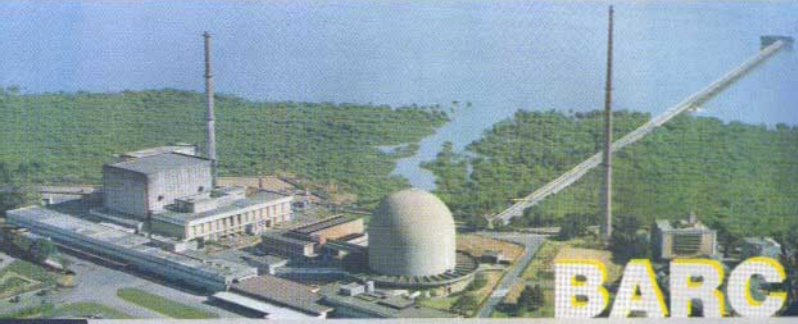

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DEVELOPMENT OF HYDROGEN SULPHIDE MONITOR *

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Introduction

In many process controls, production centres, or in environmental monitoring, the measurement of concentration of one of the gases is often a key factor. In such a situation, a sensor provides the necessary interface between the gas under detection and the back up electronic instrumentation. In the past two decades, this field has been dominated by developments of sensors based on metal oxide semiconductor thin / thick films. A wide variety of materials like SnO_2, WO_3, MoO_3, TiO_2, ZnO, etc. have been investigated and a host of sensors have been developed for many toxic and hazardous gases including NO_X, NH_3, CO, H_2, H_2S, halogen, PH_3, hydrocarbon, etc. However, the challenge of producing sensors that respond only to a specific gas - and to no other gas - as well as have quick response and long life in a hostile ambiance continues to attract the attention of scientists and technocrats. The present article describes the sensor development work carried out for Hydrogen Sulphide (H_2S) at Technical Physics & Prototype Engineering Division, BARC, to meet the condition of specificity of the sensors' response to H_2S.

*The H_2S Monitor System developed by TPPED, BARC, was awarded the Best Prototype Presentation prize at the National Seminar on Physics & Technology of Sensors, held at University of Pune, during February 14-16, 2000.

Contents

H_2S is a toxic gas and it is widely generated in nature, for example, in swamps and geothermal sources. This gas is used in large quantities in research laboratories for growing sulphide crystals and in heavy water plants as a process gas for producing D_2O. Hydrogen sulphide reacts vigorously with living tissues and causes several effects on health depending on the gas concentration. Although human nose can detect even 0.2 ppm H_2S - whereas the occupational exposure limit for H_2S is 10 ppm-8hr, our senses cannot readily distinguish different concentration levels. Also H_2S paralyses the olfactory system and, therefore, it is considered more dangerous than CO. Constant electronic monitoring of H_2S gas concentration in the ambient is the only means of protection against the ill effects of the gas. For this the gas must be detected in ppm levels in air by selective and sensitive sensors, especially when it is encountered in the presence of other gases in a wide variety of industrial and environmental situations.

Construction of H_2S Monitor

H_2S Monitor developed by TPPED consists of two parts; (i) Sensor Head, and (ii) Control cum Display Unit. The Sensor Head, which is the sensing element, consists of a thin film of one of the metal oxides (e.g. SnO_2, WO_3, MoO_3 etc.) deposited on Al_2O_3 substrates. The film is suitably doped to enhance the sensitivity and also to impart specificity to H_2S. The sensor element is fixed to a tiny heater using a glass epoxy. The heater is made by winding nichrome wire on an Al_2O_3 plate which also has a small thermistor fixed to it on the reverse side. A low working temperature solder glass was specially developed for fixing various components of the sensor assembly. A schematic of the sensor assembly is shown in Fig.1. As the concentration of H_2S in the ambient picks up, the conductance of the sensor film changes.

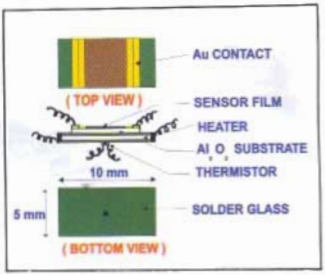

Fig. 1 Schematic of sensor assembly highlighting the way film is laid on the alumina substrate, nichrome heater is attached on the alumina plate and the thermistor is located for temperature monitoring. Also shown is the top view indicating the gold contacts used for measuring film conductance.

By measuring this change, the concentration of H_2S is inferred. In order to ensure that this change in conductance is only due to H_2S, it is essential to keep the film temperature fixed. To achieve this, a controller unit is used, and the sensor assembly is connected to an electronic temperature controller circuit that ensures the sensor film operates at a constant temperature at a preset value in the range ~180° - 250°C with a control accuracy of ±0.2°C. The sensor assembly and temperature controller circuit are sealed in a metal tube of 30 mm in diameter and 100 mm in length. The controller side is hermetically sealed while sensor compartment has a flame arrestor consisting of a SS diaphragm which allows access of gases to the sensing element. Some further details of both the sensing element and control unit are given below.

Procedure for Deposition of Sensor Films

Three different techniques have been used to deposit thin films of metal oxide on semiconductor material, viz. (i) sequential evaporation of metals on Al_2O_3 substrate held at 250°C under high vacuum conditions and subsequent oxidation / sintering of the films at 800°C in flowing O_2, (ii) deposition of films on Al_2O_3 substrate from 40 mm dia target pellet using rf sputtering and subsequent sintering as described for (i), and (iii) laser ablation of composite target material and deposition on substrates held at 600°C under partial pressure of O_2. Prior to deposition of film by any of these techniques, two Pt wire electrodes are fixed on the substrates using gold paste with setting temperatures above 850°C. These electrodes ensure stable contact resistance on the sensor film when it is used at operating temperature of 200°C continuously over time periods of several months at a stretch.

The structure related characterization of the sensor films was also carried out using analytical techniques such as X-ray diffraction, X-ray photoelectron spectroscopy (XPS), and scanning electron microscopy (SEM). Characterization of the sensor films for electrical conductance and other important properties included measurement of (i) Sensitivity, $S = (\sigma_{gas} - \sigma_{air})/\sigma_{air}$, (ii) Calibration of the curve, S versus gas concentration, (iii) Response/Recovery times, (iv) Specificity, (v) Base line, (vi) Long term stability, and (vii) Operational life.

The sensor characteristics are shown in Fig.2. It is seen that sensor response to SO_2 and H_2 is negligible as compared to H_2S. This shows the selectivity of the sensor. The response time (T90), time taken to reach 90% of the final value, is 1 min.

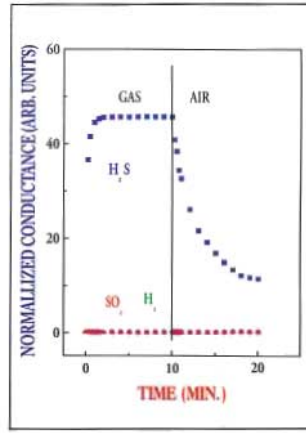

Fig. 2 Response of a typical sensor to 50 ppm H_2S, ~ 100 ppm SO_2 and 1000 ppm H_2. Note the specificity of the sensor for H_2S. The response time (T90) is ~1 min.

and recovery time (T10), time taken to reach 10% of starting value, is about 10 min. At the operating condition, the electrical resistance of different sensor films in air varies from 1 - 100 M ohm depending upon the composition of sensor film. The film resistance comes down to 10 K ohm at 50 ppm H_2S. Sensors based on SnO_2(CuO), $SnO_2(ZrO_2)$ and $(W+Mo)O_3$ materials have been developed. It is observed that sensor response of $SnO_2(ZrO_2)$ and $(W+Mo)O_3$ remains constant over prolonged periods extending over several months of continuous use.

Features of Control Unit and Full System

Control Unit : In most of the cases, the response of the sensor to gas concentration was found to be non-linear.

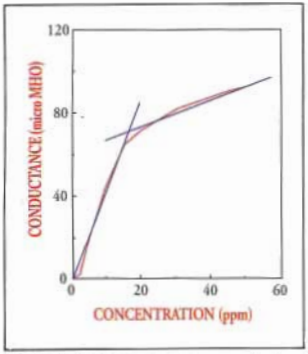

Fig. 3 Variation of film conductance as a function of H_2S concentration. Two segment linearization approach is used to obtain linear output.

Fig.3 shows, for example, the variations of film conductance as a function H_2S concentration. There are different approaches to design an electronic circuit which could convert the non-linear response to linear output. In the present work, a piece-wise linearization approach is used employing voltage dependent amplifier circuits. The voltage signal from the sensor film showing nonlinear variation of conductance with H_2S gas concentration, as shown in Fig.3, is converted to a linear output and displayed as gas concentration in 0-50 ppm range. A linear output of 4-20 mA is also provided for data logging. For field measurement of H_2S gas concentration in air, the sensor head is connected to the control unit using a five core screened cable which can be extended upto 500 metres. Fig.4 shows the photograph of the monitor with a sensor head connected to it.

The monitor has a preset alarm limit which can be adjusted over the entire range. A piezobuzzer gets activated when gas concentration near the sensor

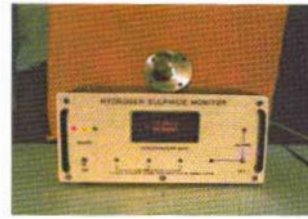

Fig. 4 Photograph of H_2S monitor showing sensor head and control unit.

head exceeds the preset value and an LED provided on the front panel starts blinking. This monitor is also provided with a fault detection circuit. In this case, an LED will be ON whenever heater/thermistor malfunction. The fault indication would also appear if the supply voltage drops below a preset level. All out puts like alarm and fault are also used to energize relays which could be used to drive any other electronic devices. The monitor has a provision for easy calibration in 0-50 ppm range. Already some of TPPED - made sensor systems that are currently installed in Heavy Water Plants for field trials have given rich experience to reach stable performance running over many months of continuous use. Experiments are now on to extend this life to over a year.

Conclusion

Solid state sensors based on metal-oxide semiconductor thin films are prepared for H_2S monitoring. These sensors are compact, robust, reliable and economical which are suitable for use in industrial environment. Associated control system with linearization circuits and having provision for alarm, fault detection, data logging, etc. has also been developed for monitoring the gas in 0-50 ppm range.

TOWARDS UNIFICATION OF MODERN SCIENCE AND INDIAN ANCIENT SCIENCE

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Introduction

Science is a secular discipline. Here the term secular has to be taken in its broadest sense. This means that the scientific study of the nature is not dependent upon any particular nation, race, colour of the people, geography, religion, social customs, ways of living, language, and the era. Thus the scientific exploration of nature may be expressed in different languages, in different terminology, in different systems of measurements. But internally the laws pertaining to a given aspect of nature have to be equivalent. From this point of view, really one cannot classify Western science or Indian science, modern science or ancient science. But because of long separations of time and distance between the two groups of humanity exploring nature and expressing in different ways, a distinction of modern science and Indian ancient science is appropriate. When we talk of modern science, it means the science that evolved in the West after the renaissance. And when we talk of ancient science, it means the science evolved in India prior to the arrival of Britishers.

The Problem of Communication

The initial writings of modern science were mostly in Greek and Latin. But subsequently English language picked up the field of scientific writing. And now, although scientific articles and books are written in Russian, French, German, Japanese, and Chinese, the bulk of the scientific literature is in English, and reliable translations of important works from other languages into English are readily available.

But Indian ancient science was written mostly in Sanskrit. Works of Buddhists were written in Pali. A great deal of books were burnt in the mediaeval period. Whatever is available, raises question of authenticity. Sanskrit grammar, though systematic, is found difficult by novices, the conceptual meaning of many words have changed over the millennia, and many times the authors have deliberately written in a style such that the apparent meaning of the text is different from the hidden scientific meaning. Sage Veda Vyas says in the beginning of *Mahabharat* (Adi-Parva, 1st Chapter, 80-81, published by Gita Press, Gorakhpur) that in this book 8,800 *Shlokas* are such that their real meaning was known to him and Sukdeo, and it was doubtful whether Sanjay knew them or not.

In *Mahabharat* this point has been clearly stated but in respect of many other books it is implied. Commentators and translators have added more confusion than enlightenment. Students studying ancient literature in Gurukul through Sanskrit medium do not understand modern science, and students studying modern science in colleges and universities are not familiar with ancient concepts and vocabulary. The result is that these two noble fields of human endeavour have remained in water tight compartments.

But, with all these limitations, now enthusiasts need not be disappointed. There are two guidelines in deciphering Indian ancient science; first of all, a conviction that a view of nature from one point always compliments the view from another point, and secondly, the description of any scientific principle involves some patterns of concepts, symbols, and logic. If we try to penetrate deeper, then the intended meaning of the author becomes apparent. For example, Panini while defining vowels short (*Hraswa*), long (*Deergha*), and very long (*Plut*) says, "According to the time taken in 'oo', any vowel is short, long or very long" (*Astadhyayi* 1.2.27). But what is this sound 'oo' and what is the measure of time, is not described throughout the *Astadhyayi*. In fact this refers to the Cock-a-doodle-doo (*Kuk-roo-koo*). Here the three vowel sounds are– short '*u*' in '*ku-*', long in '*-roo-*', and very long in the last '*-koo*'.

Empowered with these two techniques, it is possible to decipher many secrets of Indian ancient science of relevance to the present age. Some concepts of the Indian ancient sciences pertaining to different branches of knowledge are interpreted in accordance with modern concepts in the following sections.

The Different Routes of Modern Science and Indian Ancient Science

There is one very fundamental difference between the routes adopted by modern science for the exploration of nature, and that adopted in ancient India. These routes have evolved due to different climatic conditions in the West and India. The main feature of the Western climate is that their environmental temperature is much lower than the human body temperature. This made life difficult there and needed plenty of food, strong house, many layers of clothing and other warming material. In such a situation, arises a basic question: *given difficult conditions, how to make survival easier.* This drew their attention to study space, light and matter. Modern science starts from geometry from the time of Pythagoras to Euclid; then study of light by Newton, Huygen, and others; then comes atomic theory. This *space-light-matter* route can be called *horizontal route*.

The main feature of the Indian climate had been environmental temperature close to the human body temperature. So here necessities of life were much less. Here the question was not how to make the survival easier because it was already easy. Here the question was: *given easy survival, how to make life happier for longer and longer times.* Happiness is a mental phenomena. And the state of happiness or unhappiness of the mind is most affected by sound out of the five senses. Hence the Indian study of nature took the route of *time-sound-mind*. This may be called *vertical route*.

On this route evolved the art of achieving harmony in one's life with times of day and night, and seasons, development of systems of vocal and instrumental music, detailed study of sound or phonetics, research on sound patterns and finer study of mind through Yoga. The basic concepts of the two routes are quite different. Even if the same language is used to describe them, the descriptions that will emerge will not have many common points. This difference has been the basic cause of wide gap between the two sciences.

However, in spite of these major differences, one should not forget that the apparently sophisticated structure of any branch of knowledge is built upon small number of basic principles. And one basic principle of nature is related to another basic principle in some subtle way, due to the inner harmony of nature. This is an article of scientific

faith, about which Einstein says, "Without the belief in the inner harmony of our world, there could be no science. This belief is and always will remain the fundamental motive for all scientific creation."

So the path of unification of the two sciences can be found through the fundamental principles. We have to sort out the fundamental principles of the modern science on one side and comprehend what order or regularity of nature they describe. Similarly the fundamental principles of the Indian ancient science have to be sorted out, and they have to be put up into precise axiomatic language, and the order of nature they point to, has to be found. By the correlation of these orders, one can hope to bridge the gap between the two.

Logic

Modern logic, as founded by Aristotle, is based on three laws of thought: *principle of identity* (A is A), *principle of contradiction* (A cannot both be B and not B), and the *principle of excluded middle* (A either is, or is not, B). Although these three principles are like statements of facts of common experience, they have exceptions according to Indian philosophies and logic. They are not universally true. When applied to the ultimate reality of Vedanta, only the first principle holds, the other two breakdown. This is because the properties of that reality are stated as conjunction of two contradictory statements such as smaller than the smallest and bigger than the biggest.

Here it may be added that, though modern logic or mathematics do not accept contradictions, Physics does accept some apparent contradictions specially in non-classical mechanics. This is well illustrated by the dual (wave-particle) nature of quantum particles. Accepting the necessity of coexistence of certain contradictions, Niels Bohr states, "If you have a correct statement, then the opposite of a correct statement is, of course, an incorrect statement, a wrong statement. But when you have a deep truth, then the opposite of a deep truth may again be a deep truth".

Now in this respect, modern logic and Vedanta can be reconciled with a general statement, "If X is true under a set of specifications Y, then there has to be another set of specifications Y' under which -X is true. The difference between Y and Y' goes on decreasing as we approach the fundamental; and in respect of the limit of the ultimate reality, the difference between Y and Y' vanishes so that X and –X are true under the same specifications."

Mathematics

The science of mathematics starts from counting of numbers. The present versatile system of decimal numbers needed two fundamental discoveries: the *concept of zero* and the *principle of place value in powers of the radix*. And both of these were discovered in India. The place value system made the sexagesimal numbers of Babylonians obsolete (its only remains are 1 hour=60 minutes, and 1 minute=60 seconds). And now the Roman numbers are also getting gradually replaced by Arabic numerals on the place value pattern. The present numerals are called Arabic not because they were invented in Arab but because Indian things had to go via Arabian countries to Europe.

Similar to these two concepts, there is a very fundamental concept of infinity. In modern mathematics, infinity has been taken as an infinite extension of large numbers. The symbol ∞ for infinity was introduced by John Wallis (1616-1703) in seventeenth century, in connection with the

summation of non-ending series. The logical definition of infinity was given by Cantor (1845-1918) in the nineteenth century in connection with his theory of transfinite numbers. Now the mathematical definition of infinity is that it is a set which has one to one correspondence with a proper subset of itself.

In India, the concept of infinity was given deep attention in ancient times. It was found that infinity is not just a number but it is as tangible as any reality of general experience, and many of its properties were enumerated. In mathematical language, it can be defined as a universal set which is a proper subset of its every proper subset. Modern mathematics may enrich itself by working out the implications of such a definition of infinity.

Phonetics

Very extensive work was done in the science of phonetics in ancient India, and finer shades of sounds produced in the pronunciation were standardized. The entire Panini's *Shiksha* and most of his grammar is phonetics only. However, in the West, the science of phonetics came up only recently. The application of sound recording systems and techniques of observing vocal organs in action through X-rays, have given a good deal of clarity to its concepts. The Indian ancient phonetics can benefit significantly if it employs some modern concepts and terminology. For example, many ancient Acharyas struggle with words to define what is *Udatta* vowel, and *Un-Udatta* vowel. Their round-about definitions do not accurately communicate what they intend. Following modern terminology, we can define simply that *Udatta* is high frequency vowel sound and *Un-Udatta* is low frequency vowel sound.

Similarly in *Shastriya Sangeet*, the relations of *Saptak* and the change of sound from *sa* to *ni* can be more clearly explained as ascending frequency in geometric progression; and the various *Tals* can be described as chrono-patterns of sound pulses with partial symmetry. Such applications of modern scientific terminology, instead of the vague and round-about old descriptions, can simplify the comprehension of this valuable Indian ancient art which also has scientific foundations.

The unification of Indian ancient science of Phonetics with modern information theory and the binary computer logic has led this author to evolve the *Phonetic Number System* of radix 128 with mono-sound numerals and word-like numbers. Based on this system, a merely six digit self-checking Phonetic Code, pronounced though six soft sound characters, can identify about 6000 crore population, uniquely and perpetually.

Metaphysics and Philosophy

In modern times, the subject of philosophy is considered to be speculation into the unseen and mostly unknown or unknowable. It has very little concern with tangible things of relevance. But in ancient India, philosophy (*Darshan*) was treated at par with science. Its study was supposed to give clear vision of life and nature as a whole, leading to a more coherent theoretical knowledge and harmonious practical living. The culmination of Indian philosophy is said to be Vedanta. Its sources are *Brahma Sutras*, *Bhagavad Gita*, *Upanishads*, and the voluminous book *Yoga Vasishtha*. Vedanta claims to have reached such a high state of unification of nature beyond which no further unification is possible.

In physics, unified theories, with tremendous efforts, have got only partial success in unifying some forces of nature. In this background, it may be asked if the ideal of Vedanta, the highest state of unification, is ever achievable. Such an objection can be circumvented by redefining Vedanta, that it is *Asymptote to Knowledge*. It describes that most fundamental concept towards which all the basic concepts of various branches of knowledge approach and meet at infinity. But that state of unification can be intuitively grasped in a finite life-span. It is like the asymptote to an open curve which is tangent to the curve at infinity but remains at a finite distance from the origin.

Much of the confusion in Vedanta, employing mostly contradictory statements, can be removed by developing it as an axiomatic theory starting from a single postulate. In respect of its relation with the empirical world, Vedanta is supported by *Sankhya*. It represents the practical limit of unification in terms of two basic elements: *Consciousness* (*Chetan*) and *Inertness* (*Jada*). These two concepts make it possible to design binary computerizable models of basic physical or metaphysical entities.

The interrelationship of these concepts has a good deal of analogy with the modern field theory. There is one basic abstract field of the ultimate entity which has two states, consciousness and inertness. These different states behave as two distinguishable entities. Their interplay has dispersed as well as localized aspect. Its dispersed aspect is mind, and the localized aspect is body-consciousness. The system is incessantly dynamic and is represented by repetitions of many processes. Analogous to this is the electromagnetic field which has two kinds of forces: electrical and magnetic. Its dispersed aspect is undulations of wave and localized aspect is photon which is always dynamic. Now arises a question, whether photons have consciousness? However, experiments done in the University of Denver, Colorado, to test this have remained inconclusive.

Life Sciences

The evolution of life from inorganic matter, as conjectured by modern science, is that in the primordial earth, the lightening discharges in the atmosphere consisting of nitrogen, water vapour, and carbon-dioxide, produced organic molecules such as amino acids and nucleotides. Peptides (proteins) were formed from the amino acids which had catalytic properties and could perform several synthetic functions. From the nucleotides, Ribonucleic acids (RNA) were first formed. Even today some living systems like HIV, have RNA as their genetic material. Later on Deoxyribonucleic acid (DNA) which constitutes the genetic material in all cellular forms of life, was formed. Deoxyribose sugar in the nucleic acid gave a greater stability to the living system. This was an important milestone in the evolutionary process. From the primordial soup consisting of nucleic acids and proteins, unicellular organisms were evolved. They acted like seed for multi-cellular organisms and higher species. But what is that inner force which ultimately designs the life pattern of childhood, adolescence, old age and death, reproduction, metabolism, urge for survival, love for beauty etc. remains a mystery.

According to the Indian ancient science, in the field of consciousness, there are many levels. Every material system, whether apparently living or non-living, is at some level of consciousness. The so-called inanimate matter occupies the lowest level at which there is a very small zero-point consciousness. The direction of evolution is towards higher and higher freedom. Its manifestation starts

from freedom of movement, and culminates in the freedom of selection of one's own destiny.

The ancient and modern views can be reconciled if the randomness in physical systems arising due to energy-time uncertainty relation of quantum mechanics, is interpreted as expression of inner freedom. In fact, such ideas were discussed in the early days of quantum mechanics. However, they remained undeveloped.

The most important thing in this respect is that to explain higher freedom of living systems, a multiplier freedom factor has to be introduced with the Planck's constant in the energy-time uncertainty relation such that its value is unity for physical systems, and very high for biological systems. Investigation of dynamics of such a system may explain the basic features of life.

Medical Sciences

Modern traditional medical science studies the physical and chemical patterns in a large number of people and makes a broad standard for healthy people. For example, after the measurement of the blood pressure of large number of people, a broad standard can be made. Ailments are associated with departure from these standards, and they can be corrected by appropriate physical and/or chemical means.

According to Indian medical science, called Ayurveda, life is a dynamical system in which in the healthy state, there is a harmony of many chemical and physical processes. The number of these processes have been broadly classified into three called *Dosh*: *Kaph*, *Pitta*, and *Vata*. Every food and eatable can be classified into many categories depending upon which Dosh or combination of Doshas, it decreases or increases or maintains in balance. The symptoms of disease indicate which of the Doshas have increased or decreased. The administration of the compensating remedy gives the cure. Ayurveda claims to have discovered the basic principles of many other systems of treatment like allopathy, homeopathy, acupuncture, etc. But these systems were not developed to higher levels in ancient India.

The surgery described by Dhanvantari and Sushrut has become obsolete with the advent of sophisticated tools and equipment in modern surgery. But the basic principles of Ayurveda hold. They are like phenomenological theory of matter. For example, the mechanical and thermal properties like elasticity, density, specific heat, etc of gold are determined by the atomic structure of gold atoms. But a goldsmith need not go into all these details. For him the bulk properties are sufficient to make a beautiful ornament. In the same way, simplifying all the chemical process of the body in terms of increase, decrease, or balance of three Doshas suffices to restore health in a large number of cases. That is why the medical formulations of *Charak Samhita* still have relevance. But, in the light of changed environment, many of the ancient formulations need verification and standardization. However, Ayurvedic thumb rules for longevity and good health have withstood the test of time.

Cosmology

Modern theoretical cosmology begins with the application of general relativity to the universe as a whole by Einstein in 1917. The experimental cosmology begins with observation of red shift, proportional to distance, in the light of galaxies by Hubble in 1929. The red shift has been explained in terms of Doppler's shift of receding galaxies. This explanation means that the universe is expanding

isotropically. It implies that if we go backwards in time, then the universe was smaller, and at a certain time, the entire mass energy was concentrated at a point. G. Gamow in 1946 postulated that the universe was not only smaller but also hotter in the past. In the point like state, the temperature was infinite. With a sudden big bang, the energy was thrown out which subsequently led to the formation of stars and galaxies. What was prior to big bang, cannot be answered by physics.

To eliminate the big bang singularity, a steady state cosmology was put forward by Bondi and Gold in 1948, in which it was postulated that the universe has been like this all the time. But to maintain a constant density of matter in spite of the expansion, creation of matter as hydrogen atom into free space was postulated. A comprehensive C-field cosmology and a new theory of gravitation was developed by Fred Hoyle and J. V. Narlikar.

However, the steady state cosmology, though intellectually satisfying, did not satisfactorily explain the cosmic background radiation, predicted earlier by G. Gamow, and experimentally detected by Penzias and Wilson in 1965. Since then the steady state cosmology has gone into oblivion. The present standard cosmology is that of the hot big bang. It explains three main cosmological observations: receding galaxies, thermal background radiation, and nucleosynthesis of light elements. But suffers from the problem of singularity and many other inconsistencies.

Turning to the Indian ancient view on this subject, *Mahabharat* says (Adi-Parva, 1st Chapter, 40-41): "This beginningless and endless time cycle *(Kal-Chakra)* moves externally like a perpetual flow in which beings take birth and die but there is never birth or death for this. The creation of gods is briefly indicated as thirty-three thousand, thirty-three hundred, and thirty- three."

Again in *Mahabharat* itself, Bhagwad Gita describes a cyclic universe as (VIII-18): "All embodied beings emanate from the Unmanifest at the commencement of Brahma's day; at the commencement of his night, they merge in the same subtle body of Brahma, known as the Unmanifest."

These and many other statements imply that the Indian ancient view is that the universe is eternal as well as of finite age. The inference depends upon the point of view of the observer. If one observes the universe as a contemporary observer, then on the whole the universe is found to be like this only. But, if it is explored archaeologically, then it will be found to have a beginning at a point of time. Hence a unified cosmology, integrating the essential elements of steady state and big bang cosmologies, conforms better with the Indian view.

In ancient India, this integration was achieved by the concept two extra time-like dimensions. Thus the universe is a six dimensional continuum of three space, one time, and two time-like dimensions. This concept gives a logical symbol for the universe: that is two interpenetrating triangles. This figure has been verbally indicated in the above statement of *Mahabharat* that the creation is briefly indicated as thirty-three thousand, thirty-three hundred, thirty-three. Six times repetitions of three is the indirect technique of communication of Ved Vyas. The 5th and 6th dimensions have been called *Chittakash* and *Chidakash* in *Yogavasishtha*. The six dimensional universe represents higher symmetry in the two basic extensions of nature, space and time.

Physics

The physical world, consisting of matter in solid, liquid, and gaseous forms, moving in space and

time, is the most tangible of all objective realities. For the present discussion, it suffices to take only two aspects of the physical world: constituents of matter and motion of matter. The ultimate constituents of matter are elementary particles whose motion is described by quantum mechanics. For the motion of matter in larger scale, classical mechanics is quite sufficient. The essential differences between them is that whereas classical mechanics is deterministic, quantum mechanics is probabilistic.

In classical mechanics, there is a concept of thing in itself. A classical particle moves in its own strictly determined path, whether observed or not. The behaviour of a quantum particle is dependent on the observer and method of observation. For the classical particle, velocity of light is the limit for action at a distance. Quantum particle, under some conditions, can interact with another particle instantly. A classical particle is always localised, has well defined position and velocity. Quantum particle has dual nature of particle and wave. There is a probability that the quantum particle before observation existed anywhere in the universe, and actualises at a point just at the moment of observation. If a quantum system has multiple states, then one observed state is realised in our world, others are realised in many other worlds.

The Indian ancient view classifies the visible world into five elements: space, light or fire, and three states of matter (solid, liquid, and gas) represented by earth, water, and air. They are related to five senses and their five subtle forms called *Tanmatra* through a process called *Panchikaran*. Everything, irrespective of size and shape, has besides its physical body, a subtle body which is a bundle of abstract qualities and exists conceptually in the non-physical space called *Chittakash*. The subtle body in the *Chittakash* behaves like mind, and is free from many limitations of the physical space.

It is obvious to see many conceptual analogies in the two views of matter at the fundamental level. In quantum mechanics, the dynamics of a system is conceived in the abstract Hilbert space; in ancient India, it was conceived in the abstract *Chittakash*. Near the limit of fineness, inferences of the horizontal route (space-light-matter) and the vertical route (time-sound-mind) come very close to each other. Some experimental investigation into the interrelation of consciousness, mind, matter and light have been reported from Princeton University, Standford University (California), and University of Denver (Colorado).

Chemistry

The science of chemistry in India has been a great sufferer due to the destruction of the Indian ancient literature. The long heavy iron pillar near the Kutub Minar at Delhi, standing in the sunshine and rain for more than about 2000 years without getting rusted, is ample proof that chemistry and metallurgy were sufficiently advanced in ancient India. Similarly, the long and heavy statue of Buddha in the lying pose at Kushinagar near Gorakhpur, which still shines like gold in spite of remaining buried for many centuries, is a challenge to metallurgy. Similarly, many other monuments also hide great chemical secrets.

Much of the chemical knowledge is empirical rather then deductive. This is true of modern chemistry as well. Hence simply knowing a few basic principles is not enough to arrive at the process of producing the desired material. The actual method has to be either rediscovered, or may possibly be found in some hidden literature after extensive and minute survey.

Military Science

The biggest loss of ancient skills have been in the field of military science. The main reason for this loss was perhaps the *Mahabharat* war. There was so much loss of life in that war that people became allergic to things related to war. A large number of warriors were killed. Those who survived were demoralized. Almost the entire war skills, which needed regular practice and refinement, died out. Now we can get only very superficial descriptions of those weapons from *Ramayan* and *Mahabharat* which are basically literary works, and not scientific.

The weapons of ancient India can be put up into three broad categories. First is that of conventional weapons like swords, spears, bows and arrows, etc. Being simple, they survive to this age. The second were explosive based, delivered either through some projective system, or other means. They were called *Agniban*. The third were super weapons called *Brahmastra*, etc. *Brahmastra* was a sure hit weapon from which there was no escape. It had to be used in the rarest of the rare circumstances.

Brahma means creator of the universe. In the context of the war, it indicates a weapon designed through the knowledge of the creation of matter. According to *Yogashashtra* and some other writings, every particle of a block of matter is being incessantly created and dissolved. In between two occasions of creation, it remains momentarily in Chittakash in its subtle form. There its properties are more mind-like. Hence it can be acted upon by the mind of an aspirant provided it can go to that subtle state at which the matter particle has reached.

In any lump of inorganic matter, the creation and annihilation of particles is random. By mental command, they can be brought into coherence. The coherent lump can behave as a single quantum particle. With the coherence, all the constituent particles of the lump are created or annihilated simultaneously. They go to the Chittakash, and appear in the physical space, collectively. When they are in the mental form in Chittakash, they can be induced to have their next appearance in the physical space at the desired location, may be the body of an enemy. This travelling of the lump of matter is through non-physical space, so physical obstructions of walls and bunkers or long distances are no protection against this weapon.

Quantum teleportation recently reported by some physicists, is the nearest analogue to the working of *Brahmastra*. It is speculated by physicists that perhaps quantum teleportation may be the ultimate process in the control of dynamics of matter. However, so far the technique of quantum teleportation has reached the level of transmitting only states of photon. But even that has generated much excitement among physicists and has become a hot topic of research. It is anticipated to have applications in developing extremely fast computers, and communication of secured information making eaves dropping almost impossible.

In ancient India, some similar process seems to have been realised to the level of transmitting bigger masses through the phenomena of matter coherence. Just as coherence of electromagnetic waves produces very powerful laser light with unusual properties, in the same way coherence of matter can produce objects with unusual properties.

Conclusions

This brief comparative survey of the fundamental principles of modern science and Indian ancient science shows that the two are neither contradictory nor incompatible. The difference lies mainly in their vocabulary, interpretation, methods of approach,

and levels of development. Much of the confusion and inconsistencies of the Indian ancient science can be removed by introducing more appropriate modern terms with precise definitions. Modern science can also hasten its progress by accepting some of the concepts of Indian ancient science. Such a unified science can eliminate many tortuous rediscoveries of facts already known in some form or the other. In this context, the words of Werner Heisenberg are quite assuring: "It is probably true quite generally that, in the history of human thinking, the most fruitful developments frequently take place at those points where two different lines of thought meet. These lines may have their roots in quite different parts of human culture, in different times or different cultural environments or different religious traditions; hence if they actually meet, that is, if they are at least so much related to each other that a real interaction can take place, then one may hope that new and interesting developments will follow".

IAEA RESEARCH CO-ORDINATION MEETING

A research co-ordination meeting (RCM) of the IAEA's co-ordinated research programme (CRP) on "Development of Radioactively Labelled Cancer Seeking Bio-molecules for Targeted Therapy" was hosted by the Bhabha Atomic Research Centre. The meeting was inaugurated by Dr Anil Kakodkar, Director, BARC, on January 31, 2000 in Hotel Days Inn, Vashi, Navi Mumbai. Sixteen participants from 14 different countries attended the meeting held from January 31, 2000 to February 4, 2000. The participants included 6 from South America, 7 from

Dr Anil Kakodkar, Director, BARC, inaugurating the IAEA Research Co-ordination Meeting. Dr H. Vera Ruiz, Head, Industrial Applications and Chemistry Section, IAEA, is seated third from right.

Europe and 3 from Asia. Dr N. Ramamoorthy, Head, Radiopharmaceuticals Division, BARC, welcomed the participants and invitees of the inaugural function. Dr J.P. Mittal, Director, Chemistry & Isotope Group, BARC, and Dr S.M. Rao, Associate Director, Isotope Group, BARC, addressed the participants. Dr H. Vera Ruiz, Head, Industrial Applications and Chemistry Section, IAEA, spoke on the co-ordinated research programme on therapeutic radiopharmaceuticals and the role IAEA is playing to bring the benefits of nuclear medicine to the needy patients in developing countries. Dr M.R.A. Pillai, the Principal Investigator of the CRP from India, proposed a vote of thanks.

Cancer is one of the major diseases which is responsible for the morbidity of a large percentage of population the world over. Unlike many other diseases, cancer does not distinguish between the developed and the developing nations, thereby making research in cancer and cancer management a global scientific pursuit. Cancer management involves understanding the causes, minimizing the risk factor, early detection and treatment.

Participants of the IAEA Research Co-ordination Meeting.

Radioisotopes and radiation have played a major role both in the diagnosis and therapy of cancer. Nuclear medicine has contributed to a large extent for the diagnosis and therapy of cancer. The aim of the CRP is to develop radiolabelled molecules for therapy of cancer. Peptides that selectively bind to the receptors on the cancer cells are selected as the carrier molecules in the present work. As most of the tumours over-express somatostatin receptors as compared to normal tissues, peptides that are somatostatin analogs are used for labelling with radionuclides. As peptides are small molecular weight substances, their selective uptake in the tumour site will be fast thereby achieving better internalization of the radionuclide tagged to it. The peptide molecules are labelled with radioisotopes such as ^{188}Re, ^{90}Y, ^{153}Sm and ^{166}Ho. The research proposal in the CRP focuses on the use of peptides such as lanreotide and octreotide.

Scientists from different countries deliberated on the results achieved in the first two years of the CRP and worked out the future strategies.

BARC TRANSFERS TECHNOLOGY OF ANUDAQ-20

ANUDAQ-20 is a low cost IBM PC compatible Data Acquisition Card and can find extensive use in applications like radar, telephony, digital scope, spectrum analysis, vibration analysis and testing of meter windings, barcode reader, automotive ignition, acoustic emission, etc. This dual channel ADC Card has been developed by Electronic Systems Division. It can digitize analog signals at a maximum real time sampling rate of 20 mega samples per second (msps) with a bandwidth of 4 Mhz. This is a full length card having a 16-bit EISA bus interface. It allows simultaneous operation of both the channels and, in addition, has an external trigger input. It enables four triggering conditions, namely, level, edge, bitrigger and hysterisis. Sampling time can be programmed from 10 msps to 350 sps. This card has on board 64 kB static RAM per channel to increase throughput. Brief specifications of the card are, linearity : better than ± 1 LSB; resolution : 8 bit; input voltage : 2 volts unipolar/bipolar; and operating system: MS-DOS version 6.22 and MS windows 95 and upwards.

Mr A.K. Anand, Director, TC&IRG and RPG, BARC, and other senior officers of BARC seen at the time of signing the agreement for the transfer of technology of ANUDAQ-20 from BARC to M/s Electromotive Systems, Mumbai.

On January 17, 2000, an agreement for transfer of technology of ANUDAQ-20 was signed by Director, TC & IRG and RPG, BARC, and M/s Electromotive Systems, Mumbai. Technology Transfer was coordinated by TT&CD.

BARC TRANSFERS HIGH SPEED DIGITIZER TECHNOLOGY TO PRIVATE SECTOR

High speed digitizer is required in the study of many specialised fields such as Ultrasonic Imaging, High Energy Physics Experiments, Laser Studies, Mass Spectrometry Application and Testing of Materials. A "PC-add-on Single Channel High Speed Transient/ Repetitive Waveform Digitizer (TD1100T)" has been developed by Electronics Division of BARC. Some of the salient features of Waveform Digitizer TD1100T are :

(a) Capturing continuous or single shot (triggered or random) electrical signals at a selectable sampling rate of 100, 50, 25, 12.5 MSPS (million samples per second)
(b) Software selectable sampling rate
(c) Pre- and post- trigger signal capturing from 0 to full record length
(d) Multiple acquisition mode

Windows-95 based powerful 'Control & Display Software' has enabled a variety of features such as display of the captured waveform on the PC monitor, timing/amplitude analysis of the captured signal and user friendly menu driven control for optimum data acquisition.

Mr A.K. Anand, Director, TC&IRG and RPG, BARC, and other senior officers of BARC seen at the time of signing the agreement for the transfer of technology of High Speed Digitzer from BARC to M/s. Electromotive Systems.

The technology of this "PC add-on Transient/ Repetitive Wave form Digitizer (TD1100T)" was transferred on a non-exclusive basis to M/s Electromotive Systems, Mumbai, on January 17, 2000. TT&CD coordinated the Technology Transfer.

BARC SCIENTIST HONOURED

• Dr N. Ramamoorthy, Head, Radiopharmaceuticals Division, BARC, has been elected the President of Society of Nuclear Medicine, India, for the year 2000. The Society of Nuclear Medicine, India, established in 1968, is the major professional body in the field of Nuclear Medicine in India.

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