1980

# ECHO

PHYSICAL SOCIETY

UNIVERSITY OF PERADENIYA

After the evolution of "Man"

he succeeded

in developing his knowledge

in all directions

He became philosopher

Out of philosophy science evolved

As science expanded

it had to be divided into many branches

like Physics,

Chemistry, Zoology, Botany and so on

out of these

PHYSICS seems

to reverberate in all others.

Hence we hear its

E Cc Hhh Oooo........

every where.

# ECHO

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*Edited by,*

N. Mahendrarajah
W. A. D. Roy Julien

# PHYSICAL SOCIETY

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# EDITORIAL

To understand modern civilization is to come to grtps with certain stern tealities. Three of these are: the extent to which the society is fashioned and sustained by science and technology; the alienation born of an unreconciled union of a soulless, pragmatic technology with a shametessly romanticized humanism: and the bitter irony in finding science-our most powerful and creative cultural force - remote, unsocialized, unloved, and so intent on pursuing its own ends and its own perception of truth that it has become an enigma in the very civilization it made possible.

The foundation of modern civilization is the scientific-technical revolution that began in earnest in 1870. This led to a large scale coordination of science and technology or what has been called an imperfect but un-precedentedly powerful marriage of knowledge and control. Out of this has come a way-of life in which adaptation to change has replaced adjustment to stable institutions as the norm. In the society, science has become far more than a source of interlectual insight into nature and a calling for urbane adventurers who wish to explore the frontiers of knowledge, Science and technology have moved far beyond their roles as suppliers of material benifits for society, Together they have provided a model and an ideology for modernization. and they have fostered new attitudes and patterns of thought about reality and about knowledge; In addition, they have given us a rational basis for the organization of our work, our everyday lives and our governance: through research and development they offer some rational choices for the future.

Despite their profound influence and usefulness, both have tarnished public images Both stand accused of sins against spirit and flesh - with draining of warmth and beauty from the world, with darkening mans imagination and fouling his nest. But there are differences[2] although technology is everywhere present to ease of aggravate our physical and biological burdens, to offend the aesthetic and to confound the poet within us, science for most: exists in a world apart; untouchable and mysterious, imposing its immutable conclusions without favour or mercy, allowing no appeal and offering no compassions While claiming to be dealing with things, not people, it sometimes appears to be dealing with people as things. On balance, the misunderstandings between science and societyare the more profound; their origins lie deep in the social matices of both institutions.

For better or worse, science will remain the dominant cultural force in modern civilization, Yet it is so poorly understood even among many who profess it that civilization faces unnecessary perils as a consequence, misunderstanding and misuse of the methodological ethic have led, for example, to a serious loss in public confidence in technology and to wider and wider acceptance of amorality as a basis for conducting national and personal affairs We have erred in beleiving that values and ethical priorities appropriate in isolated scientific activity and in scientific modes of thought are equally appropriate in real world humanistic activity and in humanistic modes of thought, Still, it is not sufficient that science and socioty merely exist in a fitful state of amoral tension, A marriage based on mutual understanding and respect must be arranged. For teachers of science. the opportunity here would, appear imperative,

# A Message from

**Prof. B. L. PANDITHARATNA**
(Vice Chancellor, University of Peradeniya

It is encouraging indeed to find that the students of the Physical Society are able to mobilize their resources and efforts to the publication of the ECHO Magazine for this academic year, An enterprise of this nature will certainly encourage many students to put forward their views and opinions on several scientific topics and stimulate intelectual discussions and dissemination of knowledge which will help to broaden their intelectual horizons.

Congratulations for keeping this worthy tradition going from year to year,

I wish the Physical Society all success.

## *A Message from*

Prof. G. A. Dissanayake
Head of the Department of Physics
University of Peradeniya

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I quote from two famous Physicists :

"Concern for man himself and his fate must always form the chief interest of all technical endeavours Never forget this in the midst of your diagrams and equations."

—**Albert Einstein.**

"We must not forget that when radium was discovered no one knew that it would prove useful in hospitals. The work was one of pure science. And this is a proof that scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself. for the beauty of science, and then there is always the chance that a scientific discovery may become, like radium, a benefit for humanity"-

—**Mme Marie Curie.**

It is true that scientific work must not be considered merely from the point of view of its direct usefulnes, There is an excitement in the pursuit of pure science, a fascination in observing and experimenting that bring in knowledge and understanding of the world around us. But, as you pursue your study of Physics, at the University and beyond, do not be so engrossed in amassing data and in inscribing diagrams and equations that give you satisfaction, statistically and otherwise, but always recognise that the motivating force of scientific endeavour must surely be the desire to understand the world around and to enrich the life of man.

It is with pleasure that I convey my good wishes to the Committee and the membership of the Physical Society.

# Einstein's Last Dream:

# The Space - Time Unification of Fundamental Forces

Prepared by Dr. Lakshman Dissanayake, based on a lecture given by Professor Abdus Salam, Diector, International Centre for Theoretical Physics Trieste, Italy, at the UNESCO celebration of the centenary of Einstein's birth day, 9 May 1979, Paris.

During their search for the complexity of nature, physicists have discovered the existence of four basic types of interactions or forces. The weakest of the four is the *gravitational interaction* which, however, is strong enough that it could some day produce the rebirth of the Universe after completely collapsing it. Although gravity was discovered first it is not well understood in detail. Next in strength is the *weak interaction* which seems to act between all elementary particles including the neutrino (a particle that has mass only when it moves with the velocity of light). Next is the *electromagnetic interaction* which exists between charged particles, particles exhibitting magnetic properties and photons (quanta of light energy). The strongest force is the *Strong (nuclear) interaction* which affects the tnteraction between subnuclear particles. The strong interaction is $10^{39}$ times as strong as the gravitational interaction. Therefore, the gravitational interaction seems to play a negligible role in nuclear interactions. On the other hand, the strong (nuclear) interaction is of short range and therefore decreases so fast with distance, that "outside" the nucleus, it is zero. It is the electromagnetic force that holds the atoms and nucleus together. Gravitational and electromagnetic forces are long-range interactions. The four types of basic interactions can act simultaneously between particles and, therefore, their effects can interfere with each other. A universal theory would describe all forces from a unified point of view, perhaps deriving all from further still unknown principles, and it could predict correctly all observations that might be made under given experimental conditions.

Attempts at a unified theory of forces have been made by physicists from the earliest times. In this context, in the history of physics, three names stand together: Newton, Maxwell and Einstein, as among the greatest unifiers of all times. *Newton* identified and unified terrestrial gravity (the force which makes apples fall) with celestial gravity (the force which is responsible for the motion of planets around the sun). *Maxwell*, two hundr d years later, unified the forces of electricity and magnetism, and showed that light was one manifestation of this unification. *Einstein* in 1905, unified the concepts of space and time. Further, he was able to show that Newtonian gravity was a manifestation of this unification, in the sense that the gravitation signified a curvature of the united space-time manifold. Einstein then asked whether it is possible to unify Maxwell's elctromagnetism with Newtonian gravity in the same way that Maxwell had united electricity and magnetism? Can Maxwell's electromagnetism be also a manifestation of some other geometrical property of the space-time manifold, just as Newtonian gravity was a manifestation of its curvature? This was Einsteins last dream. At present it appears that Einstein's was a very valid dream and there is considreable progress towards its realization.

All matter in the universe is made up of four basic particles or "building blocks". These are the two nuclear constituents, the proton (p), and the neutron (n), and the electron (e, and the neutrino ($v$). The four basic interactions which governs the behaviour of these particles are the gravitational, electromagnetic, weak and the strong forces.

All four particles p, n, e and $v$ attract each other with a gravitational force which is proportional to their masses. The gravitational force is also responsible for the motion of planets, stars and galaxies and determine the overall features of the universe we live in.

The two charged particles (e and p) attracts each other with an electromagnetic force which is proportional to their electric charges. This force is responsible for holding the atoms together and mainly governs all known phenomena of life on earth

All four particles p, n, e and $v$ also interact with each other through a weak force provided they are closer to each other $10^{-16}$ cm. This force governs the beta-radioactive decay of nuclei and primarily responsible for the existence of heavy elements in nature.

There exists a strong nuclear force between two nuclear particles (p and n) when they are separated by a distance closer than $10^{-13}$ cm. This force is responsible for the stability of the stable nuclei and the radioactive decay of unstable nuclei. The phenomena of nuclear fusion which is responsible for making the sun and stars shine, and the nuclear fission which generates power from nuclear reactors are some of the consequences of this force.

This picture of *four* basic particles and *four* basic interactions between them represents a remarkable simplicity in concepts. But physicists are not satisfied with such a simplicity! They have hoped that they could unify the four seemingly distrinct forces into one *single* basic force of which the four known ones are different facets. Einstein went further. He assumed that such a unified force existed, as a geometrical property of the space-time manifold we live in, and wished to comprehend this single unified force.

In 1905, Einstein unified the concepts of space and time and showed that Newtonian gravity was a manifestation of the curvature of the space-time manifold.

Finally he wished to see a unification of gravity and electromagnetism as two aspects of one single force. Having shown that mass was connected with space-time curvature, the hoped that the electric charge would likewise be so connected with some other geometrical property of space-time structure. But gravity and electromagnetism are two out of the four basic forces; where does the other two-weak and strong (nuclear) forces fits into this structure? The recent post-Einsteinian developments will become relevant at this stage.

There are experimental cunsequences which follow from the idea of the unification of the *electromagntic* with *weak* interaction. If the weak force is nothing but a different facet of a basic force whose other facet is electromagnetism, the latte should show some characteristics which one had in the past associated with the weak force only. One such characteristic is the difference of force experienced by left-spinning versus right-spinning electrons. In 1978, an experiment at the Stanford Linear Accelerator Center (U. S. A.), measured this deflection with an accuracy never before attempted, which demonstrated that left-spinning electrons are deflected $1/10^4$ times more than the right-spinning electrons when scatterred off havy water. This is just what the theory predicted clinching the hypothesis that the two forces-weak and the electromagneticare indeed two facets of one basic fundamental forcet.

Another prediction concerns with apparent difference between short range character of the weak force aad the long range character of the electromagnetic force. The prediction is that if these two forces are truly two facets of a basic c'electroweak" force, then there must exist two new "heavy" elementary particles with masses around 80 and 90 times proton mass, the first electrically charged and the second neutral. These particles are predicted to [illegible] mediators of the weak orce just as the photon is the mediator of the electromagnetic force. Experiments. with energetic beams of protons and antiprotons are planned to be carried out at the European Nuclear Research Centre (CERN) during 1982, to check if these predicted patrticles exist. This experiment-the existence of the electroweak particles and in particular the heavy photon-is in some ways on par with the 1919 ecclipse measurement of deflection of light which established Einstein's theory of gravity. This time it is the unification of the weak force with the electromagnetic which is at stake. At present all indirect experimental evidence already points in the direction that the electroweak unification hypothesis is correct that the predicted partieles do indeed exist. There are not four, but three basics forces of nature.

After this experiment is done, or perhaps simultaneously with it, there will be a test of the possible unfication of the strong nuclear force with the electroweas force reducing the four basic forces to just two. This test consists of stroing 10,000 tons of water in a mine one mile deep, shielding the water from all external sources of radiation. This mass af water will be sorrounded by light-detecting devices, One proton out of the $10^{33}$ protons which make up this mass of water will turn (in the span of a year) into a positron, emitting light of a characteristic wavelength. This will be the signal of the grand unification into one force of three of the four forces-eelectrōmagnetic, weak, and the strong.

But what of Einstein's dream of finally unifying this "electroweaknuclear" force with gravity and showing that this force is a manifestation of the structure of the space-time. Amazingly, in the optimistic climate of physics today, these dreams also seem near to ralization. It could be that space-time has extra dimensions besides the four that we are conscious of - it could be that the extra dimensions are associated with electric and nuclear charges just as the gravitational charge is associated with the curvature of the four space-time dimensions we are familiar with. It could be that, as suggested by Wheeler, the electric and nuclear charges are telling us about the small scale structure of space-time, of foam like granularities, which are smoothed out when one observe coarsely. Space-time may be like some varieties of cheese with holes at places where charges are located. Some of these ideas were already formulated when Einstein lived. On some of these he worked himself. Somehow to-day, with the electroweak unification already in the offing, they appear near to being realised.

There has been no one like Einstein in this century; perhaps never in the history of human thought, so far as physical sciences are concerned. Certainly, there never has been anyone so singly-responsible for so much revolutionary thinking in physics.

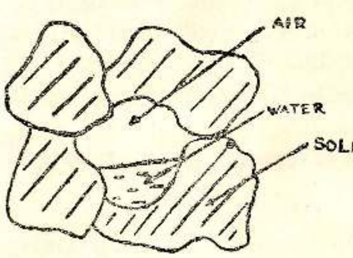
# WATER MOVEMENT THROUGH SOIL

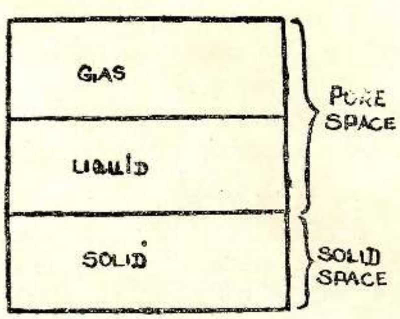
DONALD A. WITHANA

[ *Demonstrator, Department of Physics, University of Peradeniya* ]

When you apply some water on to a bare soil, sometimes it will dissappear immediately, but sometimes it won't, it will remain on the surface, and slowly it will go into the soil. There are lot of reasons for it and also many factors are responsible for this action. First of all we will try to get some idea about the properties of the soil and its behaviour because soil structure and texture play an important role in the soil water movement.

Soil is a particle media i. e., it consists of descrete particles. These particles are not bounded well as in a case of metal and at the same time these particles do not have the same degree of movement as liquids molecules. Furhermore soil is a multiphase system. It consists of three phases named as gases, liquids and solid. There are minerals, clays and quartz in solid phase, water and dissolved salts in the liquid phase and different gases and water vapour in the gaseous phase. Using a block diagram different phases can be shown as in the diagram. Again we can classify the gaseous and liquid phases together and call pore space. According to this terminology, we can consider a soil as two spaces. i, e., solid space and pore space. If the pore space is completely filled with water, we say the soil is saturated other wise unsaturated. Satura'ed soil acts in a different manner when compared to an unsaturated soil.



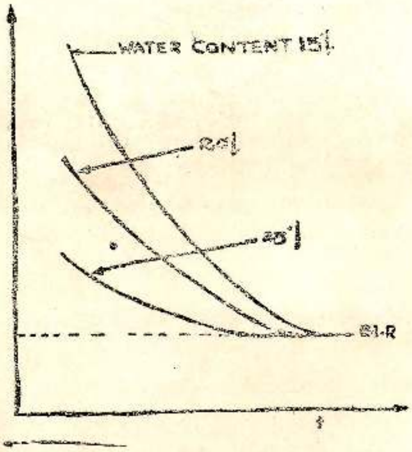




Now we will consider how does water enter to the soil. Actually, entrance of water to a soil surface is the first phenomenon of the soil water movement. This is called 'infiltration'. There are two ways of infiltration, i. e., horizontal infiltration and vertical infiltration. If the application of water is uniform over the surface one can neglect the horizontal infiltration. Rate of vertical infiltration or the depth of soil wetted in an unit time varies with the time and this variation can be given by the equation

$$I = Kt^{n}$$

where I — rate of infiltration in inches / hr; t — time in seconds.

This equation is called 'Kostiakov Equation', n and k are two constants which varies from one soil to the other. The shape of the I vs t curve depends on the initial water content of the soil. After some time the rate comes to a constant value and remains at that value for a particular soil and this constant value is defined as the 'basic infiltration rate'. For the major soil types in Sri Lanka n = -0.5 hence the equation becomes




$$I = Kt^{-\frac{1}{2}}$$

The following factors also effect the infiltration: texture of the soil, structure of the soil, soil fabric, surface sealing, slope of the land and crop cover.

Once the basic infiltration rate reaches, water enters into the soil conitnuously with that rate,

The rate of flow of water, after entering the soil profile is governed by the soil property called permeability. Naturally, the rate of flow is less when the soil is unsaturated since there are empty spaces inside the pores and water can be stored in these spaces. The flow of water within the soil obeys the 'physics' law called 'Darcy's Law' ie.,

$$Q/t = KAH/L$$

where K — permeability, A — cross—sectional area of the soil profile L — length which the water flows, H — potential difference.

For the term potential, it is necessary to consider several factors. Consider a soil media (which is a porous medium), if a point A has a higher potential than a point B, water will flow from A to B through the soil. The term 'potential' here can be understood in terms of energy. Generally since A has a higher potential, it is required to do work in bringing an unit mass from B to A. In the soils also this energy concept is valid. Here the potential (H) consists of 3 components, i.e., gravity (Z) osmotic (O) and matric (M).

$$H = Z + O + M$$

Gravity potential will be the amount of work done in moving unit quantity of water from a reference point to a pure water sample which is at the same elevation as the considering soil. Osmotic potential will be the amount of work done in bringing unit quantity of water from a pure water sample to a water sample which is having the same composition as the soil water. Matric potential will be the amount of work done in moving unit quantity of water from a water sample which is having the same composition as soil water to actual soil water.

Hence the total potential be the work done in moving unit quantity of water from a sample of pure water at a refernce point to a point in question in the soil.

Since we are talking about the flow of water inside the soil usually we neglect osmotic potential assuming any point in the soil has the same composition. Therefore only two components appear and the matric part always measure in presure units while gravity can be measured with respect to a reference point.

So to get the rate of flow through any two points across a known cross—sectional area of the soil, one has to calculate the gravity and the matric potentials at the two end points and use the Darcy's Law,

$Q/At = KH/L = Ki$

where i—total hydraulic gradient, but the continuity equation of fluid mechanies give

$Q/t = AV$

where V—velocity of the flow. Hence the Darcy's Law becomes velocity.

$V = Ki$ or flow rate $Q/t = KAi$

Now consider a rectangular cross-section of soil, therefore

$A = a \times b$.

Since the soil has voids and water flows only through voids, actual area is the cross—sectional area of the voids Av where $Av = An$

n – porosity of the soil

$$= \frac{V_v}{V} = \frac{\text{volume of voids}}{\text{total volume}}$$

Therefore Darcy's Law becomes

$Q/t = KAni;$

where K is the only property of the soil which governs the transmission of water At the same time, this value depends on the nature of water due to the impurities in the water like kerosene, alcohol etc. To eliminate this action, Intrinsic Permeability ($K^1$) is defined, where $K^1 = K$ and is called the kinematic viscosity of water and

$$N^1 = \frac{\text{absolute viscosity}}{\text{unit weight of water (w)}}$$

Therefore

$$Q/t = K^1/N^1 \ Ani$$

$$Q/t = \frac{K^1 w}{N} Ani$$

is the final equation which governs the soil water movement. Therefore we can see that water flows through soil in a similar manner, as a liquid flows through a pipe, but with little modifications.

In actual practise there can be a temperature variation within the soil profile. Then one has to consider the "entropy" at the two end points of the flow and by using the fundamentals of thermodynamics the actual rate of flow can be measured.

# PHOTOVOLTAIC CONVERSION OF SOLAR ENERGY

P. MAHESWARANATHAN. Dept. of Physics, University of Jaffna.

Sun gives the Earth all the energy it needs, and much more to sustain itself to grow and evolve-light and heat, firewood and flowing waters the wind and the rain in an endless cycle and then coal, oil and natural gas. Men have only just begun to turn their scientific and technological ingenuity to the task of converting their most abundant and realiable energy source, sunlight, into electricity, the most convenient and adaptable form of energy.

Abundant sunlight falls on the earth - about a kilowatt per square meter, when the Sun is high in a clear sky. But all of this is not usable. About 40% is available for conversion. But the energy is dilute and varies in mount low in the mourning none at night. These disadvantages are being overcome with the developement of new technologies and the refinement of old ones.

Less environmental damage, enhanced security of the energy supply, a greater self-reliance for individuals and nations and an energy system that is sustainable for as long as the earth remains habitable are the broad advantages of going solar.

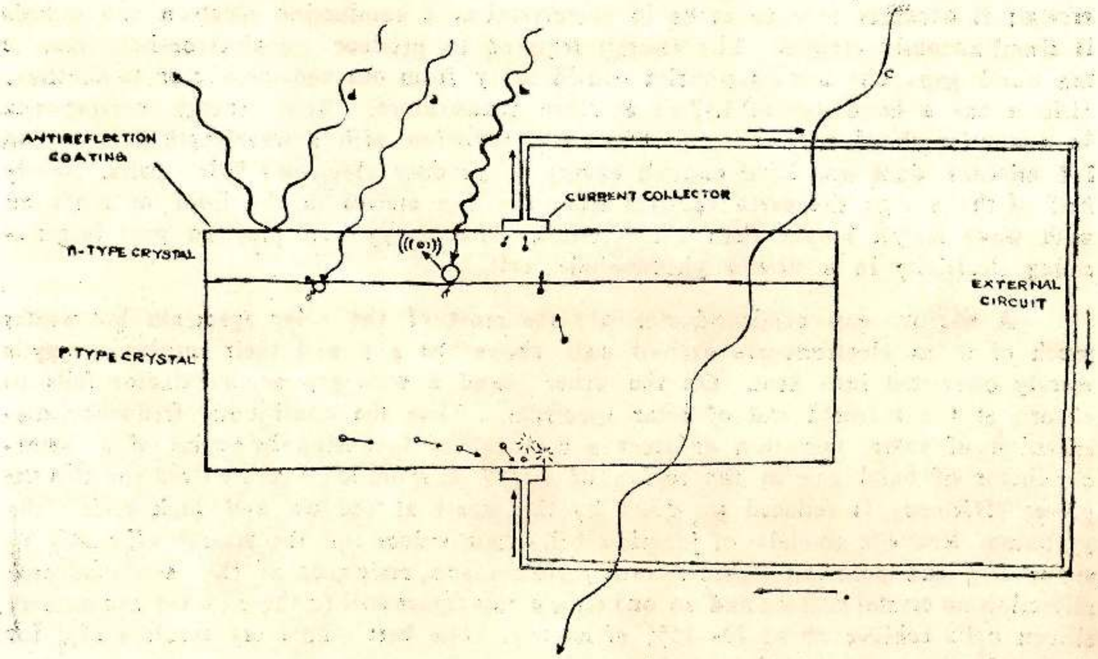
Photovoltaic solar cells convert solar energy into electricity by a purely electronic process. Such cells are expensive, would cost about U. S. $ 10. But new kinds of fabrication may make them economically competitive.

The space programme provided the incentive for the developement and production of the first practical photovoltaic device which have provided electric power in many space vehicles, manned and unmanned with extremely high reliability and for an apparently unlimited time.

Most of the solar cells are made up of silicon a semiconducting material which is one of the most abundant elements in the earth's crust. Because of the complexity of the purification process perfect crystals of semiconductor grade are very expensive. Costing about US $ 70 per kilogram.

The electrical properties of a highly purified Semiconductor material can be changed drastically by addition of small amount of impurities of certain type. A material with donor type impurities (Pentavalent elements such as P, As, Sb. which can donor electrons) is called n-type semiconductor because its properties are determined by the negative, charge carriers. Similarly a material with acceptor type impurities (trivalent elements such as B, Ga, In, Al which can accept electrons) is called p- type semiconductor because its properties are determined by the positive charge carriers "holes".

The contrasting properties of n- type and p- typ crystals make the electrons and holes as a source of electricity.




Consider a crystal that is composed of a layer of n- type silicon-consists of mobile electsons and immobile positively ionized donor atoms and a layer of p-type silicon . consists of mobile holes and immobile negatively ionized acceptor atoms. At the junction the mobile electrons and holes will recombine and the left immobile charges (positive charges on n- type, negative charge on p- type) will produce an electrostatic field.

Now if, pairs of electrons and holes are created near the junction, the affinity of the n- type crystal for electrons and that of p- type crystal for holes will reduce the randomness of their movements through the crystal. So that there is a net flow of electrons from the p- type to 'n- type and a net flow of holes in the opposite direction. In a silicon solar cell the layer of n- type silicon is of a thickness such that light falling on the surface penetrates far enough into the crystal to create electron hole pairs in the vicinity of the junction. Therefore when light falls on the cell electrons will collect in the n- type layer and holes will collect in the p- type layer untill there is a voltage built up within the crystal sufficient to push away further electrons and holes, In a silicon solar cell that voltage is about 0.65 volt. A current can be drawn from the cell through a circuit that make electrical contact with both the front surfaces of the cell,

In considering the theoretical efficiency of a photovoltaic device let us look more closely at the process by which a photon is absorbed by an electron in a semiconductor. That process is the transfer of quantum energy to a single electron. If the photon is sufficiently energetic, the energy received by the electron will release it from its normal function as a bond between two neighbouring atoms in the crystal; it becomes free to move in the crystal as a conduction electron and a hole is simultaneously created, The energy required to produce an electron-hole pair is the band gap. The band gap varies considerably from one semiconductor to another. Silicon has a band gap of 1.12 eV at room temperature. That energy corresponds to a wavelength of 1.1 microns. Therefore radiation with a wavelength longer than 1.1 microns does not have enough energy to produce electron - hole pairs. Nearly half of the energy the earth receives from the Sun arrives in the form of radiation with wave length longer than 1.1 microns. That energy can play no part in generating electricity in a silicon photovoltaic cell.

A narrow gap semiconductor absorbs most of the solar spectrum but wastes much of it as electrons are excited well above the gap and their surplus energy is merely converted into heat. On the other hand a wide gap semiconductor fails to absorb at the infrared end of solar spectrum. Thus the continuous frequency distribution of solar radiation enforces a compromise favouring the choice of a semiconductor of band gap in the region of 1.5 eV at room temperature Even for this the power efficiency is reduced to $<50\%$ by the waste at the low and high ends of the spectrum. Realistic models of junction behaviour reduce the theoretical efficiency to about 25% and practical considerations (grid contacts, resistance of the semiconductor reflection on crystal surface and so on) reduce this figure still further; Most commercial silicon cells achieve about 10—15% efficiency. The best laboratory result is 23% for GaAs cells in concentrated sunlight.

Solar cells with only 10% efficiency (up to 20% efficiency is certainly possible) need no more than 77,000 square kilometers of sunlight—just 1/250th of the total desert area — to meet all the energy needs of the world today. However due to its high costs (US $ 15 per watt) silcon cells are not in wide use. There are now intensive development projects worldwide with the object of developing economical terrestrial photovoltaic power plants.

Photovoltaic energy conversion appeared to be the most useful starting point of the current option for solar energy conversion in the Satellite solar power station. The satellite power station could convert solar energy to electricity on a nearly continuous schedule This electricity could be fed to microwave generators incorporated n a transmitting antenna in the satellite and the antenna would direct a microwave beam to a receiving antenna positioned in a direct line of sight on earth. There the microwave energy could be reconverted safely and efficiently to electricity and fed into conventional power transmission network. With additional satellite systems, power could be delivered to almost anywhere on earth.

Technical and economic feasibility studies of such systems already indicate that they could provide an economically viable, and environmentally and socially, acceptable, option for power generation on a scale substantial enough to meet a significant portion of future world energy demands.

# LASER

## The Death Beam Which Gives Hope

**A. NANTHAKUMAR** - Chemistry Special I

Early in the 21st Century the President of the United States pushes a button that turns on thin silver of intense light and direct it on to a gaseous form of Hydrogen extracted from sea water. With this laser generator No. I goes on stream.

Science fiction? Perhaps not.

Just 20 years ago laser was only a laboratory curiosity. But now it is considered as one of the most versatile discoveries at the 20th Century. The word laser stands for Light Amplification by Stimulated Emission of Radiation; The idea of stimulated emission was introduced by Einstein in 1917 to describe the absorption and emission of black body radiation.

A laser device is made up of a laser medium, either gas, liquid or solid which can be excited to a higher energy level by a process known as pumping. The excited medium is placed inside an optical reasonator or laser cavity made up of two highly reflecting and carefully aligned mirrors. Radiation passing through the medium is amplified by the process of stimulated emission and increases in intensity if more of the medium is excited than unexcited; The radiation contined inside the laser cavity is usually reflected many times between the two resonating mirrors. part of the radiation is allowed to leak out by arranging for one of the reasonator mirrors to permit a small amount of light to pass through it instead of being reflected. Excited atoms can emit light in the form of descrete packets of electromagnetic energy called photons. If the emission is stimulated by other photons the excited photons is added to the others in the wave at exactly the right instant and with the same frequency. Therefore laser radiation is monochromatic and is very directional and stays as a light parallel beam. The divergence angle of a laser beam of wavelenght $\wedge$ is $\wedge/d$ where d is the diameter of the beam. The divergence angle for visible light of beam diameter 5mm. is about $10^{-4}$ radians ie., the beam would expand to only 10 cm. diameter over a distance of 1 Km.

Since laser radiation is highly coherent and directional it can be focused to a spot with a diameter only a few times the wavelenght of light. These special properties of laser offers an important challenge to be exploited in the next few years.

## Types of Laser

The earliest type of gas laser used a mixture of helium and neon atoms The atoms are usually excited by low current electric discharge. This cheap power device gives a continuous beam of red light at 632.8 nm. and are often used as general purpose source of a straight line for aligning components.

In the Argon ion laser, laser transition is excited in atomic ions. This produces seperate wavelengths in the blue green region of the visible spectrum.

The carbondioxide gas laser is some what different in that the laser transition is between vibration - rotational levels of the $CO_2$ molecule. Excitation is caused by transfer of energy from vibrationally excited $N_2$ molecules. $CO_2$ lasers are highly efficient and up to 25 percent of the electrical input energy may be emitted as laser radiation. The wavelength is in the IR region at 10 6 m and may be continuous or pulsed.

The new type of laser are the so called excimer or exciplex laser. An excimer is an excited dimer which can exist in a complex state for a very short time, perhaps one tenth of a millionth of a second, before radiating The act of radiation breaks up the complex form. Therefore the stimulated emission is not reasorbed by gas at the lower laser levels. These are also known as tunable lasers because the wavelengths of these lasers can be varied (tuned) over a wide range. The more important tunable lasers are liquid devices in which an organic dye molecule is the active component. In the continuous dye laser an argon ion laser is used as the pump.

An important solid state laser is based on neodymium ions in a crystal or glass host material. This emitts radiation at 10.6 m. in the near IR region. Lasers, of this sort are pumped optically with light from a powerful flash lamp.

A great many applications for lasers have emerged in the physical, chemical, biological and modical sciences.

There is already considerable research going in using laser as a source of energy for nuclear fusion.

## Laser Fusion

Scientists are involved in nuclear fusion research using the Argus laser at the University of California's Lawrence Liverpool laboratory. The $ 3.5 million Argus laser until recently the most powerful of its kind in the world shoots a pulse of light out of a neodymium glass rod surrounded by powerful lamps. The light emitted is split by an optical device each of which is amplified by a series of neodymium glass disks and directed through a long line of pipes. Ultimately the beams reunite and strike a target an almost microscopic glass ball containing a gaseous mixture of deuterium and tritium. When the combined energies of both beams hit the pellet they cause it to collapse with such suddenness and intensity that the implosion produces enough heat (as much as 100 million °C) enough to fuse the hydrogen atoms inside the pellet into helium and release energy in the form of nuclear particles. The energy emitted by this fusion reaction can ultimately be converted into steam heat and used to run turbines.

Scientists are also experimenting with the $ 125 million shiva system which boasts 20 beams and is named after the 20 armed Hindu God of destruction and creation and is expected to yield ten times the power of Argus. Further ahead lies the $ 195 million system called Nova and if all goes well is expected to be completed in 1985. This will deliver 100 times the energy obtained from Argus and scientists hope that with further refinements this machine will reach the "break-even-point" where the amount of enegy produced equals or surpasses the laser energy input.

Like many scientific discoveries the laser has enormous potential for good and for ill. For instance as a beam weapon laser can be used to achieve a great strategic advantage.

## Laser As A Beam Weapon

Unlike other particle beams the laser beam makes more efficient use of the beam energy because all the photons interact with the skin of the missile. Laser beams in the right Spectral Bands can blind the infrared sensors of satellite leaving your oponent no way to monitor the launch of your missile or to observe the results of his own attack on you.

At sea level the beam has a great struggle to get through the dense atmosphere being absorbed by $CO_2$ scattered by particles in the air and spread by turbulance as the refractive index of the air changes. In addition air heated by the beam evaporates and block the radiation. Whatever the power and which ever wavelength choosen it seems unlikely that any laser will have a military useful range beyond 10 Km. at sea level. But if you mount your laser at 2500 m. and point it straight up and the story is different, Now only 3 percent of the power is lost in getting out of the atmosphere. That is why lasers can be used to dazzle the sensors, of satellites in orbit As a proof of accuracy in the early summer of 1978 a deuterium fluoride laser emitting IR at a wavelength of 3.8 micrometers destroyed a small anti-tank missile flying at supersonic speed over the desert of Southern California. But the laser system was as big as a modest factory therefore there are considerable difficulties in putting this heavy equipment in orbit.

## Machining

The high power directional laser beam focussed to produce intense heat has come into widespread use in Engineering for cutting, drilling and welding many different types of material. The laser has been used to drill brittle materials and others as hard as tungsten, titanium and diamond. The beam can be focussed through optical windows to weld and drill materials inside a vacuum. The beam can be computer controlled to give close and quick manipulation.

## Use of Laser in Medicine

The directionality and high power density in the focussed spot of a laser form a valuable tool in surgery and other medical applications. The loss of blood with the laser scalpel is very much less than with normal scalpel. Ruby and argon ion lasers are used to reattach retinas which have become detached, Carbondioxide lasers are also being widely used to treat premalignant cancerous areas of the cervix without need to administer an anaesthetic. Research into laser surgery and preventive dentistry continues with the aim of better exploiting the properties of laser and matching them to the medical requirement.

## Other Applications of Laser

One important technique available to the research scientist is spectroscopy in which the study of the absorption emission or scattering of radiation gives detailed information about extremely powerful light probe which without exaggeration has revolutionized this work. Laser spectroscopy has recently been used to measure the radii of nuclei and detect atmospheric pollutants.

When a laser light is scattered from a moving object it undergoes a change in frequency in proportion to the velocity of the moving particle: Using this technique it is possible to obtain information about the motion of a particle. This has been applied to the study of fluid flow in wind tunnels, the flow of blood in veins and in arteries in the eye, the dynamics of molecules and many other fields of research. One of the latest techniques developed is the use of laser as a probe to study how air and fuel mix and flow in the manifold of an internal combustion engine. This could be of help designing engines to run on poorer grades of fuel thus overcoming the petroleum shortage to some extent.

Laser communication technique promises to meet the needs of growing telecommunication networks and that aim is now near to being achieved using optical fibres of low light loss as the link and lasers or light emitting diodes as sources. Laser beams can also provide optical communications between satellites or ground stations where a closed circuit link may be required.

Three diamentional or holographic images can be constructed using laser beam. Applications of holography include non-destructive testing and holographic microscopy. Dramatic effects can be produced in laser light displays and in the entertainment industry and there may be future applications to three diamentional television and in cinema work.

Seletive absorption of IR laser by certain isotopes offers an important isotopic seperation method. There is active research at present in the seperation of uranium isotopes which will be important in nuclear power programmes;

To make some of the e applications possible it is necessary to develop lasers that have the right radiation properties. Due to its potential as a beam weapon research in laser will no doubt be a race for military superiority for the super powers The "Sword of Heat" and light sabre which appeared in science fiction has now turned real.

In the laser imagination and fact have met.

*References*: *No. 161/1979 Spectrum*
*New Scientist, 26, April 1979*
*No. 159/1979 Spectrum*
*Readers Digest. October 1978.*

# IMPACT OF RADIATION EFFECTS ON MAN

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Radiation, both ionizing and nonionizing, is increasingly present in the environment. Man made exposures include radiation emissions from X-ray equipment, nuclear power plants, reactor fuel reprocessing plants and electronic products such as colour television receivers, micro wave ovens lasers etc.

Exposure of man to radiation can cause biological injury, including genetic effects and cancer, The operation of the above nuclear plants results in the discharge of small quantities of radioactive waste into the environment which can reach man through air, water or food supply. Its generally agreed that any increase in radiation exposure will be accompanied by a commensurate increase in the risk of injury. Therefore, society has a responsibility to keep man-made radiation exposures as low as possible.

Nuclear energy offers man an altergative energy source for generating electricity. Electronic products have the potential for producing unnecessary radiation. Because these products operate in the home they may expose large numbers of the population to radiation, unnecessary radiation exposure should be controlled by reduction or elemination of the potential hazard.

## Effects on Human Health :

All living organisms are made up of cells. Most cells have a defined nucleus in which the heriditory material, the chromosomes are found. These chromosomes are constructed of deoxyribonucleic acid (DNA) chains and nucleoproteins and is responsible for several functions of the cell.

Any amount of radiation however small can cause damage to the cell. As far as mutation in chromosomes is concerned there's no safe dose of radiation, and exposure to radiation never fails to produce its share of mutation. The frequency of mutation increases with the dose of radiation, at a high intensity for a short time it produces more damage than when its given at a low intensity for a very long time. In addition continuous treatment produces more damage than the treatment with periodic rest dose.

Long term effects which result from either acute or protracted exposure to radiation include certain types of cancer, reduction of fertility, acceleration of the ageing process, eye damage and genetic mutation,

Considering a few of the occurance above in detail, certain dose of radiations cause deletions and rearrangment in chromosomes thereby inhibiting the proper function of the chromosom, As a rsult of this the cell begins to produce defective proteins which brings about abnormality in th particular organism exposed. Sometimes this might result in a bulk of tissue which is considered to be the caus of cancer, Any increase in exposure increases the frequency of certain cancers. For instance of about 6,000 men who are uranium miners 600 to 1,100 have been estimated to die within 20 years of work as a result of radiation exposure, principally from lung cancer.

Usually deletions in chromosomes which are caused by radiations are repaired by a few enzymes which are involved in the DNA repair mechanism. If the deletions occur very frequently the DNA repair mechanism becomes weak thereby accelerating the ageing of cells.

## Control :

So it prudent to eliminate all unnecessary radiation exposure and to reduce all excessive exposures, while attempting to maximize the benefits of each unit of prescribed exposure.

Methods are available for controlling radiation exposures from medical equipments, nuclear power plants and som electronic products. Distance, shielding and limiting exposure time are the three basic factors of protection. To control X-radiation in the healing arts we have focused on improving X-ray equipments, the X-ray facility the judgement and the training of radiation users. Unnecessary radiation exposure from electronic products compliance and with performance standards for controlling radiation exposures:

For these millions of colour televisions receivers manufactured prior to regulatory controls, service personnel can provide significant reduction in X-ray emission by proper adjustment of service controls. TV repairman should adjust the high voltage to the manufacturers' recommendations and select only replacement parts which meet design criteria for the reduction of radiation emission. Viewers themselves can provide additional precautions by maintaining a safe veiwing distance (approximately 6 - 10 ft.) from the reciever.

For reasons of public safety nuclear power plants are constructed in areas having relatively low population.

Research studies and inspections are conducted and supported to control hazards caused by exposure to radiation emissions from nuclear facilities nuclear explosives or nuclear power sources and other applications of nuclear energy.

Medical care, electrical power generation and communications are three of the growing "industries" directly benefiting from these sources of radiation. They should be concerned with the impact of radiation on man and his environment with an optimal benefit / risk ratios if they are to continue to grow and serve mankind.

*"Consider all substances; can you find among them enduring "self" Are they not all aggregates that sooner or later will break apart and be scattered"*

—The teaching of Buddha

*"I think the relation between application and basic science is like that between fish and water. Without water there can be no fish without basic science there can be no application"*

—T. D. Lee

# PHILOSOPHICAL PROBLEMS OF ELEMENTARY – PARTICLE PHYSICS

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The Physics of Elementary particles is a rapidly expanding field of modern physical knowledge at the forefront of investigations into the structure of matter. As physics develops the conceptual apparatus of the theory changes. A comparison of classical electron theory and the present day theory of elementary particles shows that the latter has such concepts as spin, isotopic spin, lepton charge, baryon charge, strangeness, helicity, parity of state, compound inversion and so forth, all of which are totally lacking in the classical theory and which make the new theory fundamentally different. The advancement of theoretical physics is possible only within the framework of a fundamentally different system of laws, which in turn, sooner or later will also become closed. For instance the specific nature of classical mechanics is determined by the laws of Newton, whereas the peculiarities of electrodynamics are defined by the system of laws expressed by Maxwell's equations, and the peculiarities of, say, non-relativistic quantum mechanics, by the system of laws expressed by the equations of De Broglie and Schrodinger and also by the commutation relations for quantum quantities. These theories possess a clear-cut closed nature due to the integrality and completeness of the law systems they consist of and; conversely the present theory of elementary particles does not have such a closed nature, Precisely because it does not yet possess and integral system of fundamental laws,

Now we consider the problem of whether the space and time are discrete in the micro world. Discreteness is known to be a general characteristic feature of the micro-world. Many particle properties-spin, electron charge, magnetic moment, parity and certain others - have quite definite discrete values. By the revolutionary concept of quantum which was put forwarded by Max Planck at the beginning of 19th Century by quantising the action, other quantities such as spin and angular momentum are also quantised Now physicists are thinking of quantising space and time as well, By considering discrete space and time, the infinite values in quantum theory can be removed without doing renormalisation.

B Abrarrenko points, in this connection, to the possibility of a curious relationship between the elementary length $l_0$, the time quantum of $t_0$ and the quantum of action h. Suppose that the elementary length is equal to 1.5x13 $^{13}$ cm., which in general is in accord with the proton dimensions. Then

$$t_0 = \frac{1.5 \times 10^{-13} \text{ c.m.}}{3 \times 10^{10} \text{ c.m./sec.}} = 0.5 \times 10^{-23} \text{ sec.}$$

Correlating $l_0$ with the corresponding spherical volume and multiplying the quantity obtained by $t_0$, we get the quantum of space-time.

$$V_{st} = 4/3 \pi l_0^3 t_0 = 7.1 \times 10^{-62} \text{ c.m.}^3 \text{sec.}$$

Further assume that this spatio - temporal volume is filled with matter of nuclear density $d = 10^{14}$ g / c. m.$^3$. Its energy will be $V_{st} d c^2 = 6.4 \times 10^{-27}$ erg. which is approximately the same as the planck constant, $h = 6.6 \times 10^{-27}$ erg sec! Whenever a new theory evolves, the laws of the earlier theory are a particular (limiting) case of the laws of the new theory into which the former pass when some characteristic parameter found in the new theory is attained. This proposition first stated by Niels Bohr for the special case of the relationship between his newly created quantum theory and classical mechanics was called the 'principle of correspondence. The principle of correspondence is corroborated by findings from all fields of Physical Science connected by asymptotic limit processes are for example the laws of wave and geometrical optics (this formally occurs when the wavelength approache zero, $\lambda \rightarrow 0$), the laws of quantum and classical statistics (for $T \rightarrow \infty$), the laws of relativistic and classical mechanics (when $C \rightarrow \infty$), the laws of quantum and classical mechanics (when $h \rightarrow 0$). The principle of correspondence also plays a very essential heuristic part in the modern theory of elementary particles. It has been applied for example in establishing physical meaning for a number of newly introduced concepts. In particular this refers to attempts to create a theory of elementary particles on the basis of the idea of quantisation of space (the introduction of what is called on a "elementary length" $l_0$ and nonlocality of interaction when $l_0 \rightarrow 0$ the theory of quantised space returns us to the laws of ordinary quantum electrodynamics

Regarding the problem of criterion of elementarity, the 1979 Nobel prize winner of physics Abdus Salam says "Deepest problem of all among all this wealth of particles what is the criterion of elementarity". In accord with the foregoing findings it remains to define the elementary particle as an entity that does not consist of any other particles. But this definitton of an elementary particle is actually tautology, "An elementāry particle is an elementary particle". Is it possible to give a nontautological definition for an elementary particle? The problem of elementariness might appear to be reducible to a certain series of divisions of matter where each division (or level) is an "elementary" step for the next and at the same time is a "composite" step relative to the preceeding division. Perhaps the familiar types of elementary particles are only relatively elementary The fact that the atom or the atomic nucleu is relatively elementary has been proved by physics, and the discovery of the atom divisibility of the ātom and the composition of the atomic nucleus is a triumph of scientific inquiry. Is that the situation as concerns the elementary particles? First of all can the relatively elementary serve as a key to the problem of elementariness?

In terms of modern physics - elementary particles underlie the structure of matter. These elementary particles (systems) of the first complexity atomic nuclei, the latter combine to form chemical atoms - particles of second complexity, molecules made up of atoms are a yet higher complexity and so on. The crux of the problem here is that the existence of elementary entities is posited; and objects of varying degrees of complexity are regarded as composite and ultimately consisting elementary entities. Modern conceptions of elementary particles, include the scheme of the Japanese physicist S. Sakata consisting of three fundamental particles: proton, neutron, and lamda-hyperon (to which are added their antiparticles) which can account for all the strongly interacting particles. But later when Gell-Mann and Zweig returned to the picture of three fundamental particles by alternating and refining Sakata's scheme, it turned out that the quantum numbers of three particles (which were given the name quarks) had to be fractional. Ofcourse only experiment can settle the question of the existence of quarks. R. Hofstsadter believes that "the search for ever smaller and more fundamental particles will continue as long as man retains the thirst for knowledge".

It will be recalled that the concepts of discontinuity and continuity of matter regarded abstractly are not applied in the physics of micro-world. In quantum theory, the discontinuous and the continuous are aspects of a unitary essence. This information of quantum theory was most fully elab rated by Neilps.

Regarding the problem of the structure of elementary particles, one may put forward two types of theories. In one type, elementary particles are point particles and their "internal" properties are described in abstract isotopic space which differs from ordinary space and time in its metric properties. In the other, the elementary particles have extension space and time "inside" the elementary do not differ from ordinary space and time but "inside" the elementary particles there are some new forms of material motion which are qualitatively different from the interactions between elementary particles. Both conceptions have their merits and demerits.

The structure of the elementary particles can be analysed using their different types of interactions. Apparently, the very first sign that one may use to judge the presence of quantitatively different forms of the motion of matter is the kind of interactions peculiar to the entities. Peculiarity of interaction is directly assoiciated with the probability of laws governing the given form of motion of matter. In the world of elementary particles, there are three essentially different types of interaction. strong, electromagnetic, weak (here we disregard the fourth gravitational force) the characteristic properties of which are different from one another. The characteristic time of the strong interaction is estimated at $10^{-23}$ Sec., of electromagnetic interaction at $10^{-18}$ Sec., the time for the weak interaction is about $10^{-9}$ Sec.

The principles of conservation plays an important role, unifying the interactions. No matter what physical theory you may take, within the system of its basic laws it contains the principles of conservation. These principles form the foundation of the established theory, and likewise serve as the starting point of any newly emerging theory. The principles of conservation may be defined as requirements of constancy of certain constituent quantities in the system of concepts of the given theory. The familiar conservation laws of elementary particle physics that reflect the conservation of properties of electric charge, spin, isotopic spin, baryon charge, lepton charge, strangeness, and so forth-constitute only special laws of conservation principles. In elementary particle physics, the classical principles of conservation remain valid (the conservation of mass, charge, energy, momentum, and angular momentum). These principles are of a general nature, and their operation in the field of elementary particles is indicative of a deep unity of nature. The largest number of conservation laws are operative in strong interactions. Electromagnetic interaction does not obey some of them. The weak interactions, as we all know today, are a continual supplier of surprises connected with violations of conservation laws. Such are the facts that led Salam, in the article on "elementary particles", to the idea that certain particles are more elementary with respect to some specific process, some particles are more elementary than others.

The ability to participate in a certain kind of interaction is undoubtedly dependant on internal structure, the existence of which in the elementary particle in no longer in doubt, despite their unique specificity. But the photon is capable of only one type of interaction (electromagnetic), the neutinos form only the weak interaction. Can their structure be of a single type, qualitatively similar, if we take into account the earlier mentioned fundamental difference between the weak, electro-magnetic and strong interaction? Rather, it would seem that we have to do with qualitatively different material structures, with qualitatively disparate types of matter, with qualitatively dissimilar forms of motion that are not reducible to one another.

The neutrine is capable of participating in only one type of interaction, while the electron can be involved in two the weak and the electromagnetic interactions, Can we regard the material structure of the electron as qualitatively homogenous-unitary? But the fundamental difference of these types of interaction, and the associated difference is of spatail scales. The electromagnetic radius of the electron is of the order of $10^{-11}$ c. m. We are justified in thinking that the electron is a more complex particle than the photon or the neutrino, and that the photon and the neutrino are relatively more elementary entities. In that case, still more complicated are particles which, due to their nature, are capable of participating in all three types of interactions, say, pi-mesons. The strongly interacting particles, as a special family has got the name hadrons. So the hadrons should have in their structure a region responsible for electromagnetic interaction, a region responsible for the strong interaction, and a region responsible for the weak interaction. These levels of structure differ in the magnitude of the energy relations, the character of interaction, and the spatio-temporal scales.

Due to the development of high energy accelarators, the number of elementary particles increase very rapidly. So now physicists are trying to classify them, using group theory. Attempts at a classification of the elementary particles with the aid of group theory are akin to the search for the periodic system of the chemical elements. The periodic law, which played a very great role in the development of physics and chemistry, was discovered by Mendelayer on the basis of a generalisation of the systematics of the chemical properties of the atoms, without any explanation of the inner causes governing these properties The periodic law was explained later by quantum mechanics, which illuminated the structure of the atom. We have something like this in the modern theory of the symmetry of elementary particles, which is also at the stage of a phenomenological description of the regularities of variation properties of microparticles. Reasoning from symmetry, Gell-Mann obtained a formula relating masses, that enabled him to prediot new particles, and their "familial relations" with known particles. A recently predicted particle was the omega-hyperon with hypercharge Y= -2 and isotopic spin I=0. This discovery contributed much to the development of ideas involving the application of the mathematical apparatus of the theory of Lie-groups in particular groups that satisfy SU (3) symmetry.

Though the group theory helps to classify the elementary particles in groups, it is hard to believe that there are several hundred elementary particles, and it is therefore natural to suggest that they might infact to composite systems of "quarks" (Gell-Mann 1964, Zweig 1964), rather as the atomic elements were found to be compostie of $e^-$, p and n.

In order to explain the structure of baryons, they considered only three types of quarks with fractional charges but with spin $\frac{1}{2}$ Viz-: up (u), down (d) and strange (s) with charges $\frac{2}{3}$,e, - $\frac{1}{3}$e, - $\frac{1}{3}$e, respectively. The quarks are bound by electrically neutral "gluons". The up and down are refered to as flavours of quarks. The third flavour is postulated in order that "strange" particles can be built. In order to build mesons with quarks, antiquarks are introduced. The antiquarks have spin $\frac{1}{2}$ but opposite charge and strangeness to the corresponding quark. Hence anti-up ($\bar{u}$) has charge -$\frac{2}{3}$e, d- has charge +$\frac{1}{3}$e and so on. But up to 1974 November, physicists were happy with their above quark hypothesis. In November 1974, a group led by Richter at SLAC in California produced a new vector meson in e+e- annihilation. They named it "psi". Independently Ting and collaborators found this meson produced in the debris of high energy proton nucleus collisions at Brookhaven, New York. They detected it by its decays and named it J. This meson has a mass of 3095 MeV and is almost stable. Within ten days the group at SLAC had found another psi- like state with mass 3684 MeV, named "psi". This was extremely stable. At the time several hypothesis too were put forward, attempting to explain these peculiar discoveries. Subsequent date have shown the correct interpretation to be, that they are the first manifestation of a fourth flavour of quark: a charmed quark (c).

Particles which can experience the strong (nuclear) force are built from quarks. In addition there exist particles, like the electron, which do not take part in strong interactions. They are known as "leptons", and appear truly elementary particles like the quarks. They either have one unit of electrical charge (like the electron), or are neutral (like the neutrino).

If nature had contained just two leptons (electron and neutrino) and two quarks (u and d), then one could build an aesthetic self constant theory combining the electromagnetic interaction with the weak interaction of radioactivity. This is the Salam Weinberg model". The problem was that nature also contains a second doublet of leptons, namely muon and a muon-neutrino. In order to implement the unified weak-electromagnetic theory, satisfactorily a second doublet of quarks was postulated. The existence of the strange quark known as the charmed quark, was postulated by Glashow etal (1970) to be a partner of the strange quark, thereby restoring the lepton quark doublet symmetry.

| | |
|---|---|
| (up quark) | (charmed quark) |
| (down quark) | (strange quark) |
| (electron) | (muon) |
| (electron neutrino) | (muon neutrino) |

Hence the charm discovery completes a nice symmetry between the lepton world and the quark world which, moreover, is needed in order to satisfactorily unify two of nature's forces

In 1976, the beautiful symmetry between leptons and quarks just established by the discovery of charm, was destroyed by the discovery of a fifth lepton (taů). There is now good evidence that this lepton is partnered by an electron neutrino, and so three "generations" of lepton doublets exist. Are there therefore also three generations of quark doublets? In the summer of 1977 a metasatble vector meson, mass 9.46 Gev was discovered in the debris of proton - nucleus collisions. In 1978 this particles is named r-. At 10 Gevr-' has been found analogus to the psi' was produced in electron - positron, anhilation at DORIS; Hamburg. It seems that we have begun to uncover the spectroscopy of a fifth, b, quark. The production rates and seem to imply that this quark has charge $-\frac{1}{3}$. There is now a deep belief that a sixth quark texists, so that the third generation of quarks is completed.

| | | |
|---|---|---|
| (u) | (c) | (t) |
| (d) | (s) | (b) |
| (e-) | (mu-) | (tau-) |
| (Ve) | (Vmu) | (Vtau) |

The number of quarks and leptons has been found to be larger than prevoiusly thought. If the number of quarks and leptons is found to increase further, then we may begin to suspect that there is something more profound, beyond the quark. Till now, not even a single quark has been found experimentally! But there is some evidence supporting the quark hypotheses, in the seattering experiments of neutrinos with protons. Suppose quark exists in nature, then what have we to do with the optimistic quark hypotheses?, Now theorists develop Quantum flavour dynamics (Q. F. D) containing Quantum electrodynamics (Q. E. D.) within it. They are also developing, recently, a theory called Quantumchromodynamics (Q.C.D.) so there is hope, if this is corrected that we may eventually achieve a grand unification of Q. F. D. and Q. C. D.

In early days. Mathematics developed from physics. Now a days, physics develops from Mathematics.

※ (see acknoledgement)

**References:**


1. R. A. ARONOV On the problem of Space and Time in Elementary particle physies
2. V. B. BERESTETKY Certain features in the Recent – Development of elementary particle Theory
3. D.J.BLAKHINTSEV Problems of structure of elementary particles
4. F. E. CLOSE "The New particles and their significance" (contemporary physics No. 3 Volume 20 May/June 1979)
5. V. Va FARIBERG (Specific feature of the Quantum Theory of elementary particles.
6. I. V. KUZNETSOV The interrelation of physical theories and the development of modern-elementary particle physies
7. S. T. MELYUKHIN On a philosophical Evalution of modern conceptions concerning the properties of space and time in the micro world
8. M. E. OMELYANOSKY The problems of elementary particles in Quantum physics
9. N. F. OVCHINNIKOV The principles of Conservation and the problem of the structure of matter.
10. B. YA. PAKHOMOV On criterion of Relative Elementariness
11. D. H. PERKINS "Neutrons and Nucleon Structure". (contemporary Physics 1, No. 2, Volume 16, March 1975)
12. SALAM "Elementary Particles" (contemporary Physics I, No. 5, 337, 1960)
13. S. SHAPIRO On the Quantisation of Space and time in Elementary Particle Theory
14. YA. A. SMORODINSKY Particles Quantawaves
15. A. A. SOKOLOV Elementary Particles



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From Johns Hopkins Megazine

# Science Conquers All

Some cheerful rules for research in a world where anything that can go wrong will,...

*This manus cript, found in the Johns Hopking Medical School office of Laura Aurelian, Ph.D†, is of unknown provenance. All Dr. Aurelian will say is. "It's been around for a long time. But a bunch of us who believe in cynicism did glorify it a bit"*

*First Law of Experiment:* In any field of scientific endeavor, anything that can go wrong will go wrong.

Corollary I: Everything goes wrong at one time,

Corollary 2: If there is a possibility of several things going wrong, the one that will go wrong is the one that will do the most damage.

Corollary 3: Left to themselves, things will always go from bad to worse.

Corollary 4: Experiments must be reproducible; they should fail in the same way.

Corollary 5: Nature always sides with the hidden flaw,

Corollary 6; If everything seems to be going well, you have overlooked something.

*Second Law:* It is usually impractical to worry beforehand about interference; if you have none, someone will supply some for you.

Corollary 1: Information necessitating a change in design will be conveyed to the designer after, and only after, the plans are complete .

Corollary 2: In simple cases, presenting one obvious right way vs, one obvious wrong way, it is often wiser to choose the wrong way so as to expedite subsequent revisions.

Corollary 3: The more innocuous a modification appears to be, the further its influence will extend and the more plans will have to be redrawn.

*Third Law:* In any collection of data, the figure that are obviously correct, beyond all need of checking, contain the errors.

Corollary 1: No one whom you ask for help will see the error.

Corollary 2: Any nagging intruder who stops by with unsought advice will spot it immediately.

*Fourth Law:* If in any problem you find yourself doing an immense amount of work, the answer can be obtained by simple inspection.

The following rules have been formulated for the use of those new to the field of research.

1. Build no mechanism simply if a way can be found to make it complex and wonderful.

2. A record of data is useful; it indicates that you have been busy.

3. Before studying a subject, first understand it thoroughly.

4. Do not believe in luck; rely on it

5 Always leave room, when writing a report, to add an explanation if it does not work (Rule of the Way Out)

6. Use the most recent developments

in the field of interpretation of experimental data.

a. Items such as Finagle's Constant and the more subtle Bougerre Factor (pronounced "bugger") are loosely grouped, in mathematics, under constant variables or if you prefer, variable constants;

b. Finagle's Constant, a multiplier of the zero-order term, may be charactorized as changing the universe to fit the equation

c. The Bougerre Factor is characterized as changing the equation to fit the universe. It is also known as the "Soothing Factor"; mathematically similar to the damping facter, it has the characteristic of dropping the subject under discussion to zero importance.

d. A combination of the two, the Diddle Coefficicnt, is characterizd as changing things so that universe and equation appear to fit without requiring a change in either, (9)

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