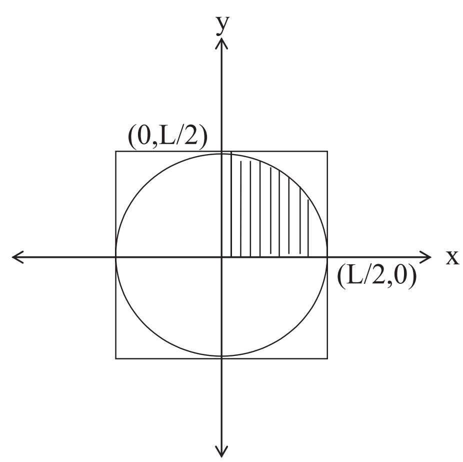

Figure - 2

This example illustrates that random sampling may be used to solve a mathematical problems, in this case evaluation of a definite integral.

$$I = \int_o^1 \int_o^{\sqrt{1-x2}} dx\ dy \qquad (3)$$

In many dimensions, Monte Carlo methods are often the only effective means of evaluating integrals.

Molecular Dynamics

In the Molecular Dynamics (M.D.) technique, the system is modeled by a limited number of particles (approx. 1000). These particles are allowed to evolve, in time, by the solution of Newton's equations of motion i.e. one solves the classical equations of motion for each particle. The initial input is the position and velocities of the particles. The positions are generated by assuming the initial configuration to be FCC, BCC, etc., and the velocities are generated by assuming a Maxwellian distribution for the velocities.

At each stage in the evolution of the system, a Potential-Energy function is employed to calculate the force exerted on each molecule. From the net force, one calculates the accelerations, velocities and new positions of the particles. These new positions are then again used to determine the forces. The process is continued, and one can then calculate the quantities of interest when the system achieves equilibrium.

The following assumptions are involved in setting up this model:

i. Dynamics of the system can be treated classically;
ii. Molecules are spherical and chemically inert;
iii. To start with, one assumes that the force between the molecules depends only on the distance between them;
iv. The choice of potential is very important in determining the correct properties of a system. Usually, a potential is chosen so as to give agreement with certain experimental results; the same potential can then be considered good enough for the system under different conditions. One of the most useful phenomenological forms of potential is the Lennard Jones potential:

$$V(r)=4 \epsilon [(\sigma/r)^{12} - (\sigma/r)^{6}] \quad (4)$$

Since, periodic boundary conditions are used in setting up the model-system, it is important that the range of the inter-molecular potential be less than the length of the box.

Also, periodic boundary conditions inhibit the occurrence of long wavelength fluctuations. The properties of systems near the critical point, where the fluctuations become important, is outside the scope of M.D.

CONCLUSION

With the advent of cheap and powerful computers, it is envisaged that Computer-Simulation techniques will help more and more scientists from the developing nations to contribute to developments at the frontiers of science and technology.

GENERAL READING

- D.W. Heerman: Computer Simulation Methods in Theoretical Physics (Springer, Berlin-Heidelberg-New York) 1986.
- K.Binder (ed): Applications of the Monte Carlo Method in Statistical Physics (Springer, Berlin-Heidelberg-New York) 1987.
- K.Binder (ed): Monte Carlo Methods in Statistical Physics (Springer, Berlin-Heidelberg-new York) 1986.
- W.G.Hoover: Molecular Dynamics (Springer, Berlin-Heidelberg-New York) 1985.
- J.Cornish: The Computer Simulation of Materials. Impact of Science on Society No.157 p.17.
- P. Bratley: A Guide to Simulation (Springer, Berlin-Heidelberg-New York)1983

- J.M. Hammersley and D.C. Handscomb: Monte Carlo Methods (Mathuen, London) 1964.
- R.Y. Rubenstein: Simulation and the Monte Carlo Method (John Wiley and Sons, New York) 1981.
- J.E. Hirsch and D.J. Scalapino: Condensed Matter Physics, Phys. Today, May 1983, p44.
- A.Sadiq and M.A. Khan: Computer Simulation of Physical Systems, Nucleus 17 (1980) 15.
- H. Gould and J.Tobochnik: An Introduction to Computer Simulation Methods (Addison-Wesley;New York) 1988.
- G. Ciccotti, D. Frenkel and I.R. McDonald (eds): Simulation of Liquids and Solids (North Holland) 1987.
- M.P.Allen and D.J. Tidesley: Computer Simulation of Liquids (Clarendon Press, Oxford) 1987.
- S. Ciccoti and N.G. Hoover (eds) Molecular Dynamics Simulation of Statistical Mechanical Systems. Enrico Fermi Course XCVII (North Holland) 1986.
- D.E. Knuth: The Art of Computer Programming vol. 2 (Addison Wesley) 1969.
- K. Binder and D.W.Heerman: Monte Carlo Simulation in Statistical Mechanics: An Introduction (Springer Verlag) 1988.
- P.Sloot: Modelling and Simulation, CERN School of Computing 1994.

BITE-OUT IN F2-LAYER AT KARACHI DURING SOLAR-MAXIMUM YEAR (1999-00) AND ITS EFFECTS ON HF-RADIO COMMUNICATION

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ABSTRACT

The main objective of this paper is to study the Bite-Out phenomenon in frequency of F2 layer at Karachi, during solar-maximum year (1999 – 00) of 23rd Solar Cycle, and its effects on HF-Communication, in the country and its vicinity. The study has been carried out both on the basis of non-classification and classification of Bite–Out (viz. Fore-Noon Bite-Out, Noon Bite-Out and Post-Noon Bite-Out), as well as in terms of severity of Bite-Out, measured by its maximum-depression (Dm). The seasonal variations of Bite-out in frequency of F2 layer are studied, using the f-plot of Karachi, for the period from July-1999 to December-2000. It is observed that the seasons, in order of decreasing trend of occurrence of Bite-Out in frequency of F2, at Karachi, irrespective of its classification, are Winter (73%), Summer (40 %) and Equinoxes (35%). Thus, the occurrence of Bite-Out in frequency of F2, at Karachi, is maximum in Winter, as compared to Summer and Equinoxes, where its occurrence is comparable. The seasons of minimum occurrence of the three categories of Bite-Out are respectively observed as Equinoxes (24.8 %, 3.7 % and 6.4 %) and maximum in Winter (35.5 %, 14 % and 23.4%). The maximum occurrence of severe (> 1.5 MHz), moderate (1.0 = Dm = 1.5 MHz) and Weak (0.5 = Dm = 0.9 MHz) Bite–Outs in frequency of F2, at Karachi, is respectively observed in Equinoxes (23.5%, 18.4%, 58.7%) and Winter (32.1%, 32.0%, 36%). The HF-Communication in Pakistan and its vicinity is likely to be disturbed / impaired highly in winter season, particularly in the morning hours. Hence, during the solar-maximum years alerts/warnings may be issued, just before the start of winter, to the national data-users in the country, for bad HF-Communication in Winter, particularly in the morning hours.

1. INTRODUCTION

From the photo-ionization of Atomic Oxygen 'O' by incoming solar radiation (800–1020ºA) in daytime, the electron-density (and hence the frequency of F2-layer) should increase. Sometimes, a depression / decrease in frequency equal to or more than 0.5 MHz is noted in the diurnal variation of frequency of F2 (ordinary wave-critical frequency of F2-layer). However, this depression in daytime, at or around Noon, is defined as the Bite-Out phenomenon (BERKNER and WELLS, 1934), if the maximum depression occurs in the Fore-Noon period, the phenomenon is called 'Fore-Noon Bite-Out' (HUANG and JENG, 1978). RAJARAM and RASTOGI (1977) reported that the cause of Noon Bite-Out was the E X B drift, where 'E' is the Electric field of Electrojet and ‘B’ is the geomagnetic field. The Bite-Out shows a marked dependence on longitude, Solar cycle epoch, magnetic disturbance, latitude and equatorial anomaly (MAEDA et al. 1942; RAO, 1963; ANDERSON, 1973 and HUANG and JENG 1978). HUANG and JENG, 1978 considered that Fore-Noon Bite-Out is caused by E X B drift (Khan et al., 1985). MAJEED (1979), using the ionospheric data of Karachi (24.95°N, 67.14°E) and Islamabad (33.75°N, 72.87°E), reported that, at times, frequency of F2 depresses more than 0.5MHz, between the two maxima, in the Post-Noon sector. In analogy of the definition of the Fore-Noon Bite-Out given by HUANG and JENG (1978), he called it as the “Post-Noon Bite-Out “. While discussing the cause of Post-Noon Bite-Out , MAJEED (1981) attempted to associate the Post-Noon Bite-Out with the effect of E X B drift. Later, MAJEED (1982) reported that the cause of Post-Noon Bite-Out cannot be determined at this stage, and further research is clearly required. KHAN et al (1985), from a seasonal study of frequency of F2 data of Karachi and Islamabad, concluded that both the Fore-Noon and Post-Noon Bite-Outs are caused by meridional winds (and not by E X B drift); which could satisfactorily

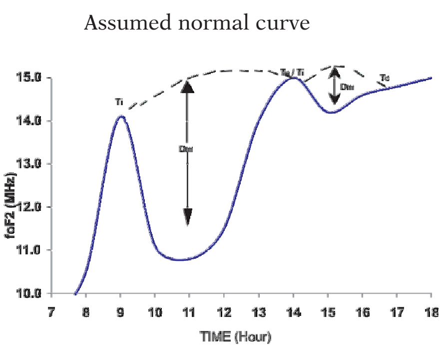

Figure - 1: A Typical Example of the Occurrence of Constructive Fore-Noon & Post-Noon Bite-Outs at Karachi on 13 October 2000

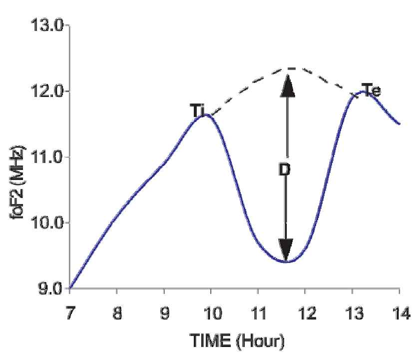

Figure - 2: A Typical Example of the Occurrence of Bite-Out at Karachi on 23 December 2000

explain the pole-ward and equation-ward propagation of maximum depression in frequency of F2.

The main objective of this paper is to study the seasonal variations of the phenomenon on a Bite-Out in frequency of F2 at Karachi, during Solar Maximum (1999-00). As the sudden depression in frequency during day-time due to Bit-Out in frequency of F2 may impair / disrupt the HF-communication, the alerts/warning for (e.g. Army, PN, PAF, PBC, PIA, etc) the bad propagation conditions prevailing in the country and the around will be issued to the National HF data-users, well in advance.

2. EXPERIMENTAL TECHNIQUE

This study employs the ionospheric data of Karachi acquired by Digisonde DGS–256 for exploring the ionosphere. The Digisonde DGS–256 is a highly sophisticated digital-ionospheric sounder, which was commissioned at Karachi Ionospheric Station (KIS), of SUPARCO in March, 1987. Since then, the Digisonde has been operating round-the-clock, acquiring the local ionospheric data at 15-minute intervals.

3. METHOD

The method used for the present study consists of the following steps:

3.1 Determination of the Bite-out Phenomenon

A maximum depression (Dm) in frequency of F2 > 0.5 MHz, occurring during the daytime from the assumed normal frequency plot (f-Plot), has been adopted as a criterion to decide whether a Bite-Out in frequency of F2 has occurred or not (Figure-1). This criterion has been used earlier by Huang and Jeng (1978), Majeed (1979) and Khan et. al (1985).

3.2 Classification of Bite–out, Based on the Time of Occurrence

Based on the time of the occurrence of Dm in f- plot, the phenomenon of Bite–Out in frequency of F2 has been classified into three categories, viz. Fore Noon Bite–Out (F.N.B.O.): Noon Bite–Out (N.B.O.); and Post Noon Bite-Out (P.N.B.O.) (Figs. 1 & 2). These categories of Bite-Out are defined as under:

i) F.N.B.O. : The Dm during this Bite-Out occurs in the Fore Noon sector.
ii) N.B.O. : The Dm during this Bite-Out occurs at Noon or around.
ii) P.N.B.O. : The Dm during this Bite-Out occurs in Post Noon sector.

3.3 Classification of Bite-out

The phenomenon of Bite – Out in frequency of F2 has been classified into three categories, (viz. weak, moderate and severe), according to the intensity of depression

(Dm) in frequency observed during the Bite-Out. The following criteria have been adopted for selection of three categories:

i) Weak Bite – Out : 0.5 = Dm = 0.9 Mhz
ii) Moderate Bite – Out : 1.0 = Dm = 1.5 Mhz
iii) Severe Bite – Out : Dm > 1.5 MHz

3.4 Selection of the Period for Solar-Maximum Year (1999 – 00)

The period of Solar-Maximum years (1999 – 00) for the purpose of present study is carefully selected from the 11- year Solar Cycle number 23, beginning from November, 1996. The Solar Cycle 23 is taken from Solar-Geophysical Data Prompt Report, number 670, Part – 1 of NOVA, NGDC, Boulder, Colorado, USA. This Solar maximum period is characterized by Sunspot No. 169.1 (SGD, 2001).

3.5 Classification of Seasons

The ionospheric data of Karachi have been divided seasonally for the present study. For this purpose, the following standard classification of seasons (for northern hemisphere) has been employed:

SEASON	**MONTHS**
Summer	May, June, July & August
Equinoxes	March, April, September & October
Winter	November, December, January & February

This seasonal classification has been used earlier by many authors, working in the field of Ionospheric Physics (SINKLAIR and KELLEHER, 1969; DOMENICI, 1975; etc).

3.6 Determination of Seasonal % Occurrence of Bite–out over Karachi at Solar Maximum Year (1999 – 00)

The % occurrence of the respective Fore-Noon, Noon and Post-Noon Bite-Outs shall be determined using the following formula:

$$\% \text{ Occurrence (in a Season)} = NB / ND \times 100 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where NB = Number of days of Bite-Out in a season
and ND = Number of days in a season when the data were available
This formula is applicable for all the three categories of Bite-Out.

3.7 Ionospheric Parameter

The present study uses the ionosheric parameter frequency of F2 (Ordinary Wave Critical Frequency for F2 – Layer), at one hour interval. This parameter can be seen in

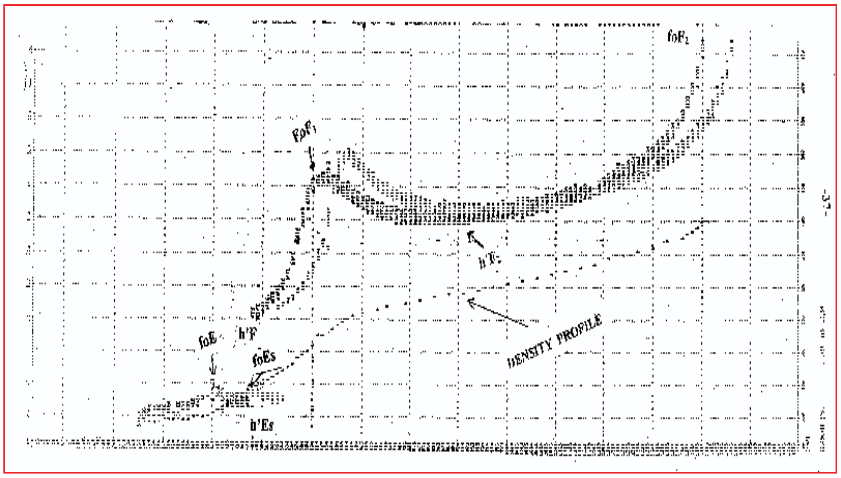

Figure - 3: An Ionogram of Digisonde at Karachi, Showing frequency of F2

the ionogram (Figure-3) acquired by Digisonde. As Digisonde uses UT (Universal Time) unit, the later has been converted into PST (Pakistan Standard Time) unit using the following relation: (PST = UT + 5 Hours).

3.8 Drawing of Graphs for Seasonal % Occurrence of Bite-out in frequency of F2

Following graphs have been drawn to carry out this study :

i) The graph drawn for the seasonal % occurrence of Bite-Out in frequency of F2, irrespective of its classification is shown in Figure-4.
ii) The graph drawn for the seasonal % occurrence of Bite-Out in frequency of F2, based on its classification into three categories, is shown in Figure-5.
iii) The graph drawn for the seasonal % occurrence of Bite-Out in frequency of F2, based on its severity, is shown in Figure-6.

4. RESULTS AND DISCUSSIONS

The present study shows:

i) The seasons in decreasing order of maximum occurrence of Bite-Out in frequency of F2 at Karachi, irrespective of its classification, are Winter (73%), Summer (39.5%) and Equinoxes (35%). Thus, the occurrence of Bite-Out in frequency of F2, at Karachi, is maximum in Winter and comparable (39.5%, 35.5%) in Summer and Equinoxes (Figure-4). As the occurrence of Bite-Out in frequency of F2 irrespective of its classification is maximum in Winter, the HF-Communication is likely to be disturbed / impaired due to occurrence of Bite-Out in frequency of F2 in Winter more than in Summer and Equinoxes. So, during Solar-Maximum years,

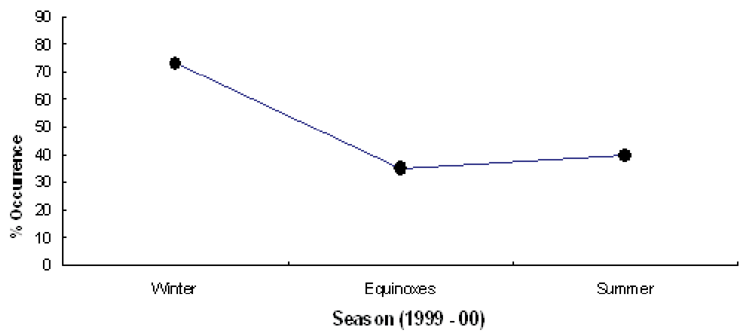

Figure - 4: Seasonal % Occurrence of Bite-Out over Karachi at Solar-Maximum Year (1999-00)

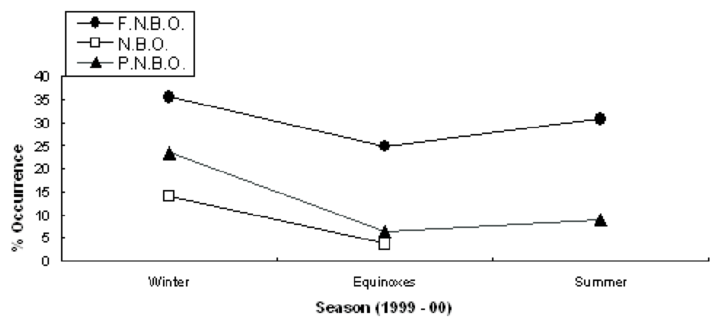

Figure - 5: Seasonal % Occurrence of F.N.B.O., N.B.O. & P.N.B.O at Karachi during Solar-Maximum Year (1999-00)

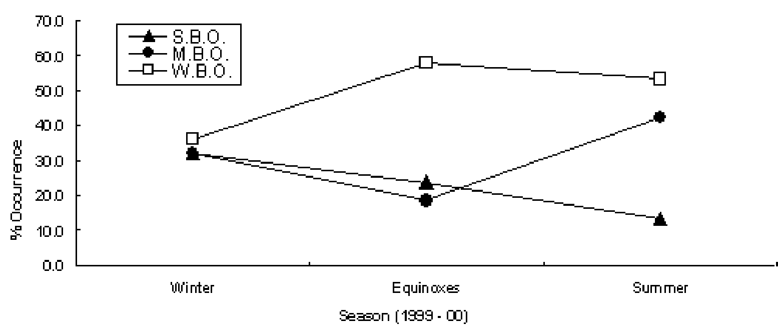

Figure - 6: Seasonal % Occurrence of Three Categories of Bite-Out (S.B.O., M.B.O. & W.B.O.) In frequency of F2 at Karachi during Solar-Maximum Year (1999-00)

we can issue alert/warning to the national data-users in the country just before the start of Winter season.

ii) The occurrence of Fore-Noon, Noon and Post-Noon Bite-Outs at Karachi is maximum in Winter and is 35%, 14% and 23.4% respectively (Figure-5). Thus, the occurrence of Fore-Noon Bite-Out in Winter is the highest among the three categories of Bite-Outs. The HF-Communication is, therefore, likely to be disturbed / impaired in Winter often in the morning sector.

iii) The occurrence of severe Bite-Out in frequency of F2 at Karachi in Winter, Equinoxes, and Summer is respectively observed to be 32 %, 23.3 % and 13.3 %. Thus, its occurrence is maximum in Winter and minimum in Summer. As the occurrence of severe Bite-Out in frequency of F2 at Karachi is maximum in Winter, the HF Communication is likely to be disturbed / impaired highly in Winter due to the Bite-Out in frequency of F2.

iv) The occurrence of moderate Bite-Out in frequency of F2 at Karachi in Winter, Equinoxes and Summer is respectively observed to be 32.1 %, 18.4 % and 42.2 % (Figure-6). Thus, its occurrence is maximum in Summer and minimum in Equinoxes.

v) The occurrence of Weak Bite-Out in frequency of F2 at Karachi in Winter, Equinoxes and Summer is respectively observed to be 36 %, 58 % and 53.3 % (Figure- 6). Thus, its occurrence is maximum in Equinoxes and minimum in Winter.

5. CONCLUSIONS

This study has concluded that :

i) The occurrence of Bite-Out in frequency of F2, at Karachi, irrespective of its classification into Fore-noon, Noon and Post-noon Bite-Out, is maximum in Winter.

ii) The occurrence of Fore-noon Bite-Out in frequency of F2, at Karachi, is maximum in Winter. This further leads to conclusion that the occurrence of Bite-Out in frequency of F2 at Karachi is maximum in Winter in the morning hours.

iii) The occurrence of severe Bite-Out in frequency of F2 at Karachi is maximum in Winter.

In view of the above conclusions, it may be finally concluded that the HF-Communication in Pakistan and its vicinity is likely to be disturbed / impaired highly in Winter season, particularly in the morning hours. Hence, during the Solar Maximum years Alerts / Warnings may be issued just before the start of Winter to national data-users in the country, for bad HF-Communication in Winter particularly in the morning hours.

ACKNOWLEDGEMENT

The authors are highly indebted to Chairman, SUPARCO, Mr. Raza Husain, *Engineer; for promoting the Ionospheric/geomagnetic research in Pakistan, Mr. M. Ayub, Manager is acknowledged for providing the ionospheric data of Karachi.*

REFERENCE FOR FURTHER READING

Anderson, D. N.	1973	Planet. Space. Sci., 21, 421.
Berkner, I. V. and Wells, H. W.	1934	Terr. Magn. Atmosph. Elec., 39, 215.
Huang, Y.N. and JENG, B. S.	1978	J. Atmosph. Terr. Phys., 40. 581
Khan, Z.M.; Ara, H.; Iqbal, S & M. Nasir	1985	J. Atmosph. Terr. Phys., 47, 719–724
Maeda, K., Uyeda, H. & Shinkawa, H.	1942	Phys. Inst. Radio. Waves, (Rep. No. 2.)
Majeed, T.	1981	Pak. J. Sci & Indus. Res., 24, 138
Majeed, T.	1982	Canadian. J. Phys., 60, 1176.
Majeed, T.	1979	M.S.c. Thesis submitted to Department of Physics, University of Karachi, Pakistan.
Rajaram, G. & Rastogi, R. G.	1977	J. Atmos. Terr. Phys., 39, 1175.
Rao, B. C. N.	1963	J. Geophys. Res., 68, 2541.
Dominici, P.	1975	Radio Sci., 7, 699.
Rastogi, R.G. & Sanatani S.	1968	Annls. Geophysics. 18, 315

SUSTAINABILITY OF LIFE ON PLANET EARTH: ROLE OF RENEWABLES

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ABSTRACT

The very life on this Earth is due to consumption of energy. Importance of energy cannot be over emphasized in the wake today; the global politics basically aim at controlling the energy-sources the world over.

The main energy-sources that we use today are coal, oil and gas, in short the fossil-fuels. The way these energy-sources are used, is highly non-sustainable. Primarily these fossil-fuels are a great threat to the environment and the lives of the habitants on Earth.

The demand - supply gap of energy is on the increase. Further the distribution of global energy is highly uneven. Now, the challenge to all the nations of the world is to extend the commercial energy services to the people who do not have it; the progress in this direction is the test of sustainability of our energy-systems. In this ever deteriorating scenario, renewable-energy technologies can give us solutions to many problems.

A number of renewable-energy sources are becoming progressively compatible and can play a vital role in keeping peace and sustaining life on the planet Earth, maintaining the standard of living, and in improving the socio-economic conditions of billions of people in the developing world. This paper specifically highlights the role of Renewable-Energy Technologies in this regard.

1. LIFE AND ENERGY

The very existence of the Universe is the result of the energy in action i.e., the Big-Bang. When there was nothing, there was energy that exploded and generated our universe, the planets, and eventually, the life on Earth. Thanks to the discovery of the Einstein's energy-equation—another mile stone in the history of physics – which explains that all material things, living or non-living have strong relation with the energy and these two are mutually convertible. All this explains that the life on the planet Earth came into being from some form of energy and hence, this life needs energy for its sustainability.

All living things, i.e. animals and plants, on this globe need energy for their birth, growth, and sustainability of their life. Without energy no living thing can survive. The plants get energy from Sun, and the animals take their energy-needs by digesting plants to sustain their life, and this cycle continues. So the nature has established a balance to sustain life on this planet.

The human-beings, the most intelligent specie on this globe, have discovered numerous energy-sources and developed technologies to use these for their comfort and survival. When man discovered fire, it became so important that all the early wars were fought to have the control on this extremely important source of energy, known at that time. Even today, all the modern comforts of life require some energy and it is the energy that keeps the wheel of the industry going. For this reason, the energy-consumption per capita is considered as the index for the socio-economic development and prosperity of a nation. It is for this reason that global politics aims to control the field of energy and governments spend billions of dollars, every year, for the safe flow of these sources of energy.

2. FOSSIL-FUELS AND THEIR IMPACT ON LIFE

In this modern era, most of the energy-sources are coming from the fossil-fuels that provide 75% of the world's energy-supplies, whereas 13% of global energy-needs are met by bio-mass that is used as traditional fuel in the developing countries [1]. Hydro-power sources, if taped fully, can cater only 13%, whereas nuclear is meeting only 10% of our present needs. We have limited reserves of fossil-fuels and these are fast depleting[2]. American oil-production has already crossed the peak in nineteen hundred and seventies, whereas world-oil production, excluding Middle-East, has already reached its peak. Extraction of Oil from the Middle-East is expected to start declining after another fifteen years [3]. So after 2020 demand-supply gap will fastly increase. This gap is to be filled by alternate or renewable-energy sources. It is believed that after 2050, fifty percent of the world's energy-supplies will come from renewables. Present energy- systems have failed to provide energy-services to two billion people (one third of the world population) that are living below the poverty level.

The fossil-fuels on combustion, release toxic gases into the air and have harmful impact on the environment. These are creating great health-risks through respiratory diseases. At the present rate of consumption, the total damage costs about US$ 3.6 trillion every year. Globally the fossil-fuels are releasing over 5giga tonnes of CO_2 into the atmosphere annually, raising CO_2 concentration, 315 ppm in 1960 to 360ppm in 1995 [4-5]. Prices of fossil-fuel do not include external costs such as, health risk, environmental degradation, and military expanses to have a control on the energy-sources and to have safe flow of oil. In case these external costs are included into the price of the fossil-fuels, they would have become unaffordable by many people of the world. Hence, fossil fuels are heavily subsidized.

The energy and environment is the biggest issue of the present time. It concerns all countries of the world and is on high-priority of UN agenda. The subject was much discussed during the 'Earth Summit', held in Rio, in June 1992. The summit concluded that the present course of world-energy is unsustainable.

The distribution of global energy is very uneven. Sixty percent of the global energy-supplies are used by 20% of the population living in the advanced countries [6]. Rest 30% of energy is used by 50% of world's population. There are two billion people (30% of the world population) that are living below the poverty level and do not have access to any commercial energy. Another $60x10^6$ GJ of energy is needed annually to provide them the basic necessities of life. How are we going to meet this? The answer lies in the development of renewable-energy technologies.

The structure of present energy-system is such that it encourages masses to migrate from rural to urban areas. This migration is creating unmanageable mega-cities and is a serious issue of industrialized world. Globally, in 1950, there were only 83 cities, with population of 1 million. Now this number has increased to 280 in 50 years [7, 8].

3. RENEWABLE-ENERGY AND SUSTAINABILITY

Renewable-energy sources, having reasonable magnitude, are solar, wind, biomass, and geothermal. Their usable volume is enormous. It is 140 times the worldwide annual energy-consumption and is enough to meet all our growing energy-needs for long times. Presently, only 0.1 % of these are being used [1,2]. There are number of incentives for the Governments to promote renewable-energy sources. These include, clean environment, new employment-opportunities, energy independence, provision of social services, improving the living conditions in the remote areas, reduction of mass migration from the rural to urban areas, and saving of foreign-exchange on import of energy. These incentives provide enough driving-force for the governments to fund and support the development of renewable-energy market.

Renewable-energy sources are decentralized in nature. It helps the local communities in the remote areas to become self-sufficient in energy. It cuts down all the overhead expenditures on energy-networking, transportation, etc; and reduces the energy-import bill. The activity generates local employment to help improve the socio-economic conditions of the country. It also helps to reduce the mass migration from

Table - 1: Renewables - The Installation World Over

Source	Generation	
Solar		
Photovoltaic	3,766 MW upto 2003	5,092 MW upto 2004
Solar Thermal		6000 – 9000 MW, 2020
Geothermal	7,974 MW for Power-Generation Upto 2000	17,174 MW for Thermal Heating upto 2000
Wind	39,294 MW, 2003	47,427 MW expected in 2004.
Biomass	7,500 MTOE, 2003	
Microhydel		19,000 MW in 2004

rural to urban areas.

This all explains that we do not have the scarcity of energy. The only thing we need to do is to shift from the conventional energy to the renewable-energy. This process has already been started and it is expected that by 2050, fifty percent of world's energy-supplies will come from the renewables. European Union has taken even bolder steps and has announced that they will meet this target by 2040. So this process of change has already started and there is a need to feel it and get ourself ready for the change.

Table-1 shows the world's installation of different renewable-energy resources. In photovoltaic 3,766 MW was installed in 2003 and in the current year, it is expected that 5,100 MW would be installed through out the world. 6000-9000 MW was expected in solar thermal in 2004. In geothermal it was 7,974 MW for power-generation and 17,174 MW for thermal heating in year 2000. According to World Wind-Energy Association the total installation for the year 2003 was 39,294 MW and they were expecting 47,427 MW by the year 2004. Biomass energy dominates current renewable Energy statistics and it was 7500 MTOE in 2003. In case of microhydel the total installation were expected to reach to 19,000MW all over the world by 2004.

4. RENEWABLES AND PAKISTAN

Pakistan is an energy-deficit country and it spends 3 Billion US dollars every year to import oil and this bill is increasing with annual growth-rate of nearly 1% [9]. There are large areas in the country having extreme remote character. These are far away from the gridline and there is no hope that these areas will get electricity even in coming 20 years. Energy services are to be extended to the poorest of the poor, living in the far-flung areas, to raise their standards of living, to a respectable level. This goal can be achieved by utilizing renewable-energy sources.

The most viable sources of renewable energy, in the country, are solar, wind, small hydro, biogas, and biomass. The available resources of different renewables are given in Table-2. This shows that Pakistan is blessed with plenty of renewable-energy sources, of which solar-energy is the most abundant and widely spread in the country. Biomass in the form of wood and agricultural waste is the main domestic energy-source in the rural areas. Pakistan is consuming 0.3 x 109GJ of biomass annually [10]. The way it is burned is not environment-friendly. On one hand, we are cutting down our jungles and on the other, the burning of agricultural waste is causing serious diseases among the community. There is quite a scope and need to adopt the new biomass-digester technology and to introduce energy-farming in this country. Disposal of municipal and industrial waste and its use in energy-sector is another important area to be looked in to.

Our Northern Mountains are rich with small hydro-sources [9-11]. About 300 MW has been estimated in the mountainous region of Pakistan. Currently only 1% is being utilized. This energy source, if taped properly, could be a good source of electric power,

Table - 2: Available Resources of Different R.E.Ts

TECHNOLOGY	RESOURCE AVAILABLE
Photovoltaic	• Sunny days : 250-300 days/years • Average solar radiation : 4.7 – 5.2 KWh/m^2 • Present energy-supplies : 47 MTOE/year Needs land area : 22 Km x 22 Km @ 10% efficiency
Micro-hydel	Mountains mini(100-500KW range) :400MW micro(<100KW) : 20MW Canal Falls small(1-10MW) :586MW micro(5-500KW) :200MW ----------- Total :1206MW (=2.08MTOE per year) ========
Biogas	13 billion cubic meter/year 180 million tones of fertilizer/year = 46 million tones of wood/year = 8 billion litter of kerosene oil/year
Biomass	Municipal solid-waste: 11000 tons/day (equivalent to 150 MW) in Lahore and Karachi only. Agriculture residue : **Million Tons** Field based : 64.53 Process based : 84.38 From Wood residue : 1.79 --------------- Total : 155.70 (=45.59 MTOE) =========
Wind	• Quite a number of pockets for use of small wind-turbine • For large production (grid-connection) needs resource assessment.

to meet the needs of local people.

With regard to solar energy, it is abundant, widely distributed and freely available through out the country. The average annual solar radiation being over 2 MW on one square meter in a year. It is so much in magnitude that it can cater all of our energy-requirements. It has been estimated that using only 20% efficient-devices solar energy falling on 0.25% of Baluchistan area is enough to meet the requirements of present day total energy-consumption of Pakistan. Further, more solar-energy technologies have wide applications, from power-generation to space-heating and cooling; from water-heating to drying the agricultural products, etc. Currently PV is being used on economical basis for applications such as, standalone telecommunication-systems, highway emergency phones, water pumping, etc. Only a total of about 800KW of PV has been installed in the country. There are large areas in the country that have the extreme remote character and are far away from the gridline. Baluchistan is such an example where there are no approach-roads. Even the tehsil headquarters are without electricity. Load-factor is very low, and there is no hope that these areas will get electricity even in coming 50 years. The power-requirement of these areas is very small. Most of the houses need only two bulbs and one point for Radio, TV or a fan at maximum. The use of PV is a very viable option for providing electricity for the welfare of the people in such areas. The initial investment in case of PV is higher, but the integrated cost due to extremely low maintenance of PV, becomes lower after five years, as compared to wind and ten-years in case of diesel. The extension of grid for

Table - 3: Renewable-Energy Technologies: Installed Capacity in Pakistan

Technology	Net Installed	Unit Size
Bio-mass	1500 units (during last 2 years)	3-35 m^3 / day
Biomass Improved Stoves	70, 000 units	12-28% efficient
Micro-hydel HHLD LHHD	300 units (3 MW) 225 units in pipeline 25 KW- in pipeline	3-300 KW 25-75 KW
Wind Mills (for water lifting)	30 units	150-8000 gph
Wind Turbines (for power generation)	134 units	0.3-0.5 KW
Photovoltaic	800 KW 65 KW- in pipeline	5-56 KW
Solar Water-Heaters	Limited production	Family size
Solar Cookers	3,000 units	250-750 watts
Solar Desalination	15,000 gal/day	250-6000 gal/day
Solar Dryers (for fruits)	Effectively being used in northern mountain regions.	

Figure - 1: A Panoramic View of the Village Gul Muhammad, 1st Pakistani Village Electrified by PCRET using Wind-Energy

small load in rural areas is also expensive as compared to PV. Other than PV, the thermal character of solar radiation can directly be used to heat the water, dry agricultural products, cook food and to produce potable water from saline water. These technologies are very simple and easy to adopt. The net installed capacity of such renewable-energy technologies are given in Table-3.

Realizing the importance and necessity of renewable-energy technologies, Govt. of Pakistan decided to establish the Pakistan Council of Renewable Energy Technologies (PCRET), in May 2001. The Council aims to take up R&D and promotional activities in different renewable-energy technologies. The main objectives of the Council are to establish facilities and expertise; to do research and develop suitable technologies to produce materials, devices, and appliances in the fields of renewable-energy; to workout policies and make short and long-term programmes to promote renewable-energy technologies; to establish national and international liaison in the field; and to advise and assist the government and relevant industries in the area.

The Government of Pakistan has the realization about the importance of renewable-energy for the future, and has given due recognition in the coming 5-year plan (2005-10), by allocating sizeable amount for the development and demonstration of renewable-energy. The solar-energy technology and microhydel are well developed in the country, whereas the wind-energy and biomass are growing fast.

About 300 units (of 4MW) of MHP plants have already been installed, whereas more than 200 are in the pipeline. During the last two years, four villages were electrified using PV and PV-hydride system, and four more are being electrified in Baluchistan. Under another project 125 mosques and schools will be electrified. More than 600 houses have been powered by wind in Baluchistan and Sindh. Figure-1 shows the first village electrified by PCRET using wind-energy. A number of parties in private-sector has also developed small wind-turbines and these are being tested. Solar drying is another important application and is being effectively used in the northern mountainous areas of the country. Under a new project, PCRET is now designing to install five solar-drying plants to dry dates, in date growing areas. PCRET has made an ambitious programme to develop these and other renewables, such as modern biomass and geothermal in the coming five years.

REFERENCES

1. World Energy Assessment: Energy and the Challenge of Sustainability, 2000, UNDP (United Nations Development Programme), New York.
2. P. Akhter (2001), Renewable Energy Technologies - An Energy Solution for Long-Term Sustainable Development; Science, Technology and Development; 20 (4) 2001, pp 25-35.
3. Energy for Tomorrow's World: Acting Now, 2000, World Energy Council, London.
4. Emerging Technology Series: Hydrogen Energy Technologies; 1998, UNIDO, Vienna.
5. White House Initiative on Global Climate Change, 2000, Office of Science and Technology Policy, Washington D.C. (www.whitehouse.gov/initiatives/climate/greenhouse.html).
6. Energy for Tomorrow's World Acting Now, 2000, World Energy Council, London.
7. World Energy Assessment: Energy and the Challenge of Sustainability, 2000, UNDP (United Nations Development Programme), New York.
8. Urban Air Pollution in Megacities of the World; United Nation Environment Programme and World Health Organization (UNEP & WHO), 1992, Blackwell Publisher.
9. Pakistan Energy Year book 2003, Hydrocarbon Development Institute of Pakistan, Islamabad.
10. M. Geyer and V. Quaschning: Solar Thermal Power – The Seamless Solar Link to the Conventional Power World, Renewable Energy World, 3(2000) 184-191.
11. Renewable Energy in South Asia, Status and Prospects, 2000, World Energy Council, London.

ROLE OF PHYSICS IN RENEWABLE-ENERGY TECHNOLOGIES

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ABSTRACT

The economic development of modern societies is crucially dependent on energy. The way this energy is produced, supplied and consumed, strongly affects the local and global environment and is therefore, a key issue in sustainable development, that is, development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. The research work reported in this paper gives a stark warning that not withstanding the considerable effort, now being made to reduce greenhouse gases and global emissions, will continue to increase unless the governments and communities collectively choose to change their pattern of the use of energy. Thermal design applications reported in this paper are based on the principles of heat-energy or work done and the principle job used is the engineering design to arrive at the amount and type of collection-equipment, necessary to achieve the optimum results. It is obvious that this kind of work is very much useful in Pakistan, as this country is very rich in solar energy. Keeping in view all the data-sets and observations, the feasibility of using renewable-energy technologies in the country like Pakistan, and especially in the tropical region of the country, is discussed.

INTRODUCTION

The most vital set of the contemporary challenges democracies and physicists are poised against is the pollution, the dwindling reserves of fossil-fuel and a rapidly changing global climate. The environment is one issue that gives enormous scope for new ideas, for widening the physics-based energy-technology possibilities, and for influencing governments to take wise decisions in energy-policy that will lead to greater climate-stability. It is physicists who know about these issues and it is physicists who should be at the forefront of debate on energy-use and climatic change. Continuing concern for the climate led to agreements to reduce emissions of greenhouse-gases, including CO_2. The economic development of modern societies is crucially dependent on energy. The way this energy is produced, supplied and consumed strongly affects the local and global environment, and is therefore a key issue in sustainable development, that is, the development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. Energy will become the major issue for international stability in the next century, as the world's population grows and people move away from regions with inadequate energy-supplies. Even conservative-estimates of population-growth indicate that major progress in energy-conservation and nuclear-power generation will not be enough to sustain humanity. Beyond the middle of the next century, new sources of energy that have a low impact on the environment and produce relatively harmless waste, will be needed.

Physicists should certainly support governmental initiatives to develop renewable-energy technologies such as wind-power, wave-power, solar-energy and hydroelectricity. It should be clearly pointed out that government's targets for reducing CO_2 can only be met through a growing programme of Renewable-Energy Technology. The environmental case for the role of nuclear plants in reducing emissions of carbon-dioxide should be strongly presented, in spite of the unfavorable press for nuclear energy. USA and Scandinavian countries are the perfect examples that have invested heavily in renewable-energy technologies and as a result the pollution levels of these countries fell dramatically. Research into renewable-energy technology needs the direct support of the entire physics-community. Physicists should lead a stronger lobbying effort for the progress of research in these technologies.

The renewables are fast becoming economic in niche markets, in developed countries and some renewable, have already become the cheapest options for stand-alone and off-grid applications, especially in developing countries. Hydro-power is well established in the country (Pakistan). Bio-mass, in the form of wood-fuel for heating and cooking, has been used extensively in Pakistan. Typically, the capital costs of renewable-energy technologies, the dominant cost-component for most renewables, have halved over the last decade. With further research and development and increased levels of production, costs are expected to be halved again over the next ten years, offering the prospect of widespread deployment in the near future.

There are also many other types of renewable-energy sources that could reduce our dependence on fossil-fuels. These include photovoltaics, fuel-cells, and the use of hydrogen as an energy-storage medium - whether in compressed or liquid form, or in solid carbon or metal structures. If RETs are to play a major role, then energy-storage technology will play a vital part in this development. Batteries, flywheels and superconducting magnets are among the other energy-storage methods that need to be supported.

Energy-policy cannot be divorced from energy-technology, and alternatively fuelled vehicles; with consequent cleaner air for cities, is one example. The huge potential for physics and physicists to get more involved in energy-technology and in lobbying for a sensible energy-policy that can deliver results is a future opportunity that should be grasped. It is up to physicists to give the lead where others feel unsure of the way ahead.

The research work reported in this study gives a stark warning that, notwithstanding the considerable effort now being made to reduce greenhouse-gases and global emissions will continue to increase unless government and communities collectively choose to change their pattern of energy-use. This change will involve not only a dramatic move away from the current situation in which most of world's energy is supplied by fossil fuels, but also a reduction in the energy and pollution-intensity due to economic activities. Along with other technologies, which will mitigate the CO_2 problem, this will involve a much more rapid growth in the deployment of renewable-sources of energy, the "renewable", than has not yet been achieved or planned for in Pakistan. Indeed, in the longer term, RETs must provide a large - and eventually the dominant - part of the country's (Pakistan's) energy-mix, so that economic growth is no longer dependent on fossil fuels.

RENEWABLE-ENERGY SOURCES

Renewable energy is power that comes from renewable sources such as the sun, wind and organic matter. These sources are constantly replenished by nature and are a cleaner source of energy. There are a number of renewable-energy sources, some of which include: Solar, wind, biomass, geothermal, hydrogen (Fuel Cells), hybrid systems, ocean energy, etc.

Solar Energy

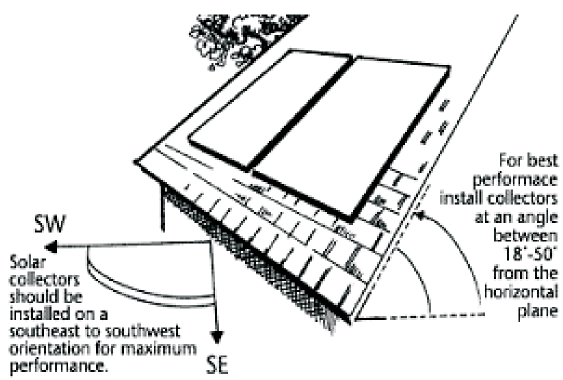
Solar energy is a clean and abundant resource of energy. It can be used to supplement most of the energy-needs. It can be utilized as a form of heat, electricity and space-heating. The amount of solar energy falling on Earth each day, is more than the total amount of energy, consumed by 6 billion people over 25 years. Using the power of the sun is not new. Now solar energy can be harnessed in different ways to provide heat and power, i.e., solar electric or photovoltaic systems, solar thermal or solar hot-water systems, solar air-systems or mechanical heat-recovery systems and passive solar systems.

Solar Thermal Systems: Solar thermal systems use energy from the sun to pre-heat water for hot-water or space-heating needs. Like solar electric systems they are very straightforward to install at home or business. Solar tubes or solar flat-plates, act as collectors of sunlight. When water is passed through them, it is heated and then pumped into the hot-water cylinder or boiler. Solar hot-water systems can save upto 50% of hot water/space-heating needs. A $3m^2$ solar thermal tube system would cost £3,000-£5,000, while a $4m^2$ flat-plate panel system would cost around £2,500-£4,000 to install. The cost would be dramatically lower if the system is installed without any industrial help. Consumers often ask if there is enough sunlight in Pakistan to support solar applications, such as water-heating. In fact, there is enough solar energy to deliver an average of 2500 kWh of energy per year. This means that a solar water-heater can provide enough solar energy to meet about one half of the water-heating energy-needs for a family of four. Heating-Water is one of the most cost-effective uses of solar energy, providing hot-water for showers, dishwashers and cloth-washers. Every year, several thousands of new solar water-heaters, are installed worldwide. Pakistani manufacturers have developed some of the most cost-effective systems in the world. Consumers can now buy “off-the-shelf” solar water-heaters that meet industry-wide standards, providing a clean alternative to gas, electric, oil or propane water-heaters. Freeze-protected solar water-heaters, manufactured in Canada have been specifically designed to operate reliably through the entire year, even when the outside temperature is either well below freezing or extremely hot.

A solar water-heater, reduces the amount of fuel needed to heat water, because it captures the sun's renewable energy. Many solar water-heaters use a small solar electric (photovoltaic) module to power the pump, needed to circulate the heat transfer fluid through the collectors. The use of such module allows the solar water-heater to operate even during a power outage. Solar water-heaters can also be used in other applications, for example, car washes; hotels and motels; restaurants; swimming pools; and laundry mats. There are many possible designs for a solar water-heater. In general, it consists of three main components: Solar collector, which converts solar radiation into useable heat, Heat exchanger/pump module, which transfers the heat from the solar collector into the potable water and storage tank to store the solar heated water.

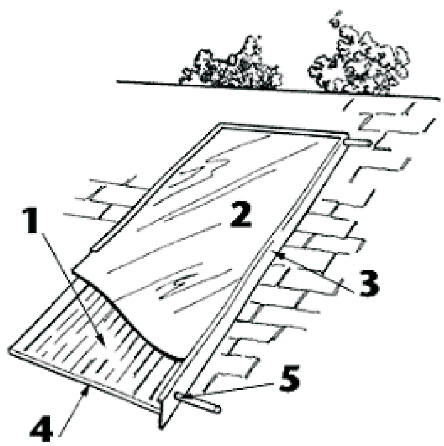
The most common types of solar collectors used in solar water-heaters are flat-plate and evacuated tube-collectors. In both cases, one or more collectors are mounted on a southerly-facing slope or roof and connected to a storage tank. When there is enough sunlight, a heat-transfer fluid, such as water or glycol, is pumped through the collector. As the fluid passes through the collector, it is heated by the sun. The heated fluid is then circulated to a heat-exchanger, which transfers the energy into the water-tank.

When a homeowner uses hot water, cold water from the main water supply enters the



Installation of Solar Panels

bottom of the solar storage-tank. Solar heated water at the top of the storage-tank, flows into the conventional water-heater and then to the taps. If the water at the top of the solar storage-tank is hot enough, no further heating is necessary. If the solar heated



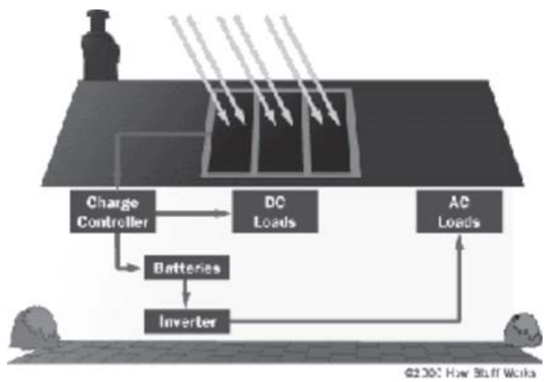
Cutaway View Showing Glazed Flat Plate: 1. Metallic Absorber, 2. Glazing, 3. Housing, 4. Insulation and 5. Heat Transfer fluid–inlet

water is only warm (after an extended cloudy period), the conventional water-heater brings the water up to the desired temperature.

Solar water-heaters available in Pakistan fall into two categories: year-round and seasonal. Year-round systems are designed to operate reliably through the entire year, in all extremes of weather. These systems are generally more expensive than seasonal systems, and usually provide more energy-savings. Seasonal solar water-heaters are designed to operate only when outdoor temperatures are above freezing point. Seasonal systems must be shut down during the winter months, when the temperature drops below the safe-operating range, stated by the manufacturer. Compared to year-round systems, these systems tend to be less expensive since they do not include the additional freeze-protection equipment. These heaters also produce less energy annually, because they operate for a shorter duration. Seasonal systems are ideal for summer-vacation homes and areas that do not experience freezing conditions.

Solar water-heaters are designed to last many years with little maintenance. A solar water-heater can reduce water-heating energy-needs by one-half, by giving significant savings, as well as clean energy. Solar water-heating systems for buildings have two main parts: a solar collector and a storage tank. Typically, a flat-plate collector (a thin, flat, rectangular box with a transparent cover) is mounted on the roof, facing the sun. The sun heats an absorber plate in the collector, which, in turn, heats the fluid running through tubes within the collector. To move the heated fluid between the collector and the storage-tank, a system either uses a pump or gravity, as water has a tendency to naturally circulate as it is heated. Systems that use fluids other than water in the collector's tubes, usually heat the water by passing it through a coil of tubing in the tank.

Photovoltaic (PV) Cells: Solar panels are devices that convert light into electricity. They are called solar after the sun or "Sol", because the sun is the most powerful source of the light to use. They are sometimes called 'photovoltaics', which means "light-electricity". Solar cells or PV cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charge-layers. Solar Photovoltaic (PV) systems generate electricity. PV will work in any weather, as long as there is daylight. The electricity can be used straight away or linked back into the power-grid. A typical house uses about 4000 kWh/yr of electricity. The average house probably has about $20m^2$ of south facing roof space. Photovoltaic (or PV) systems convert light-energy into electricity. The term "photo" is a stem from the Greek "phos," which means "light". "Volt" is named for Alessandro Volta (1745-1827), a pioneer in the study of electricity. Most commonly known as "solar cells", PV systems are already an important part of our lives. The simplest systems power many of the small



calculators and wrist-watches every day. More complicated systems provide electricity for pumping water, powering communications equipment and even lighting houses and running electrical appliances. In a surprising number of cases, PV power is the cheapest form of electricity for performing these tasks.

Solar PV does not convert all the energy from the sun directly into electricity. It is generally between 10 and 20% efficient, which means to gain about 150kWh/yr for every m^2 of PV. For a system, which is 15% efficient; around $22m^2$ of PV is needed to match the total electricity-demand of 3,300kWh/yr. Consider however that a gas-fired power-station is about 35% efficient at burning gas to form electricity, and the national grid loses 10% of that electricity in transmitting it great distances. This makes gas-fired power-stations only around 5 to 10% more efficient than solar PV, and of course burning gas to produce electricity is very damaging to the environment.

Among the three different forms of solar-energy technology, Solar PV can be the most expensive, but is potentially the easiest to install, manage and maintain. A typical household system can cost between £8,000-£20,000. This will provide approximately 35% of electricity or could save around £100 off the electricity bill every year.

Solar Air-Systems and Passive Solar-Systems: Solar air-heating is mainly used to heat incoming fresh air for ventilating a house. The simplest solar air-system needs no special panels, since it uses the slates or tiles on your roof as a solar collector. Other solar systems use mechanical extraction units, which extract hot air (heated by the sun) to colder parts of the house. Passive solar system uses the design and fabric of home to make the most of the sunlight available, i.e., south-facing houses get more sunshine.

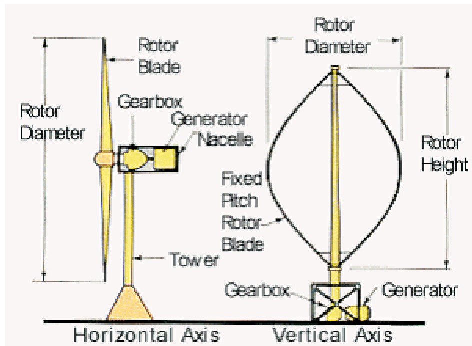
Passive solar system is best used when designed into a building from the outset. However, passive solar-technology can be utilized in existing home, by installing a conservatory. In this way, the fabric of the building can be used effectively to maintain constant temperatures at house or business, whatever the weather outside. Many large commercial buildings can use solar-collectors to provide more than just hot-water. Solar-process-heating systems can be used to heat these buildings. A solar ventilation-system can be used in cold climates to pre-heat air as it enters a building. The heat from a solar-collector can even be used to provide energy for cooling a building.

A solar-collector is not always needed when using sunlight to heat a building. Some buildings can be designed for passive solar-heating. These buildings usually have large, south-facing windows. Materials that absorb and store the sun’s heat can be built into the sunlit floors and walls. The floors and walls will then heat up during the day, and slowly release heat at night (a process called “direct gain”). Many of the passive solar-heating design-features also provide day-lighting. Day-lighting is simply the use of natural sunlight to brighten up a building’s interior.

WIND-ENERGY

Wind-energy is a converted form of solar energy. The sun’s radiation heats different parts of the Earth at different rates, most notably during the day and night, but also when different surfaces (for example, water and land) absorb or reflect at different rates. This in turn causes portions of the atmosphere to warm differently. Hot air rises, reducing the atmospheric pressure at the Earth's surface, and cooler air is drawn in to replace it. Resultantly wind is generated.

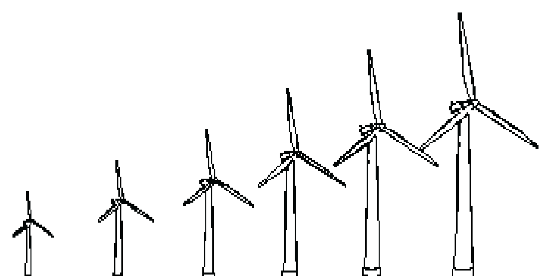
A wind-energy system transforms the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use. Mechanical energy is most commonly used for pumping water in rural or remote locations, the “farm windmill”, still seen in many rural areas of Pakistan, is a mechanical wind-pumper, but it can also be used for many other purposes (grinding grain, sawing, pushing a sailboat, etc). Wind electric turbines generate electricity for houses and businesses and for sale to utilities.



Wind Turbine Configurations

There are two basic designs of wind-electric turbines: vertical-axis, or "egg-beater" style and horizontal-axis (propeller-style) machines. Horizontal-axis wind-turbines are most common today, constituting nearly all of the "utility-scale" (100 kW capacity and larger) turbines in the global market.

Turbine subsystems include: a rotor, or blades, which convert the wind's energy into rotational shaft-energy; a nacelle (enclosure) containing a drive train, usually including a gearbox and a generator; a tower, to support the rotor and drive train; and



	1981	1985	1990	1996	1999	2000
Rotor (m)	10	17	27	40	50	71
Rating (KW)	25	100	225	550	750	1,650
Annual MWh	45	220	550	1,480	2,200	5,600

Source: www.awea.org/faq/tutorial/wwt_basics.html (15 Feb. 2005)

electronic equipment, such as controls, electrical cables, ground-support equipment, and interconnection equipment.

Wind turbines vary in size. This chart depicts a variety of turbine-sizes and the amount of electricity they are each capable of generating (the turbine's capacity, or power rating).

The electricity generated by a utility-scale wind-turbine is normally collected and fed into utility power-lines, where it is mixed with electricity, from other power-plants and delivered to utility-customers. The ability to generate electricity is measured in watts. Watts are very small units, so the terms kilowatt (kW = 1,000 watts), megawatt (MW = 1 million watts) and gigawatt (GW = 1 billion watts) are most commonly used to describe the capacity of generating units like wind-turbines or other power-plants.

Electricity production and consumption are most commonly measured in kilowatt-hours (kWh). A kilowatt-hour means one kilowatt (1,000 watts) of electricity produced or consumed for one hour. One 50-watt light bulb left on for 20 hours consumes one kilowatt-hour of electricity (50 watts x 20 hours = 1,000 watt-hours = 1 kilowatt-hour). The output of a wind-turbine depends on the turbine's size and the wind-speed through the rotor. Wind-turbines being manufactured now have power-ratings, ranging from 250 watts to 1.8 megawatts (MW). A 10-kW wind-turbine can generate about 10,000 kWh annually at a site, with wind-speeds averaging 12 miles per hour, or about enough to power a typical household. A 1.8-MW turbine can produce more than 5.2 million kWh in a year, which is enough to power more than 500 households. The average Pakistani household consumes about 10,000 kWh of electricity each year.

Wind-speed is a crucial element in projecting turbine's performance, and a site's wind-speed is measured through wind-resource assessment, prior to a wind system's construction. Generally, an annual average wind-speed greater than 4 m/s (9 mph) is required for small wind-electric turbines (less wind is required for water-pumping operations). Utility-scale wind-power plants require minimum average wind-speeds of 6 m/s (13 mph).

The power available in the wind is proportional to the cube of its speed, which means that doubling the wind-speed increases the available power by a factor of eight. Thus, a turbine operating at a site with an average wind-speed of 12 mph could, in theory, generate about 33% more electricity than one at an 11mph site, because the cube of 12 (1,768) is 33% larger than the cube of 11 (1,331). A small difference in wind-speed can mean a large difference in available energy and in electricity produced, and therefore, a large difference in the cost of the electricity generated. There is little energy to be harvested, at very low wind-speeds (6-mph winds contain less than one-eighth the energy of 12-mph winds).

Utility-scale wind-turbines for land-based wind-farms come in various sizes, with rotor diameters ranging from about 50 meters to about 90 meters, and with towers of roughly the same size. Offshore turbine-designs, now under development will have larger rotors. At present, the largest turbine has a 110 meter rotor- diameter, because it is easier to transport large rotor-blades by ship than by land. Small wind-turbines, intended for residential or small business use, are much smaller. Most have rotor-diameters of 8 meters or less and would be mounted on towers of 40 meters in height or less.

Most manufacturers of utility-scale turbines offer machines in the 700 kW to 1.8 MW range. Ten 700 kW units would make a 7 MW wind-plant, while ten 1.8 MW machines would make a 18 MW facility. In the future, machines of larger size will be available, although they will probably be installed offshore, where larger transportation and construction equipment can be used. Units larger than 4 MW in capacity are now under development.

An average Pakistani household uses about 10,000 kWh of electricity each year. One MW of wind-energy can generate between 2.4 million and 3 million kWh annually. Therefore, a MW of wind, generates about as much electricity as 240 to 300 households use. It is important to note that since the wind does not blow all of the time, it cannot be the only power source for that many households without some form of storage-system. The "number of homes served" is just a convenient way to translate a quantity of electricity into a familiar term that people can understand. The most economical application of wind-electric turbines is in groups of large machines (660 kW and up), called "wind-power plants" or "wind-farms".

Wind plants can range in size from a few megawatts to hundreds of megawatts in capacity. Wind-power plants are "modular", which means they consist of small individual modules (the turbines) and can easily be made larger or smaller as needed. Turbines can be added as electricity-demand grows. Today, a 50 MW wind-farm can be completed in 18 months to two years. Most of that time is needed for measuring the wind and obtaining construction permits. The wind-farm itself can be built in less than six months.

No one knows yet, how successful green-programs and products will be in the electricity-marketplace. If consumers learn more about the air pollution, strip mining, and other harmful environmental impacts of electricity-generation and decide to "vote with their dollars" for clean-energy, green-power could become a large and growing business over the next decade and beyond.

A wind-turbine will vary in cost, depending on the size of the machine and where it is installed. The following table gives an idea of the sorts of costs involved.

It is not easy to install a wind-generator at home or business, particularly in an urban-environment, but wind-turbines are typically four times more effective than solar PV at

Size of System	Application	Rated Output	Typical Installed Cost
Small	Batter charging	50/70W	£350-£500
Small	Batter charging	600W	£3000
Medium	Batter charging/ Grid connect	6kW	£18,000
Medium	Grid connect	60kW	£90,000
Large	Grid connect	600kW	£390,000
Large	Grid connect	2MW	£1.4 M

producing electricity in the right conditions. For smaller scale turbines, the p/kWh figures will be very high with payback periods in the region of over 50 years. For grid-connected turbines, simple payback periods can drop to under five years. Together with operation and maintenance costs (about 2-3% of the capital cost), running costs for larger wind-farm projects are around 2.5-3p/kWh. The great thing about that figure is it starts to become competitive with the main CO^2 producing fuels: gas, oil and coal.

BIOMASS ENERGY

The energy contained in biomass such as trees, grasses, crops and even animal manure, can be used very efficiently. Although biomass material is not strictly speaking “infinite” as a resource, it is still considered renewable, because it can be replaced at the same rate, as which it is used. Biomass is also referred to as “bioenergy” or “biofuels”. Over 100 sewage-farms in the UK generate heat and electricity from waste. Biomass can be used for heating or for electricity-generation and can serve a single household, a larger building like a school or linked together into a “heat network”, to supply hundreds or even thousands of homes, schools, hospitals and universities.

There are broadly two categories of Biomass:

a. *Woody biomass including:*
   1 Forest residues - from woodland thinning and “lop and top” after felling,
   2 Untreated wood-waste, such as that from sawmills and furniture factories,
   3 Crop residues, such as straw
   4 Energy Crops such as Short Rotation Coppice (SRC) (like willow and poplar), and miscanthus (elephant grass)

b. *Non woody biomass including:*
   1 Animal wastes, e.g. slurry from cows and pigs, chicken litter
   2 Industrial and municipal wastes including food-processing wastes
   3 High-energy crops, e.g. rape, sugarcane, maize.

There are the costs of getting the machinery to burn the biomass fitted and then the costs of the materials themselves. Total costs will depend on how large the system is and how much fuel is used. This guide shows the costs of installing and running a small domestic-size plant of around 10-15kW. The table below gives a summary of the

Fuel	Capital costs/kW	Unit energy costs
Logs	£500	1.7 p/kWh
Wood Pellets	£600	1.78 p/kWh
Wood Chips	£650	1 p/kWh
Oil, e.g. rapeseed oil	£150	1.89 p/kWh

Source: Postgraduate Distance Learning Services in Renewable erngy System Technology, CREST, 2000 installed costs, per kW of heat output, installed by a professional.

Biomass often replaces electricity, peat or oil as fuel for heating homes, all three of which have significant environmental impacts, including releasing carbon-dioxide into the atmosphere. Biomass is “carbon neutral”, i.e. the amount of carbon it absorbs while growing is the same as the amount it produces when burned. In some cases, treating the biomass also avoids the release of methane, which is 25 times stronger than carbon dioxide, in terms of its global-warming impact. There are smoke control areas throughout Britain that affect the rules on burning fuel and all chimneys need to conform to building-regulations. Burning dry-wood on decent credible appliances outside these areas is no problem. Inside, wood can only be burnt on ‘Exempted-Appliances’, to ensure emissions are below a certain level. Wood, when burnt, has a low ash-content and is high in potash, which makes it a great low-grade fertilizer.

GEOTHERMAL ENERGY

In the uppermost six miles of the Earth’s crust, there is a whopping 50,000 times the energy of all oil and gas resources in the world. The energy stored in the Earth, escapes to the surface in several ways, most spectacularly from volcanoes or bubbling hot-water springs. In Iceland, water comes to the surface at 200-300°C. In fact the city of Reykjavik is almost entirely heated with geothermal heat. In the UK, the geothermal resource is not as hot, but deep underneath the city of Southampton is a layer of sandstone, at a temperature of 76°C. Since 1986, the city has been tapping this underground-resource, to provide heating to council buildings, hospitals, university, hotels and even a supermarket. The temperature, just a few metres below the surface in the UK, is generally around 12°C. Ground-source heat-pumps can access this heat and be used to power individual houses. For every unit of electricity used to power a heat-pump it can deliver between 3 and 4 units of heat to the point of use, within the home or office. Heat can be extracted from the air, water or ground outside the building, even when the temperature to us seems very cold.

Ground-Source Heat-Pumps: The good thing about a ground source heat-pump is that it produces more units of heat than the units of electricity needed to power it. Pumps generally produce between 2.5-4kWh of heat for every kWh of electricity used. Heat pumped from the ground also means less CO_2 and other pollutants are released: the best gas-condensing boiler still produces 35%-50% more CO_2 than a heat-pump does, and gas is the least carbon-intensive of the fossil-fuels. Traditionally, the refrigerants in heat-pumps have been chlorofluorocarbons and hydrochlorofluorocarbons (CFCs and HCFCs), which are responsible for global warming and the depletion of the ozone-layer. After trying many alternatives, these are being phased out in favour of hydrofluorocarbons (HFCs), which do not affect the ozone-layer.

The market for heat-pumps is still in its infancy, but it is growing fast. The figures below show a summary of the installed costs, for kW of thermal output, for a professional installation of a ground-source heat-pump for an individual dwelling.

Capital costs/kW thermal installed	**Full capital costs inc. Underfloor distribution system**	**Ground Loop- and Heat Pump**	**Ground-Loop**	**Heat-Pump**
Vertical borehole GSHPs	£1,400 - £1,700	£1,000	£600	£400
Horizontal slinky and GSHPs	£1,200 - £1,500	£800	£400	£400

Source: A Resource Audit and Market Survey of Renewable Energy Resources in Cornwall CSMA, 2001

Due to the one-off cost of a ground loop, the minimum price for a small system, is about £4,000, while the cost of installing a typical 8kW pump hovers around the £6,400-£8,000 mark. But as the technology matures and the industry grows, these prices are likely to drop and, as always, it's about the long-term investment. Heat-pumps are ideally suited to newly-built houses, where they do not have to compensate for poor insulation. Before installing a pump in an existing property, it's probably wise to look into improving its energy-efficiency. Running the pump costs one-third to one-quarter of the cost of electricity, and in highly-insulated homes significant savings can be made. Payback-periods may be quite long, compared to conventional gas and still tend to be in excess of 10 years, compared to heating oil, but can really pay off in smaller houses.

HYDROGEN-ENERGY (FUEL-CELLS)

Hydrogen is the simplest element, and importantly, it is the most plentiful element in the universe. Hydrogen does not actually occur naturally as a gas alone, it is always combined with other elements. Water, for example, is a combination of hydrogen and oxygen (H_2O). Fuel cells have been designed to combine hydrogen and oxygen to form electricity, heat and water. A conventional battery converts the energy created by a chemical reaction into electricity. Fuel cells do the same thing for as long as hydrogen is supplied. Fuel cells are being developed for providing heat and power to individual or multiple homes, and for powering cars. They operate best on pure hydrogen, but other natural gases can be converted into hydrogen too. Technically speaking, a fuel cell is an Electrochemical Energy Conversion Device. A fuel cell converts the hydrogen and oxygen into water, and in the process, it produces electricity. A battery has all of its chemicals stored inside and it converts those chemicals into electricity too. This means that a battery eventually "goes dead" and it is either thrown away or is required to be recharged. Within a fuel cell, the chemicals constantly flow, so it never goes dead. As long as there is a flow of chemicals into the cell, the electricity flows out of the cell. Most fuel cells, in use today, use hydrogen and oxygen as the chemicals. A fuel cell provides a DC (direct current) voltage.

There are several different types of fuel cells, each using a different chemistry. Fuel cells are usually classified by the type of electrolyte they use. Some types of fuel cells work well for use in stationary power-generation plants. Others may be useful for small portable applications or for powering cars.

The Proton-Exchange Membrane Fuel Cell (PEMFC) is one of the most promising technologies. This is the type of fuel cell that will end up powering cars, buses and maybe even houses. It uses one of the simplest reactions of any fuel cell. There are four basic elements of a PEMFC: (a) The anode, the negative post of the fuel cell, has several jobs. It conducts the electrons that are freed from the hydrogen molecules so that they can be used in an external circuit. It has channels etched into it that disperse the hydrogen-gas equally over the surface of the catalyst; (b) The cathode, the positive post of the fuel cell, has channels etched into it that distribute the oxygen to the surface of the catalyst. It also conducts the electrons back from the external circuit to the catalyst, where they can recombine with the hydrogen-ions and oxygen to form water; (c) the electrolyte is the proton-exchange membrane. This specially treated material, which looks something like ordinary kitchen plastic wrap, only conducts positively charged ions. The membrane blocks electrons; and (d) the catalyst is a special material that facilitates the reaction of oxygen and hydrogen. It is usually made of platinum powder very thinly coated onto carbon-paper or cloth. The catalyst is rough and porous so that the maximum surface-area of the platinum, can be exposed to the hydrogen or oxygen. The platinum-coated side of the catalyst faces the PEM.

Fuel-Cell Stack: The reaction in a single fuel-cell produces only about 0.7 volts. To get this voltage up to a reasonable level, many separate fuel-cells must be combined to form a fuel-cell stack. PEMFCs operate at a fairly low temperature, i.e. about 176°F (80°C), which means they warm up quickly and don't require expensive containment-structures.

Fuel-Cell-Powered Electric Car: If the fuel-cell is powered with pure hydrogen, it has the potential to be up to 80% efficient. That is, it converts 80% of the energy-content of the hydrogen into electrical energy. But, as we know that the hydrogen is difficult to store in a car. When a reformer is added to convert methanol to hydrogen, the overall efficiency drops to about 30 to 40%. We still need to convert the electrical energy into mechanical work. This is accomplished by the electric motor and inverter. A reasonable number for the efficiency of the motor/inverter is about 80%. So we have 30 to 40% efficiency for converting methanol to electricity, and 80% efficiency for converting electricity to mechanical power. That gives an overall efficiency of about 24 to 32%.

There are several other types of fuel-cell technologies that being developed for possible commercial uses:

a. Alkaline-Fuel Cell (AFC): This is one of the oldest designs. It has been used in the U.S. space program since the 1960s. The AFC is very susceptible to contamination, so it requires pure hydrogen and oxygen. It is also very expensive, so this type of fuel-cell is unlikely to be commercialized.

b. Phosphoric-Acid Fuel-Cell (PAFC): The phosphoric-acid fuel-cell has potential for use in small stationary power-generation systems. It operates at a higher temperature than PEM fuel-cells, so it has a longer warm-up time. This makes it unsuitable for use in cars.

c. Solid-Oxide Fuel-Cell (SOFC): These fuel-cells are best suited for large-scale stationary power-generators that could provide electricity for factories or towns. This type of fuel-cell operates at very high temperatures (around 1,832 F, 1,000 C). This high temperature makes reliability a problem, but it also has an advantage: the steam produced by the fuel-cell can be channeled into turbines to generate more electricity. This improves the overall efficiency of the system.

d. Molten-Carbonate Fuel-Cell (MCFC): These fuel cells are also best suited for large stationary power-generators. They operate at 1,112°F (600°C), so they also generate steam that can be used to generate more power. They have a lower operating temperature than the SOFC, which means they don't need such exotic materials. This makes the design a little less expensive.

Domestic Power-Generation: General Electric will be offering a fuel-cell generator system, made by Plug Power. This system will use a natural gas or propane-reformer and produce upto seven kilowatts of power. A system like this produces electricity and significant amounts of heat, so it is possible that the system could be used for domestic water and air-heating operations, without using any additional energy.

Large Power-Generation: Some fuel-cell technologies have the potential to replace conventional combustion power-plants. Large fuel-cells will be able to generate electricity more efficiently than today’s power-plants. The fuel-cell technologies being developed for these power-plants will generate electricity directly from hydrogen in the fuel-cell, but will also use the heat and water, produced in the cell to power-steam turbines and generate even more electricity. There are already large portable fuel-cell systems available for providing backup power to hospitals and factories.

HYBRID SYSTEMS

Hybrid systems are two or more energy systems-combined in one, a flexible answer to making the most out of the energy-sources at your disposal. As well as making sure your energy supply is constant and is not as reliant on power from the grid, hybrid systems match up supply and demand more precisely, which means bigger savings for you. For renewable-energy, hybrid systems can help in the following ways:

Minimising the impact of intermittent supply: The intermittent nature of many of the renewable-energy sources means that there is a need for some form of back up system, to generate electricity when the wind doesn’t blow or the sun doesn’t shine. The availability of grants and the reduction in capital costs mean that an increasing number of systems are being installed, even where there is grid-supply available. Here the grid provides the back-up function. Where the renewable-energy plant has been installed as a stand-alone system, back up is often provided by a diesel-generator. The renewable-generator would usually be sized to meet the base load demand, with the diesel supply being called into action only when essential. This arrangement offers all the benefits of the renewable-energy source in respect of low operation and maintenance costs, but additionally ensures a secure supply.

Matching seasonal supply and demand: Renewable energy is by nature linked to seasonal variations in resource, particularly in the case of wind, hydro and solar. Whilst this is a disadvantage for any one renewable-energy source, hybrid systems can make the best use of the advantages of a range of renewable-sources. For example, systems can be designed to utilise high winds, during the winter and the higher sunshine hours during summer, with a combined wind-turbine and solar-PV system. Another relatively common combination is the use of solar water-heaters during the summer, combined with a wood-stove or similar to provide hot-water during the winter.

Reducing capital costs: Hybrid systems can also be a sensible approach in situations where occasional demand peaks are significantly higher than the base load-demand. It makes a little sense to size a system to be able to meet demand entirely from a renewable-energy source, if for example, the normal load is only 10% of the peak demand. By the same token, a diesel-generator set, sized to meet the peak demand would be operating at inefficient part-load for most of the time. In such a situation, a PV or wind-diesel hybrid would be a good compromise, or alternatively a biomass-oil boiler hybrid to supply heat.

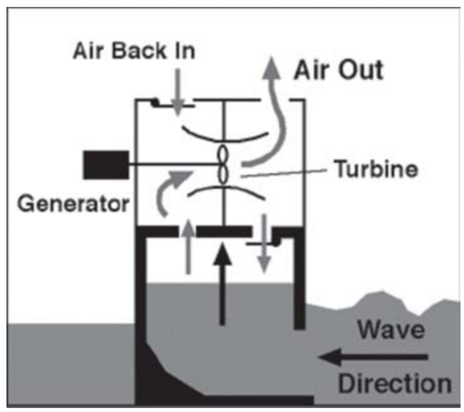
Reducing reliance on grid-supply for key loads: Some renewable-energy systems require an electrical supply to operate, for example the solar controller and pumps for a solar water-heater or the compressor and pumps on a ground source heat-pump. Solar PV panels have been used to provide the electrical supply, necessary for solar water-heaters and some research has been undertaken considering the potential for hydro-plant, to provide the electrical input for ground source heat-pumps.

OCEAN ENERGY

The world's ocean may eventually provide us with energy, but there are very few ocean-energy power-plants and most are fairly small. There are three basic ways to tap the ocean for its energy, i.e., through ocean's waves, through ocean's high and low tides or by using the temperature differences in the water.

Wave-Energy: Kinetic energy (movement) exists in the moving waves of the ocean. This energy can be used to power a turbine. In the figure below, the wave rises into a chamber. The rising water forces the air out of the chamber. The moving air spins a turbine, which can turn a generator. When the wave goes down, air flows through the turbine and back into the chamber through doors that are normally closed. This is only one type of wave-energy system; others actually use the up and down motion of the wave to power a piston that moves up and down inside a cylinder. That piston can also turn a generator. Most wave-energy systems are very small, but they can be used to power a warning buoy or a small light house.

Tidal Energy: Another form of ocean-energy is called 'tidal energy'. When tides come into the shore, they can be trapped in reservoirs behind dams. Then when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric



power-plant. Tidal energy has been used since about the 11th Century, when small dams were built along ocean estuaries and small streams. The tidal water behind these dams was used to turn water-wheels to mill grains. In order for tidal energy to work well, one need, large increases in tides. An increase of at least 16 feet between low to high tide is needed. There are only a few places where this tide change occurs around the world. Some power-plants are already operating using this idea. One plant in France, makes enough energy from tides (240 MW) to power 240,000 homes. This facility is called the 'La Rance Station' in France. It began making electricity in 1966. It produces about one fifth of a regular nuclear or coal-fired power-plant. It is more than 10 times the power of the next largest tidal station in the world, the 17 MW Canadian Annapolis station.

Ocean Thermal Energy-Conversion (OTEC): This technology uses the temperature difference of water to make energy. The water is warmer on the surface because sunlight warms the water, but below the surface, the ocean gets very cold. Power plants are built that use this difference in temperature to make energy. A difference of at least 38°F is needed between the warmer surface of water and the colder, deep-ocean water. This type of technology is being demonstrated in Hawaii.

CONCLUSIONS

The global demand for energy is set to increase significantly for the foreseeable future. If this demand is to be met without irretrievable damage to the environment, renewable-energy sources must be developed to complement more conventional methods of energy-generation. This paper shows that renewable-energy can make significant contributions to reduce greenhouse and acid-gas emissions. Renewables have their own environmental impacts, but these are often small, site-specific and local in nature. Nevertheless, their deployment should be accompanied by the many methods identified in this review for ameliorating their potential impacts.

There are other types of renewable-energy that are not utilized as much as solar, wind, biomass or geothermal energy, but still have great potential. For example, Hydrogen-energy can be used to power cars, as well as buildings. Ocean or wave-energy captures the power of the sea. Then there are hybrid systems that make use of more than one energy-source, be it all renewable or a combination of renewable and non-renewable sources.

The basic reason that we have a problem is due to exponential growth, which creates a non-equilibrium use of our resources. The failure to understand the concept of exponential growth by planners and legislators is the single biggest problem in all of 'Environmental Studies and Management'. The two principle problems with energy management are: (a) failure of policy-makers to understand the concept of exponential growth and (b) failure of legislation to be formulated and passed to give us a long-term energy-strategy. Exponential growth drives resource-usage for a very simple reason and that is the increase in human-population exponentially. Accurate trend-extrapolation is the most important part of future planning. However, failure to assume exponential growth will always lead to a disaster. Therefore it is of vital importance to always assume exponential growth, when planning anything. No matter what the growth-rate is, exponential growth stars out being in a period of slow growth and then quickly changes over to rapid growth with a characteristic doubling time of 70/n years; where n =% growth rate. Its important to recognize that even in the slow growth-period, the use of the resource is exponential. If we fail to realize that, we will run out of the resource pretty fast.

Material	Rate	Exhaustion Timescale
Aluminum	6.4%	2007 - 2023
Coal	4.1%	2092 - 2106
Cooper	4.6%	2001 - 2020
Petroleum	3.9%	1997 - 2017
Silver	2.7%	1989 - 1997

Note: *The above estimates include recycling*

Better design alleviates the burden on the individual to make a sacrifice, which is effectively dependent on the cost. Gasoline is a prime example where high cost promotes conservation/fuel-efficiency, while low cost promotes high usage. Subsidized energy-usage also does not promote conservation. Cost of energy exceeds inflation-rate, which ultimately results in helping the conservation efforts. Real costs of energy include those associated with discovering new sources and getting production out of those new sources.

REFERENCES

1. Chandler, William U. Energy Productivity: Key to Environmental Protection and Economic Progress. Washington, D.C.: Worldwatch Institute, c1985. Biodiv TJ163.2.C4825 1985.
2. Devins, D. W. Energy, Its Physical Impact on the Environment. New York: Wiley, c1982. Main TD195.E49 D48 1982.
3. Duncan, Trent. Renew the Pub Lands: Photovoltaic Technology in the Bureau of Land Management. Albuquerque, NM: Sandia National Laboratories, 1996. Biodiv TJ163.5.P8 D86 1996.
4. Flavin, Christopher. Electricity's Future: The Shift to Efficiency and Small-Scale Power. Washington, D.C., USA: Worldwatch Institute, c1984. Biodiv TK1001 .F53 1984.
5. Flavin, Christopher. Energy and Architecture: The Solar and Conservation Potential. Washington, D.C.: Worldwatch Institute, 1980. Biodiv TJ163.5.B84 F52.
6. Global Environment Protection Strategy Through Thermal Engineering. New York: Hemisphere Pub. Corp., c1992. Biodiv TD169 .G57 1992.
7. Miami International Conference on Alternative Energy Sources. Solar Collectors Storage. Ann Arbor, MI: Ann Arbor Sciences, c1982. Main TK1056 .M53 1981.
8. Miller, Alan S. Growing Power: Bioenergy for Development and Industry. Washington, D.C.: World Resources Institute, 1986. Biodiv TD195 .B56 M64 1986.
9. Oguti, Takasi. Sun-Earth Energy Transfer. Oslo, Norway: Norwegian Academy of Science and Letters, 1994. Main QC883.2 .S6 O48 1994.
10. A Sustainable Energy Blueprint. Washington, D.C.: Communications Consortium Media Center, 1992. Biodiv HD9502 .U52 S87 1992.
11. Williams, J. Richard. Solar Energy: Technology and Applications. Ann Arbor, MI: Ann Arbor Science Publishers, 1974. Main TJ810 .W54.
12. New Renewable Energy Resources: A Guide to the Future, World Energy Council, Kogan Page Ltd, 1994. ISBN/ISSN 0749412631
13. Kordesch, Karl, and Günter Simader. Fuel Cells and Their Applications. New York: VCH, 1996. [14] Linden, David. Handbook of Batteries and Fuel Cells. New York: McGraw-Hill, about 1984.
15. Lischka, J. R. Ludwig Mond and the British alkali industry. New York: Garland, 1985.
16. Norbeck, Joseph. Hydrogen Fuel for Surface Transportation. Warrendale, PA: Society of Automotive Engineers, about 1996.
17. Dyer, Christopher K. “Replacing the Battery in Portable Electronics.” Scientific American. July 1999. P 88.

18. America's Energy Choices: Investing in a Strong Economy and Clean Environment. Cambridge, MA: Union of Concerned Scientists, c1991-c1992. Biodiv REF TJ163.25 .U6 A54 1991.
19. Berger, John J. Charging Ahead: The Business of Renewable Energy and What it Means for America. Berkeley, CA: University of California Press, 1998. Pub TJ807.9.U6 B47 1997.

BIBLIOGRAPHY

- Bengt J., Pal B., Ericsson K., Lars J. Nilsson and Svenningsson P., The use of biomass for energy in Sweden: critical factors and lessons learned, Department of Technology and Society, Environmental and Energy Systems Studies, Lund University (2002).
- Charles E. Wyman, Biomass ethanol: technical progress, opportunities and commercial challenges, Annual Review of Energy and the Environment 24: 189-226 (1999).
- D. Lew, Micro-hybrids in rural China: rural electrification with wind/PV hybrids, RE-Focus, Apr, pp. 30-33 (2001).
- Dieter H., A critique of renewables policy in the UK, Energy Policy 30(3): 185-188 (2002).
- Hong Yang, He Wang, Huacong Yu, Jianping Xi, Rongqiang Cui and Guangde Chen, Status of photovoltaic industry in China, Energy Policy 31(8): 703-707 (2003).
- Paul Maycock, The world PV market – production increases 36%, Renewable Energy World 5(4): 146-161 (2002).
- Lysen E. Photovoltaics: an outlook for the 21st century, Renewable Energy World 6(1): 42-53 (2003).
- Tong Jiandong, Small hydro on a large scale–challenges and opportunities in China, Renewable Energy World 6(1): 96-102 (2003).

CONSTITUTED WEBSITE LINKS

1. http://www.yourenergyfuture.org/press.cfm?ID=3
2. Http://www.soton.ac.uk/~engenvir/environment/alternative/hydropower/energy2.htm
3. http://www.cc.utah.edu/~ptt25660/tran.html
4. http://www.knowledgehound.com/topics/altenerg.htm
5. http://www.crest.org/index.html

USE OF IONIZING RADIATIONS IN MEDICINE

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ABSTRACT

This paper is an overview of the practical application of ionizing radiations in Pakistan for medical purposes. Information about major radiation-equipment used in different modalities of biomedical imaging and radiotherapy departments in Pakistan and the relevant number of professionals is given in the paper. A minor risk of radiation-induced biological damage is associated with the use of all ionizing radiations, and is dependent on the amount of the dose of radiation. The average radiation-dose received by individuals undergoing different diagnostic tests are also presented.

SOME HISTORICAL EVENTS IN RADIOLOGY

- 1895 Roentgen discovers x-rays
- 1896 First medical application of x-rays in diagnosis and therapy are made
- 1913 The Coolidge hot-filament x-ray tube is developed
- 1905 Radioactivity is used as a tracer for medical research
- 1940 Gamma radiation is used for diagnosis
- 1948 High-energy radiation from Betatron is used for treatment of cancer
- 1948 First fluoroscopic image intensifier is developed
- 1973 First CT scanner is developed

RADIOLOGY

The clinical use of ionizing radiation is called 'Radiology'. It has three branches:

1. Diagnostic Radiology;
2. Radiation Therapy;
3. Nuclear Medicine.

Diagnostic Radiology

The use of x-rays in the diagnosis is so common today that almost every adult in Pakistan has an x-ray of his teeth or other parts of the body at least once in a lifetime. Patients in hospitals have about one x-ray study every week.

Diagnostic Radiology Imaging Modalities

- Film-Screen Radiography
- Fluoroscopy
- Digital Fluoroscopy/Digital Subtraction Angiography (DSA)
- Mammography
- Xero-radiography
- Computerized Tomography (CT)
- Digital X-ray Imaging

RADIATION THERAPY

Radiation therapy is recognized as an important tool in the treatment of many types of cancer. Every year, about 40 thousand new cancer patients are registered in hospitals in Pakistan. About half of all cancer patients receive radiation, as part or all of their treatment.

Success of Radiation Therapy

The success of radiation-therapy depends on:

- The type and extent of cancer;
- The skill of radiation therapist;
- The kind of radiation used; and
- The accuracy with which the radiation is administered to the tumor.

Radiation Delivery in Radiation-Therapy

- An error of 5% to 10% in the radiation-dose to the tumor can have a significant effect on the results of the therapy.
- Accuracy in radiation-delivery is the responsibility of the Medical Physicist.
- 90% of the Medical Physicists employed in hospitals in Pakistan are working in the field of radiation-therapy Physics.

TYPES OF RADIATION THERAPY

1. External or Teletherapy
2. Internal or Brachytherapy

External Radiation Therapy or Teletherapy

- Conventional X- or Gamma-Therapy
- Electron Therapy
- Intensity-Modulated Radiotherapy (IMRT)
- Heavy-Particles Therapy

- Radio-surgery

Internal Radiation-Therapy or Brachytherapy

- Temporary Interstitial Implants
- Permanent Interstitial Implants
- Intra-cavitary Therapy

NUCLEAR MEDICINE

In Nuclear Medicine, radioactivity is used for diagnosis of diseases and, sometimes, for therapy. Many of the instruments used in Nuclear Medicine were originally developed for basic research in Nuclear Physics

Nuclear-Medicine Tests

There are about 30 different routine nuclear-medicine studies performed on patients in a modern medical centre. Although many nuclear-medicine tests are concerned with the detection of cancer, others are used to detect problems of the heart, lungs, thyroid, kidneys, bones and brain, etc.

Types of Nuclear-Medicine Imaging

- Conventional Planar Imaging
- Single-Photon Emission Tomography (SPECT)
- Positron Emission Tomography (PET)

Number of Hospitals in Pakistan Dealing with Radiology

Diagnostic Radiography Departments	not known
Radiotherapy Centers	21
Nuclear-Medicine Centers	19

Approximate Number of Medical Professionals in Radiology in Pakistan

Radiologists	400
Radiation Oncologists	85
Nuclear-Medicine Physicians	130

Approximate Number of Para-Medical Professionals in Radiology in Pakistan

Medical Physicists	60
Radiographers	not known
Radiotherapy Technologists	100

Nuclear-Medical Technologists	65
Radio-pharmacists	5

EQUIPMENT

Approximate Numbers of X-ray Equipment used for Diagnostic Radiology in Pakistan

X-Ray/Fluoroscopy units	not known
Digital Fluoroscopy (DSA)	15
CT Scanners	46
Mammography units	25

Approximate Number of Radiation-Generators used for Radiation-Therapy in Pakistan

Linear Accelerators	15
Co-60 Teletherapy Units	22
Deep X-Ray Therapy Units	5
Superficial X-ray Therapy Units	3
Brachytherapy Afterloading Units	14

Equipment of Nuclear-Medicine in Pakistan

Gamma Cameras (SPECT)	35
PET	Nil

DOSAGES

Radiation Doses in Radiology

Chest X-Ray	0.2 mSv
IV Uro-graphy	5 mSv
Barium Meal	5 mSv
CT Head Scan	2 mSv
CT Abdomen	8 mSv
Fluoroscopy	1 mSv/min

Radiation Doses in Mammography

Average dose to glandular tissue in breast, is 2 mGy per mammogram.

Radiation Doses in Nuclear-Medicine Studies

Brain Scan	4 mSv

Liver Scan	0.85 mSv
Bone Scan	4 mSv
Thyroid Scan	0.8 mSv
Abscess Imaging	18 m Sv
Lung Ventilation	0.1 mSv
Cardiac and Vascular Imaging	6 mSv
Renal Imaging	0.3 mSv

CONCLUSIONS

Ionizing radiations, such as x- and gamma-rays, are extensively used in medicine in the fields of diagnostic imaging and radiation-oncology. Almost every person had an x-ray at least once in a lifetime and about 50% of the patients of cancer undergo radiation-therapy. A small fraction of the population has taken diagnostic tests by using radioisotopes. The equipment used in these disciplines of medicine, has become the very symbol of high technology. Most of the developments are the direct or indirect outcome of research in physics. Ionizing radiation, a discovery of physics, is a tool in the hands of a physician. This is particularly true when using high-energy radiation for radiotherapy.

APPENDIX - I

[ABSTRACT OF THE PAPER PRESENTED AT THE MEETING OF NOBEL LAUREATES, HELD AT LINDAU, GERMANY, 2004]

Abstracts of some lectures by the laureates are given below

ABSTRACT OF THE LECTURE BY PROFESSOR HERBERT KROEMER

Negative Optical Refraction

Our point of departure is a hypothetical substance for which, in a certain frequency range, both the dielectric constant (DC) and the magnetic permeability (MP) become negative. In this range the group-velocity and the phase-velocity of electromagnetic waves have opposite directions, and the refractive index becomes negative. Such negative refraction (NR) would be of both fundamental and practical interest, especially if it could be obtained at optical (infrared and higher) frequencies. New optical imaging elements would be possible, for example, a simple plate with a refractive index n = - 1 would provide a perfect 1:1 imaging. That would be of interest for microscopy, photolithography, integrated optics, and other applications.

A negative DC at optical frequencies is, in principal, achievable in a weakly damped electron plasma. But because of the absence of magnetic monopoles, a negative MP would require a suitable magnetic dipole interaction. That is much harder to achieve and the necessary parameters are inaccessible at optical frequencies, where NR would be of greatest interest.

At microwave frequencies, usable magnetic dipole interactions can be achieved via metallic resonators. A periodic lattice of suitably designed metallic resonators, with a sufficiently small lattice constant, can simulate a uniform medium with negative n, and thereby make possible NR. But if such structures are scaled down in size for optical wavelengths, they have hopelessly large losses.

An alternative route to NR at optical frequencies, which does not involve magnetic interactions at all, draws on the properties of purely dielectric periodic lattice structures (so-called 'photonic crystals'), inside which only the DC changes periodically. Wave propagation in periodic media, invariably exhibits band-structures, with allowed and forbidden bands of propagation, regardless of the nature of the waves. This is a familiar phenomenon for the propagation of electron-waves through the periodic potential inside a crystal, where it forms the basis of the physics of the electrical transport properties of crystals. It is equally true for the propagation electromagnetic waves through a periodically varying DC.

To discuss the refraction properties of photonic crystals, it becomes necessary to introduce a new distinction between two kinds of refractive index: a longitudinal and a transverse index. A negative transverse index leads to NR, even when the longitudinal index remains positive. The allowed photonic bands may contain regions inside, which the transverse index becomes negative, permitting negative refraction. This approach does not suffer from the problems while achieving a negative MP at optical frequency, and hence is the appropriate way towards achieving NR in the optical range.

ABSTRACT OF THE LECTURE BY PROFESSOR ARNO PENZIAS

A Classical View of the Universe

Throughout the human history, the heavens above us have offered our eyes, instruments and imaginations, an immensely rich variety of objects and phenomena. In a virtuous circle, observations have provoked the creation of scientific tools, thereby increasing understanding, which suggested further observations. Astronomy, therefore, has catalyzed - and benefited from - advances in many of the principal branches of classical physics, from mechanics to general relativity.

As we all know, the laws of classical mechanics emerged in the 17th century as a successful model of solar-system dynamics. Nonetheless, when applied to that era's "universe" (a static infinitude of equidistant stars), these same laws produced an awkward instability - one that was to remain unresolved for some two hundred years. In the interim, progress in astronomy went hand- in - hand with progress in fields such as, optics, chemistry, and thermodynamics.

In the early 20th century, Albert Einstein's seemingly innocuous assertion of the equivalence of gravitational and inertian mass, spurred far-reaching change in our notions of time and space. When applied to the then – prevailing cosmology (a static infinitude of island galaxies) this updated mechanics left Einstein facing the same problem that had vexed Newton: mutual attraction between component masses leads to universal collapse. In the end, a fully satisfactory solution to this dilemma took some fifty more years to emerge, with the now widely- accepted model of the explosive origin of the universe from an initial hot origin, in which the light chemical elements were formed, and from which a relict radiation permeates space to the present day. Here again, this advance in our astronomical understanding owes much to related progress in a terrestrial science – in this case, nuclear physics. Until recently, quantum theory-emerging, as it did, from the study of nature at ultra- small dimensions has had little to do with astronomy. Now, a compelling body of evidence points to an explosive origin of our universe. The "point" of this origin confronts astronomy with dimensions of time and space, too small for physics - at least as most of us know it - to work. Although unimaginably small by any laboratory standard, this miniscule "comic egg" allows ample room for imaginative and exotic extrapolations of quantum field theory. Several theories have gained adherents, but none has yet produced testable predictions.

In the earlier times, cosmologists could produce theories, comfortably expecting that they would not be tested within the lifetimes of their creators. Will the same thing now happened superstring theories, and its competitors? Current progress in observational astronomy – notably the widening use of gravitational lensing techniques, suggest otherwise .For example, sensitive studies of small-scale irregularities in the cosmic background radiation have allowed astronomers to compare the observed angular size distribution of condensations, with calculations based upon known properties of cooling primordial gas at the time of its recombination. Much like measuring the magnifying power of lens by looking through it at a checkerboard, the lens (in this case, the curvature of intergalactic space) turned out to have no curvature at all: thereby implying a so-called 'flat universe', dominated by dark-matter and dark-energy.

As plans for future observations, based upon these findings take shape, the dark-matter and dark-energy will become tools, as well as targets for further observations. This, in turn will help astronomers to probe their nature, as well as seek hints to what, if any-thing, future theorists can say with confidence about how Nature works in the realm of the Planck Limits.

Leaving the universe's first nanosecond, or so, aside, we still have much to explore and discover out their, in the more familiar, four-dimensional portion of the universe: the seeding, and life stories of the galaxies, and the clusters they inhabit; the silent majority of the matter and energy has escaped detection until recently; the myriad life cycles of stars; and (just possibly) their role in seeding the life-cycles of the curious creatures.

ABSTRACT OF THE LECTURE BY PROFESSOR DOUGLAS OSHEROFF

Understanding the Columbia-Shuttle Accident

On February 1,2003, the NASA Space-shuttle, Columbia, broke apart during re-entry over east Texas at altitude of 200,000 feet and velocity of approximately 12,000 mph All aboard perished. The speaker was a member of the board that investigated the origins of this accident, both physical and organizational. In his talk he described how the board was able to determine, with almost absolute certainty, the physical cause of the accident; in addition, the speaker discussed its organizational and cultural causes, which are rooted deep in the culture of the human space-flight program. Why did NASA continue to flight the shuttle-system despite the persistent failure of a vital sub-system that it should have known did indeed pose a safety-risk on every flight? Finally, the speaker touched on the future role humans are likely to play in the exploration of the space.

ABSTRACT OF THE LECTURE BY PROFESSOR IVAR GIAEVER

How to Start a High-Tech Business

The main reason to start a business is probably to try to get rich, but our motivations were different (not that we mind making money). First it is and was very difficult to get funding for interdisciplinary science in the USA from the regular granting agencies despite claims to the contrary, so to fund our research, we applied for grant through the small business innovation research program (SBIR) and were successful. Second, like all scientists, we wanted to have an impact on development of science and decided that we probably could have more significant impact by supplying the right instruments than just writing papers. This paper recounts our experiences as we tried to enter into the commercial sphere.

Our min and hard earned lesson is that business, to no one surprise, is very different from science. In the business world you are forced to make decision with incomplete knowledge, a very difficult thing for scientist. The proverb" If you make a better mousetrap, people will beat a path to you door" is unfortunately not true. The product (including the science behind it) is really not the most important aspect of a high-Tech business; marketing is where the action is. As an example some clever Americans managed to sell" pet stones" a few years ago using ingenious marketing.

ABSTRACT OF THE LECTURE BY PROFESSOR ROBERT HUBER

Aerobic and Anaerobic life on Carbon Monoxide

CO is colorless, order less gas, which is highly toxic to most forms of life. Despite the toxicity CO can be used by several bacteria and archaea as a chemolithoautotrophic growth substrate, providing these microbes with energy and a carbon source. CO dehydrogenases are the key enzymes in this process and catalyze the formal reaction. Two structurally unrelated principle types of CO dehydrogenases have been described. The CO dehydrogenases from the aerobic CO –oxidizing bacterium Oligotropha carbo xiovorans is 277-kDa Mo and CU- containing iron sulfur flavoprotien. The enzyme's active site in the oxidized or reduced state and after in activation with potassium cyanide or n-butylisocynaide has been reinvestigated by multiple wavelength anomalous dispersion measurements up to 1.09 A resolution. We gained evidence for binuclear hetrometal (CUSMoOOH) cluster in the active site of the oxidized or reduced enzyme, in which both metals are bridged by u –sulfido ligand The cluster is coordinated through interactions of MO with the dithiolate pyran ring of molybdopterien cytosine dinuceleoyide and the CU with The cluster is coordinated through interactions of MO with the dithiolate pyran ring of molybdopterien cytosine dinuceleoyide and the CU with SY of cystiene388. The structure of the enzyme with the inhibitor n- butylisocynaide bound has led to a model for the catalytic mechanism of CO oxidation, which involves a thiocarbonate-like intermediate state. The homodimeric nickel–oxide CO dehydrogenase from the anaerobic bacterium structure.

ABSTRACT OF THE LECTURE BY PROFESSOR MARTINUS VELTMAN

The Development of Particle Physics

Particle physics mainly developed after World War II. It has its roots in the first half of the previous century, when it become clear that all matter is made of atoms, and atoms in turn found to contain a nucleus surrounded by electrons. He nuclei were found to be bound state of the protons and neutrons and together with the idea of photon (introduced by Einstein in 1905) all could be understood in terms of few particles, namely neutrons, protons, electrons and photons. That was just before WW II.

During WW II and directly thereafter information on the particle structure of the universe came mainly through the investigation of cosmic rays. These cosmic rays were discovered by Wulf (1911) through balloon flights. It took a long time before the natures of these cosmic rays become clear: just after WW II the new particle was discovered by Conversi, Piccoini and Pancini.This Particle has mass of 105.66 Mev.Which led to the Development of particle physics.

ABSTRACT OF THE LECTURE BY PROFESSOR ROBERT C. RICHARDSON

Pesudo Science, Marvelous Gadgets, and Public Policy

People want to believe in magic. Since the beginning of civilization, charlatans have taken advertisements in the magazines found in the seat – back pockets of airplanes; I have collected a number of entertaining examples. The advertised gadgets are loosely based upon the laws of physics. Some of the devices play upon fears the public has Concerning electric and magnetic fields. Public policy has sometimes reacted to the alarming claims made in advertisements.

ABSTRACT OF THE LECTURE BY PROFESSOR K.A. MULLER

Some Remarks on the Super-Conducting Wave-Function in the Cooperates

A large part of the community considers the macroscopic super conducting wave – function in the cooperates to be of near pure d- symmetry. The pertinent evidence has been obtained by experiments in which mainly surface phenomena have been used such as tunneling or the well-known tricrystal experiment (1).

However recently, data probing the property in the bulk gave mounting evidence that inside the cuperate superconductor a substantial s- component is present, and there fore I proposed a changing symmetry from pure d at the surface to more s inside, at least (2).

This suggestion was made to reconcile the observations stemming from the surface and bulk. But such a behavior would be at variance with accepted classical symmetry properties in condesed matter.(1,3).

In this respect, lachello, applying the interacting boson- model, successful in nuclear theory, to the C4v symmetry of the cooperates, showed that indeed a crossover from a d- phase at the surface, over a d + s, to a pure s- phase could be present (4).

Attempts to estimate this crossover from known experiments will be presented. It makes also plausible why the face stiffness of the d- component is preserved over a whole sample, i.e. in a SQUID. Furthermore most recent experiments indicating a full gap in the bulk at low temperature will be commented on.

ABSTRACT OF THE LECTURE BY PROFESSOR BRIAN JOSEPHSON

Pathological Disbelief

This talk mirrors Pathological Science, a lecture given by Chemistry Laureate Irving Langmuir (1) Langmuir discussed cases where scientists, on the basis of invalid processes, claimed the validity of phenomena that were unreal. My interest is in the counter-pathology involving cases where phenomena that are almost certainly real are rejected by the scientific community, for reasons that are just as invalid as those of the cases described by Langmuir.Alfred Wagener's continental drift proposal.

(2) Provides a good example, being simply dismissed by most scientists at the time, despite the overwhelming evidence in its favor. In such situations incredulity, expressed strongly by the disbelievers, frequently takes over: no longer is the question that of the truth or falsity of the claims; instead, the agenda centers on denunciation of the claims.Ref.3, containing a number of hostile comments by scientists with no detailed familiarity with the research on which they cast scorn, illustrates this very well. in this denunciation mode, the usual scientific care is absent; pseudo-arguments often take the place of scientific ones .Irving Languor's lecture referred to above is often exploited in this way, his list of criteria for Pathological science being applied blindly to dismiss claims of the existence of specific phenomena without proper examination of the evidence. We find a similar method of subverting logical analysis in a weekly column supported by the American Physical Society.

ABSTRACT OF THE LECTURE BY PROFESSOR MASATOSHI KOSHIBA

The Birth of Neutrino Astrophysics

Neutrino Oscillations discussed with the latest experimental results. The implications of these new findings were also discussed. The first observation by Kamiokande that the number of the muon neutrino in the atmosphere is not in accordance with the theoretical expectations has led to the non-zero mass of the neutrinos and the neutrino oscillations are among the three kinds of neutrinos.

ABSTRACT OF THE LECTURE BY PROFESSOR NICOLAAS BLOEMBERGEN

Laser Technology in Peace and War

An over view was presented in the most important applications of lasers during the past forty years. These include Optical fiber systems for global communications and various types of surgery.

ABSTRACT OF THE LECTURE BY PROFESSOR WALTER KOHAN

New Perspectives on Van Der Waals Interactions Between Systems of Arbitrary Size, Shape and Atomic Compositions

Density functional Theory, in principle, includes Van der Waals energies, but approximations rooted in the local density approximations, such as generalized gradient approximation do not. The talk included the recent and on going work to use time dependent density functional theory.

ABSTRACT OF THE LECTURE BY PROFESSOR KLAUS VON KLITZING

Spin Phenomena in the Electron Transport of Semiconductor Quantum Structures

The conductivity of semiconductor structures is normally dominated by the charge and not by the spin of the electrons. Recent experiments on two dimensional, one-dimensional and zero dimensional electron system demonstrate, that also the spin electrons may influence drastically the conductivity in these low dimensional systems.

ABSTRACT OF THE LECTURE BY PROFESSOR GERARD T'HOOFT

Super-theories

The Universe appears to be controlled by laws of physics that can be deduced from observations and have consequences that can be derived and understood.

We know that the four forces in the universe control all the interactions between the particles what is reeled that the force known at present originate at the sub atomic level these are the smallest structures that are known at the present. But finding the ultimate law, which governs all sort of phenomena s, the challenge to every physicist.