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Breakthrough, Vol.16, No.4, January 2014

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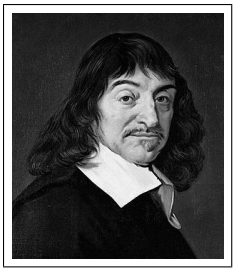
Series Article



General Article

Organizational News

Commentary

The Unnao gold hunt of 2013

George Joseph

In September 2013, a Sadhu named Shobhan Sarkar from Daundia Khera village in the Unnao district of Uttar Pradesh had a fancy dream. In his dream, a 19th-century king of Daundia Khera, Raja Ram Bux Singh appeared and told him that a thousand tons of gold treasure lies buried under his palace. No one can deny him the right to dream, but it would have been more appropriate for a Sadhu to dream about spiritual rather than material wealth. What was most inappropriate was for the ASI (Archaeological Survey of India) to go hunting for the fabled/mythical gold like nineteenth century pirates. Even pirates would depend on more reliable information.

The ASI is a publicly funded institution that is entrusted with the job of conducting scientific study of our hidden past. For this there are standard methods and procedures that are to be followed. Flouting all those norms and practices, the ASI in this case went ahead with excavations.

On October 18, 2013 the ASI team started digging in the midst of much fanfare in the presence of Sadhus chanting mantras, trigger-happy policemen on the lookout for thieves and a large crowd of curious onlookers holding their breath, waiting for something spectacular to happen. After 3 weeks of frenzied digging, nothing worthwhile was found, except mud and slush. The ASI had to quietly call off its dream project.

Even though this episode may appear as a comedy, it reflects the unscientific mindset spreading in the society. All right thinking people should condemn such acts of public institutions, which sends a wrong message to the people. The BSS appeals to the students and the general public to strive to uphold scientific temper in the society to counter this type of obscurantism.

Obituary

Dr. Subhasis Maiti (1960-2013)

Dr. Subhasis Maiti, a member of the Editorial Board of this journal, breathed his last on 3rd October after a prolonged illness after being afflicted by abdominal cancer. In his death the science movement in India lost an untiring fighter.

Dr. Maiti was born in the village of Ektarpur in the Midnapur district of West Bengal. After doing his schooling in the Banamalichatta High School, he studied physics at the Narendrapur Ramakrishna Mission College and did his master's degree from the Calcutta University. He did his Ph.D. degree from the Saha Institute of Nuclear Physics.

The science magazine Breakthrough was first published in 1984. Dr. Maiti joined the magazine soon after its first publication. For many years he looked after the press work. Those days the financial status of the magazine was quite poor, and so he had to search for cheaper ways of printing. He experimented with many techniques. In fact, the widely-used technique of offset printing with the mask prepared by laser-printing on tracing paper was first done to print this magazine, in his initiative.

Slowly the magazine started taking organizational shape as science clubs started nucleating in different places. Along with other organizers, Dr. Maiti took initiative in building up many science clubs. Finally, Breakthrough Science Society was born through an All Bengal Science Conference in 1995. Dr. Maiti was elected its Assistant Secretary. Since then, for so many years, he was at the centre of activities. Many of his contributions in this regard were particularly noteworthy.

One of the major programmes of science movement is the popularization of astronomy, because many of the common superstitions centre around misconceptions about the objects in the sky—planets, stars, constellations, comets, and asteroids. So popularization of astronomy through sky-watching, slide shows, and lectures has been a major plank of our activity from the very beginning. But that requires somebody to learn it, to train others, and to lead this line of work. In our organization this role was played by Dr. Maiti.

In the early 1990s, a major health problem was noticed in the state of West Bengal. It was revealed that people were being slow-poisoned by arsenic in ground water. One of the activists of our organization, Dr. Nikhil Ranjan Jana, invented a convenient method to detect the concentration of arsenic in water. We took the decision to launch a very large-scale programme to detect arsenic in tube-wells to make people aware of the danger, and to build a mass movement demanding safe drinking water. Every Sunday our teams would visit remote villages to set up makeshift labora-

Obituary

Prof. Basudeb Bhattacharya speaking at the condolence meeting held on 8th October 2013, at the Tripura Hitasadhani hall-2, College Street, Kolkata.

tories where tests would be done, and at the end of the day they would announce which wells are contaminated and which are yet safe. Under this programme we have tested more than 10,000 water samples all over the state. A laboratory was also set up in Kolkata. Dr. Maiti coordinated the whole activity from the centre. That is why, when our organization was invited to present its findings at an International Conference on the arsenic problem in Dhaka, Bangladesh (February 1998), Dr. Maiti was chosen to represent the organization. He presented a paper titled "A Report on Low Cost On-Spot Arsenic Detection in Tubewell Water Conducted by Breakthrough Science Society in West Bengal, India."

Another important line of work for our organization was to initiate teaching of science through low-cost experiments. We observed that in most schools there was no experimental facilities, and the students have to learn science by rote. We decided to counter this problem by taking low-cost experiments to the schools. But the problem was: which experiments will be appropriate? Some such experiments were available in the book "Quest", but more had to be added, and the whole programme had to be conceptualized in the form of a mass-activity. Again, in this work Dr. Maiti took the lead.

Unfortunately, two years back Dr. Maiti was diagnosed to be suffering from abdominal cancer. Our organization did everything necessary for a proper treatment. We collected a sum of Rs. 3,62,000 from activists and well wishers, and spent the money on his treatment. But alas, the ailment was of such a kind where a cure is not yet known to medical science. He being a man of science, knew this only too well. Yet, he never stopped thinking positively; he never showed any sign of depression which are only too common among cancer patients. Anybody visiting him would be surprised to hear how well he was feeling that day.

After suffering for about two years, Dr. Maiti's struggle against the killer disease came to an end. The Breakthrough Science Society remembers him with love and affection. □

Story of Atomic Models : A tribute to Niels Bohr on the occasion of centenary of his model

Madhusudan Jana*

THE TERM *atom* comes from two Greek words meaning 'not' and 'cut'. The atomic structure of matter was suspected from very early stage of civilization. All material things are supposed to consist of some basic granular units. These ultimate constituents of matter were called atoms which cannot be cut into more smaller portions.

The Greek thinker Democritus had postulated in the fifth century B.C. that all matter was made up of atoms and that different substances were composed of the common primordial atoms which differed in shape and size. The same hypothesis was supported by the Roman philosopher Lucretius in the first century B.C. in his work entitled De Nature Rerum.

This simple model, however, involved some serious difficulties.

i) The permanent existence of different elements in nature could not be explained by mere variation of shape and size of fundamental units.

ii) The difference between elements could not be explained by a change in the shape and size of the atoms.

iii) Since the atoms have size and shape, so these are extended bodies, however small their extension might be. So it should be divisible into something smaller, which goes against the hypothesis of indivisibility of the units.

Because of these serious objections, the old atomic theory was not accepted universally. Other philosophers led by Aristotle thought the matter as continuous in structure and infinitely divisible. Researchers with modern view substantially modified the theory of atomism from the beginning of 19th century. In favour of atomism their arguments were

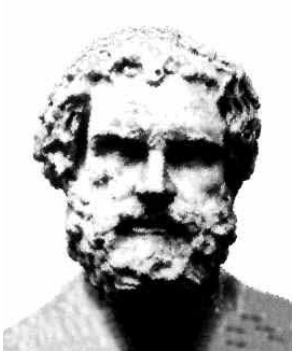
1. Compressibility of matter: If the matter is continuous then it cannot be compressed to very small fraction, rather, if it is thought to consist of discrete atoms with space separation, it can be compressed by making them close together.

2. The regular forms of crystals: This can be attributed to the arrangement of discrete atoms in a well-designed space lattice.

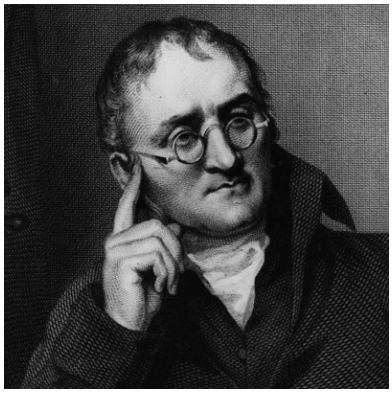
3. Diffraction, Osmosis, Brownian movement, etc.: These phenomena clearly support the existence of discrete minute particles with space between them, moving continuously.

4. The law of multiple fraction: The famous chemist John Dalton discovered a law governing chemical combination for which he is known as 'Father of the atomic theory'. When the atoms of two elements combine to form different compounds, the proportion of one element which combines with the same constant amount of the other should be integral

*Dr. Jana is an Assistant Professor at the Tamralipta Mahavidyalaya, Tamluk- 721636, WB.



Democritus (460 BC to 370 BC)



John Dalton (1766-1844)

multiples (and not fraction) of the lower. This observation is consistent with with the hypothesis that each element consists of identical, indivisible, and discrete atoms.

5. The periodic law among elements: The arrangements of elements according to their atomic weights supported the atomic structure of elements. It also indicated the fact that atoms are built up in such a way that there is repetition of properties periodically. This, however, did not support the idea that the atoms are the ultimate individual units. Rather it pointed to the possibility that these are composed of some smaller units, the arrangement of which gives the periodic repetition. So there were two schools of thought, one believing discontinuity and the other continuity in the ultimate structure of matter.

Thomson's Model

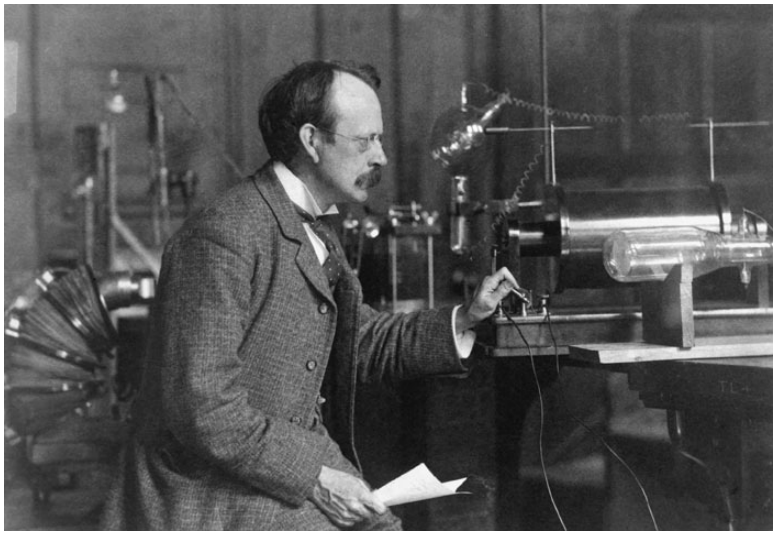
The current idea of the atom started with J. J. Thomson's discovery of electron. It proved that

1. Electrons are constituent of all atoms.
2. Atoms as a whole are electrically neutral, consisting of same amounts of negative and positive charges.

In his experiment, a beam of X-rays was passed through matter; from the scattering cross-section it was possible to get the number of electrons per atom. It was found that this number is proportional to the atomic weight of the element. Thomson assumed that the positive charge was uniformly distributed in an atom, which he assumed to be spherical. He also assumed that the electrons were so arranged that their mutual repulsions were exactly balanced by the attraction towards centre of the sphere. His model looked like raisins stuck on the surface of a lump of pudding. He also attempted to account for the observed spectra of hydrogen by vibration of electrons about their positions of equilibrium, giving rise to electromagnetic radiation. This could not explain the line spectra of hydrogen.

Rutherford's Model

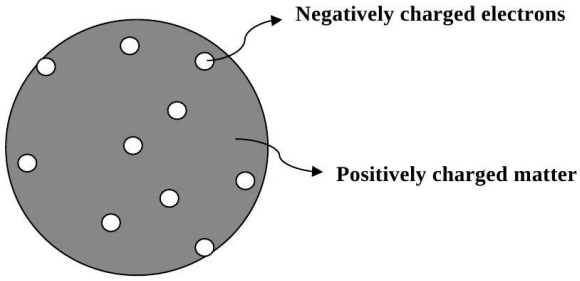
Then came Rutherford with his famous experiment. The scattering of alpha particles by a thin sheet of gold is caused by Coulomb interaction between alpha particles and the charges inside gold atoms. However, electrons were not expected to show any effect because of their extremely small mass compared to that of alpha par-



J. J. Thomson with his experimental set-up.

ticles. Thus any deflection of alpha particles would be due to positive charges of gold atoms. Some alpha particles experienced very large deflection, which could not be explained by the Thomson model. Rutherford, therefore, proposed concentration of positive charges in a very small region called atomic nucleus. The electrons were supposed to be situated outside the nucleus in some ordered manner.

This was named as the 'nuclear atom' model. Rutherford thought that the negative electrons orbited the nucleus in a manner like the solar system where planets orbit the sun.

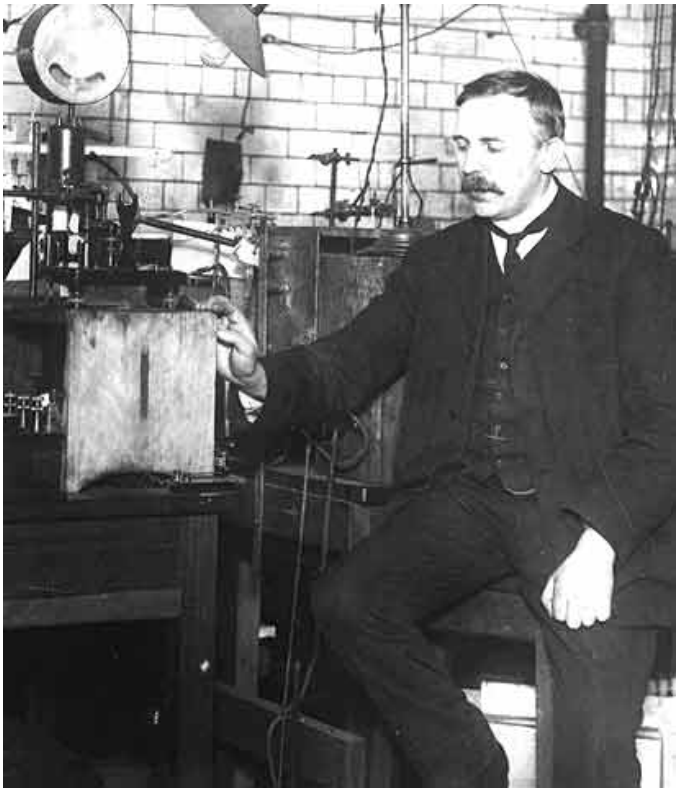


Schematic of Thomson's atomic model.

Rutherford's model suffered from instability of the atom as a whole. According to his model, electrostatic attraction between the negative charged electron and positive charged nucleus would be balanced by the centrifugal force arising out of revolution of electron around nucleus. According to electromagnetic theory, a revolving electron should radiate energy continuously. This energy can only lead to lowering of electron's energy, resulting in reduction of its orbital radius in a spiral path towards the nucleus and ultimate merger with the latter. The overall stability of the atom thus became suspect. Experimentally, atom are found to emit discrete spectral lines of definite frequency, not supported by the Rutherford model.

Bohr's Model

The defects of Rutherford's model was solved by Niels Bohr, who applied Planck's theory of quanta in addition to an adhoc postulation. To get rid of the stability problem, Bohr modified the Rutherford model by adding a requirement that the electrons

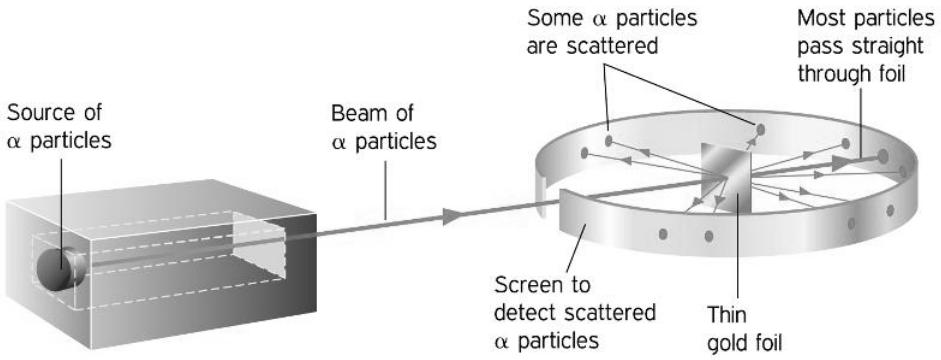


Rutherford with his experimental set-up.

move in orbits of definite size and energy. The energy of an electron would depend on the size of the orbit and should be lower for orbits closer to the nucleus. Emission (absorption) of radiation can occur only when an electron jumps from a higher (far) orbit to a lower (nearer) orbit. The atom should be stable with electrons filling all lower orbits, since there would be no orbit of lower energy to which the electron can jump.

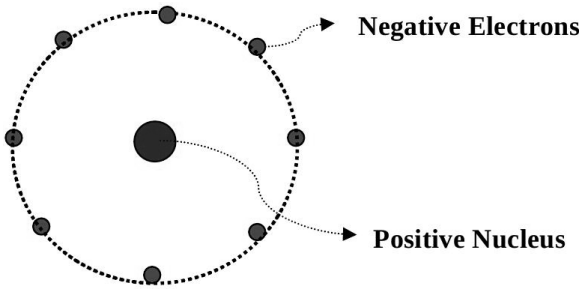
Bohr's greatness was to realize that atomic stability could never be explained by classical mechanics alone. A stable atom has a definite size so that any equation describing it must have some fundamental constant or combination of constants with a dimension of length. The classical fundamental constants, as for example the charges and masses of the electron and the nucleus cannot be combined arbitrarily to give atomic size. Bohr noticed that the constant formulated by the German physicist Max Planck (commonly known as Planck's constant or h) has dimensions which, when combined with the mass and charge of the electron, can give a measure of length. Numerically, the measure is close to the known size of atoms. This encouraged Bohr to use Planck's constant in developing a theory of the atom.

Planck introduced his constant in 1900 when he was trying to explain black body radiation. Classically, a hot body should emit radiation at all frequencies. This is not only contrary to observation but also implies that the total energy radiated by a heated body should be infinite. To combat this absurd result, Planck postulated that



Rutherford's alpha scattering experiment.

energy can only be emitted or absorbed in discrete amounts, which he called quanta (the Latin word for "how much"). The energy quantum is related to the frequency of the light by a new fundamental constant, h. According to classical theory, when a body is heated, its energy of radiation in a particular frequency range is proportional to the temperature of the body. Planck's hypothesis, however, showed that the radiation can occur only in discrete amounts of energy. If the radiant energy is less than the required quantum, there would be no radiation. Planck's formula could correctly describe the distribution of radiation from heated bodies. Planck's constant has the dimensions of action, which may be expressed as units of energy multiplied by time, units of momentum multiplied by length, or units of angular momentum.

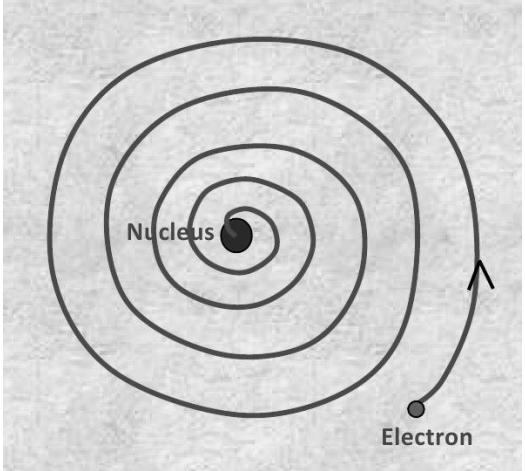


Rutherford's model of the atom.

Using Planck's constant, Bohr succeeded in obtaining an accurate formula for energy levels of the hydrogen atom. He postulated that the angular momentum of the electron moving in different orbits is quantized, i.e., it can have only some discrete values. He also assumed that electrons obey the laws of classical mechanics by traveling around the nucleus in circular orbits. Because of the quantization, the electron orbits have unchanging sizes and energies. The orbits are labeled by an integer, called the quantum number n.

Bohr explained how electrons could jump from one orbit to another orbit only by emitting or absorbing energy in fixed quanta. This means if an electron jumps to an orbit closer to the nucleus, it must emit energy equal to the difference of the energies of the two orbits. Conversely, when the electron jumps to a higher orbit, it must absorb a quantum of light equal in energy to the difference in orbits.

Three basic postulates were given by Bohr viz., mechanical equilibrium of electron following classical laws, quantization of angular momentum of electron and absorption or emission of quantized energy during jumping to higher/lower orbit.



Orbital instability in Rutherford's model.

Failures of the Bohr Model

Although the Bohr model was a major step toward understanding the atom, it does not give a correct description of the nature of electron orbits. Some of the shortcomings of the model are:

a) It cannot explain why certain spectral lines are brighter than others. There is no mechanism for the calculation of transition probabilities.

b) It treats the atom as if it were a miniature planet in two dimensions. This is not in conformity with the Heisenberg uncertainty principle which dictates that position and momentum cannot be simultaneously determined to arbitrary accuracy. Moreover, atom itself is three dimensional.

c) The existence of fine structure and hyperfine structure in spectral lines, which are known to be due to a relativistic variation of mass and due to possession of spin of electron, cannot be explained by the Bohr model.

d) The Zeeman effect—changes in spectral lines due to external magnetic fields—cannot be explained by Bohr's model. This is explained with the help of complicated quantum principles as an interaction of external magnetic field with electronic spin and orbital magnetic fields.

e) Doublets and triplets, close lines, appear in the spectra of some atoms. Bohr's model cannot explain why some energy levels should be very close to each other.

f) Many-electron atoms do not have energy levels as predicted by the model. It doesn't work even for (neutral) helium atom.

g) A rotating charge such as the electron classically orbiting around the nucleus would constantly lose energy in form of electromagnetic radiation. But such radiation is not observed.

Modifications Over Bohr's Original Model

It is mentioned that the splitting of spectral lines in magnetic field could not be explained by Bohr's model. A German physicist, Arnold Sommerfeld, modified the original Bohr model to explain these variations. According to the Bohr-Sommerfeld model, not only do electrons travel in certain orbits but the orbits have different shapes and may be oriented differently in space in the presence of a magnetic field. Orbits can appear circular or elliptical. The shapes of orbits and their angles with respect to the magnetic field could only have certain discrete values, called space quantization. This allowed possibilities for different spectral lines to appear. This brought in the vector atom model, which also included electron spin in addition to space quantization, into closer agreement with experimental data. The conditions of the state of the orbit were assigned quantum numbers. The three primary ones were orbit's number (principal quantum number n), orbit's

Niels Bohr (1885-1962)

shape (orbital angular momentum quantum number l) and orbit's tilt or orientations (orbital magnetic moment quantum number m_l).

In 1924 an Austrian physicist, Wolfgang Pauli predicted that an electron should have spin while it is moving around the nucleus. This spin was considered as a fourth quantum number: spin angular momentum quantum number (s). There may be two possible orientations of spin magnetic moment quantum number $m_s = +1/2$ or $-1/2$ for an electron.

Distribution of two electrons in He atom obeying Pauli's exclusion principle

Pauli gave a rule governing the behavior of electrons within the atom in agreement with experiment. If an electron has a certain set of four quantum numbers (n, l, m_l, m_s), then no other electron in that atom can have the same set of quantum numbers. Physicists call this "Pauli's exclusion principle." It remains valid to this day.

In 1924 Louis de Broglie thought that if light can exist as both particles and waves, atomic particles should also behave like waves. In 1926 the Austrian physicist Erwin Schrödinger presented an interesting idea: all particles should be associated with their characteristic waves called matter waves, represented by Ψ (psi) which obeys a wave equation of motion. In 1926, a German physicist, Max Born proposed a property of 'psi', that they resemble waves of chance or *probability*. These ripples created places where particles may be found and places where no particles may be observed. However they cannot exist as both waves and particles simultaneously.

In 1925, the German physicist Werner Heisenberg came up with a theory of his own called matrix mechanics which also explained the behavior of atoms. The two theories seemed to have entirely different sets of assumptions and approaches, yet both achieved the same result. Heisenberg based his theory on mathematical quantities called matrices whereas Schrödinger based his theory on waves. Again in 1927, Heisenberg formulated a remarkable idea that no experiment can measure the position and momentum of a quantum particle simultaneously to any extent. This is known as "Heisenberg's uncertainty principle." This implies that as one measures the position of a particle more and more accurately, the uncertainty in its momentum becomes correspondingly larger.

The atom is now visualised as an electron "cloud" which surrounds a nucleus. The cloud consists of a probability allocation map which determines the probable locations of an electron.

The nature of the nucleus remained yet unclear. Most of the mass of an atom is due to its nucleus. Protons (positive charged particles) apparently accounted for this mass. However, a nucleus with twice the charge of another should have twice the number of protons and twice the mass. But

Cover Article

Mechanical equilibrium of electron following classical law

The centrifugal force = mv^2/r is balanced by the Coulombian attraction between the positively charged nucleus and negatively charged electron

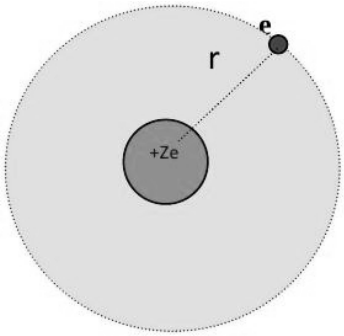
$$= \frac{Ze^2}{4\pi\epsilon_0 r^2}.$$

This gives kinetic energy of the electrons $T = \frac{1}{2}mv^2$ and potential energy

$$U = -\frac{Ze^2}{4\pi\epsilon_0 r}.$$

Therefore, total energy,

$$E = T + U = -\frac{Ze^2}{8\pi\epsilon_0 r}.$$



this was not supported by experiments. In 1920, Rutherford hypothesized that there exist electrically neutral particles with the protons to make up the missing mass, but no one accepted his idea at that time. In 1932, English physicist James Chadwick finally discovered the neutron. He found it to be slightly heavier than the proton and with no charge. The protons and neutrons are together named as "nucleons."

In general, atoms of a particular element have the same number of protons, however, some of these atoms have slightly different masses. These variations in mass result, more or less, from the number of neutrons in the nucleus of the atom. Atoms of an element having the same atomic number but different atomic masses known as "isotopes" of that element.

In 1928, Paul Dirac formed equations which predicted the existence of positively charged electron. In 1932, by the experiments with cosmic rays, Carl Anderson discovered the anti-electron, which proved Dirac's equations. This positively charged electron is known as positron.

Physicists now believe that antimatter exists. For each variety of matter there should exist a corresponding particle of opposite characteristics in some aspects. The matter and antimatter annihilates whenever they come in contact. So they cannot coexist for very long. However, an unsolved problem remains as to why the universe consists of mostly "normal" matter and not an equal amount of antimatter. This is called "symmetry breaking". There exists not only anti-electrons but since 1955, the anti-proton, and later the anti-neutron as well. This leads us to consider the existence of anti-atoms, a true form of antimatter.

Now the question arises why the positively charged protons should remain so close to each other without exploding. Obviously, there must exist new forces at work and the origin of that force must lie within the nucleus. People knew that the force which holds the protons together must overcome the electromagnetic repulsive force between the protons. It was also thought that such a force must act over very small range of distances (inside nucleus, otherwise they would have noticed this force in interactions between the nu-

Angular Momentum Quantization

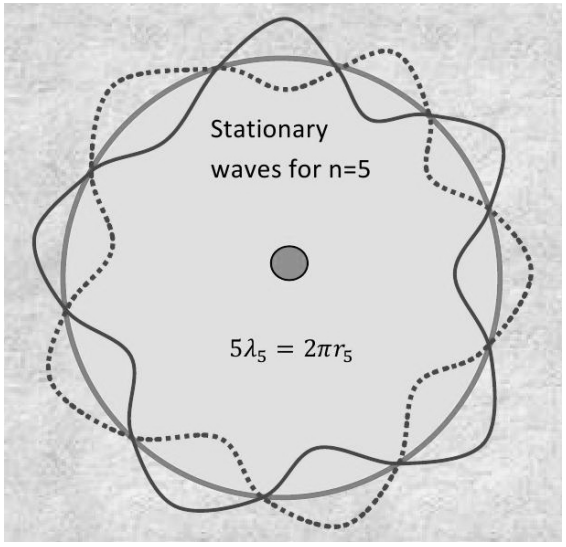
The wavelength associated with the electron is given by the De Broglie relationship $\lambda = h/(mv)$.
The stationary wave condition is that circumference = whole number of wavelengths. So the number of waves equal to principal quantum number is given by $2\pi r = n\lambda$. These can be combined to get an expression for the angular momentum of the electron in orbit.

$$L = mvr = \frac{hr}{\lambda} = \frac{hr}{\frac{2\pi r}{n}} = n\frac{h}{2\pi}$$

Thus L is not only conserved, but constrained to discrete values by the quantum number n. This quantization of angular momentum is a crucial result which results in orbit radii and energies.

cleus and the outer electrons).

To explain such strong force between the nucleons, an exchange force via an exchange particle was proposed. In 1935 Yukawa suggested that these particles should be about 250 times as heavy as an electron. Later, in 1947, the physicist C. F. Powell detected this particle and called it the "pion." The strong force gets transmitted by the pions only at relatively larger nuclear levels.



The de Broglie waves in an atom.

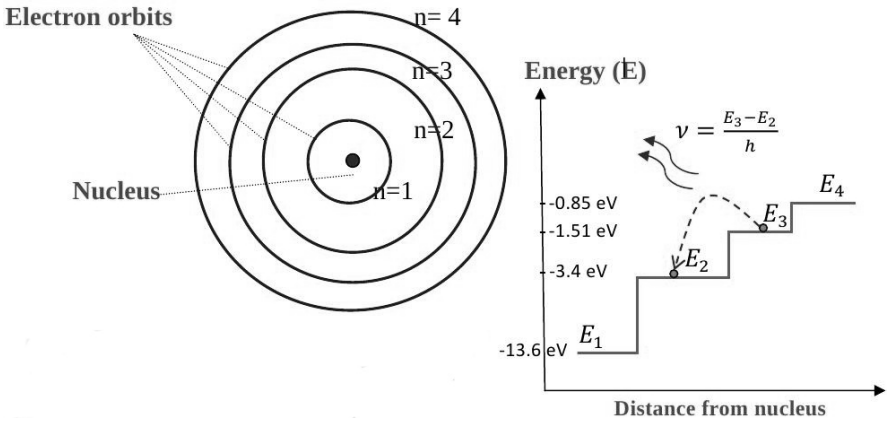
At present it is thought that all the forces in the universe get carried by some kind of quantum particle. This very idea was started in 1928 with Paul Dirac stating that photons transmit the electromagnetic force. The theory is now called "quantum electrodynamics," or QED, developed from work by Richard Feynman, Julian Schwinger, and others since the late 1940s. There are four fundamental forces known today. Their corresponding particles are tabulated in Table 1.

In 1960, Murray Gell-Mann proposed that electrons, protons etc. consisted of more basic units called quarks, which may be of three types, 'up,' 'down,' and 'strange.' From 1974 to 1984 the theory predicted three more quarks called 'charm,' 'bottom,' and 'top.' Also each quark has its corresponding anti-quark.

The theory of the quark enables us to explain the existence of several particles including the nucleus of the atom. In fact the proton and neutron are thought to be made up of three quarks each and the force which holds the quarks together come from particles called 'gluons.' The existence of Higgs boson was announced at CERN on 4 July, 2012. It appears to confirm the existence of the Higgs field. It would

Table 1

Force	Particle	Example	Relative strength	Range (m)
Strong	Gluon	Force holding nucleus together	1	10^{-15}
Weak	W+,W-,Z	β decay	10^{-6}	infinite
Electromagnetic	Photon	Light, electricity	1/137	10^{-18}
Gravitational	Graviton	Gravity	6×10^{-39}	infinite



Emission of radiation. Here the first Balmer transition is shown, in which an electron jumps from $n = 2$ to $n = 2$ producing a photon of red light with energy 1.89 eV and wavelength 6560 Angstrom.

explain why some fundamental particles have mass when the symmetries controlling their interactions should require them to be mass-less, and why the weak force has a much shorter range than the electromagnetic force. With this, the so called Standard Model, which explains all atomic and sub-atomic phenomena, seems to receive a confirmation. The modern story of the atom, which started with Bohr, now stands on irrefutable grounds, until the next scientific revolution in this domain.

Conclusions

From the time of the ancient Greeks till today, the visual image of the atom has often proved elusive and obscure, yet the mathematical concepts have grown stronger. Although nothing has yet been proved absolute, humans can now predict the behavior of atoms with great accuracy. But the world of the atom, the quantum domain, appears so strange that we can no longer visualize what we think and talk about. The particles have an aura of randomness about them; and yet the methods of quantum electrodynamics (QED), quantum chromodynamics (QCD), and the whole of quanum mechanics provide such precise, useful, and powerful tools, that it explains all observed phenomena in this domain. Predictions of quantum mechanics have been verified time and again, to a precision better than

Rydberg formula

The energy of a photon emitted by a hydrogen atom is given by the difference of two hydrogen energy levels:

$$E = E_i - E_f = R_E \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

where n_f is the final energy level, and n_i is the initial energy level. The R_E is the constant given by $R_E = (me^4)/8h^2\epsilon_0^2$.
Since the energy of a photon is $E = hc/\lambda$ the wavelength of the emitted photon is given by

$$\frac{1}{\lambda} = R \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

This is known as the Rydberg formula, and the Rydberg constant R is nothing but R_E/hc. This formula was known in the nineteenth century to scientists who were engaged in studying spectroscopy, but there was no theoretical explanation for this form or a theoretical prediction for the value of R, until Bohr. However, Bohr's derivation of the Rydberg constant, and agreement of his formula with experimentally observed spectral lines of the Lyman ($n_f = 1$), Balmer ($n_f = 2$), and Paschen ($n_f = 3$) series, and successful theoretical prediction of other lines not yet observed, was one reason that his model was instantly accepted.

one part in a billion.

The Bohr model gave us the basic concepts of electronic orbits and energies. The precise details of spectra and charge distribution must be left to quantum mechanical calculations, e.g., the Schrödinger equation. However, because of its simplicity, and some correct results for hydrogen atom, the Bohr model is still commonly taught to introduce students to quantum mechanics, before moving on to the more accurate, but more complex, picture of atom.

Niels Bohr won the Nobel Prize in 1922. Bohr extended the model of hydrogen atom to give an approximate model for heavier atoms. This gave a physical picture which reproduced many known atomic properties for the first time. Heavier atoms have more protons in the nucleus, and hence can accommodate more electrons. Bohr's idea was that each discrete orbit could only hold a certain number of electrons. After that level is filled, the next level would have to be used. This gives the atom a shell structure, in which each shell corresponds to a Bohr orbit. This shell model was extended to the nucleus, with nucleons playing the role of electrons, by his son. Therefore, Bohr's contribution towards the understanding the atom and atomic phenomena had a long-lasting impact and we must bow to him before starting the study of atoms and molecules. □

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Niels Bohr — An Eternal Inspiration

Ashwin Kalyan *

NIELS BOHR was one of the most influential physicists of the 20th century. He was awarded the Nobel Prize for his work on the structure of atoms. He was a guiding force for many young and talented physicists like W.Heisenberg, W. Pauli, P.A.M.Dirac, G.Gamow to name a few. Apart from being a physicist of great calibre he was also a great human being and a strong advocate of peace and harmony.

Birth and Early Life

Neils Bohr was born in Copenhagen on the 17th of October, 1885 to Christian Bohr and Ellen Adler Bohr. His father was a professor of physiology at the University of Copenhagen and was well known for his work on physical and chemical aspects of respiration. His mother came from a family distinguished in the field of education. Niels Bohr had a conducive environment at home to foster a research oriented mind and grew up inculcating human values from a young age. His father encouraged creative thought and always engaged his children in discussions. According to Bohr, his father played a major role in him taking up physics. He was very close to his younger brother Harald Bohr who went on to become an eminent mathematician.

Schooling

Bohr attended the Grammelholms School along with his brother. He had a good academic record and always was in the top three or four in his class. He developed a strong inclination to mathematics and physics and read works that were ahead of his class and it goes that his teachers were sort of frightened by his doubts! He excelled in physical education and was an excellent soccer player. He played for a club by name Akademisk Boldklub based in Copenhagen along with his brother Harald. It is interesting to note that his brother went on to become a part of the medal winning Danish team at the 1908 Olympics.

Education

In 1903, he enrolled at the University of Copenhagen to study philosophy and mathematics. He was taught by Christian Christiansen and Harold Hoffding, both whom were his father's friends and known to him. Neils and Harald Bohr were part of the group Ekliptika formed by Hoffding which met regularly to discuss on issues concerning science and philosophy. This group consisted of only 12 members and all of them went on to become eminent persons in various fields. During these discussions both the brothers showed a deep understanding of each other and often they would refine their thoughts. It is evident from these that Bohr preferred to think out loud about a particular thought and that he enjoyed discussing his ideas with likeminded people. There can be hardly any doubt regarding why Copenhagen became a centre for theoretical physicists under Niels Bohr attracting the sharpest of minds to the in-

*Mr. Kalyan is a student at NIT Suratkal.

stitute.

In 1905, The Royal Danish Academy of Sciences and Letters announced a competition for the best research paper. This attracted Bohr' attention and he worked on the surface tension of water and aimed at extending Rayleigh's theory on surface tension. He conducted experiments in his father's laboratory and came out with a paper — 'Determination of Surface Tension of water by method of jet vibration' which won him a gold medal. He was not a good writer and he always dictated his papers to someone and this being no exception was dictated to his brother Harald. This success inspired him to take up physics research for the rest of his life. It is noteworthy that his father forced him to stop his experiments to write the paper as the deadline for the paper submission was approaching. Bohr had been reluctant to start the paper-work as he had not been satisfied with the results. This shows Bohr's sharp mind for perfection that he had at a young age.

Early Research work

He continued his studies at the University of Copenhagen under the physicist Christian Christiansen and received his doctorate in 1911 for his thesis — 'The electron theory of metals' which remains till date a classic work in that subject. As a post-doctoral student, his father arranged for him a grant from the Carlsberg brewery to further his studies. Later, Carlsberg brewery also played a major role in funding the Institute of theoretical physics of the University of Copenhagen established by Niels Bohr. It is humorously added that Carlsberg beer gave the necessary impetus for the research work at the institute.

After having done doctoral research on electrons it was natural for him to desire to work under J.J.Thomson at Cambridge. There Bohr tried to draw his attention by pointing loopholes in the group's research work. Though J.J.Thomson gave him some guidance, Bohr felt that his research was not progressing. At this juncture, Bohr was lucky to hear a talk by Ernest Rutherford who had become famous for his experiment that led to the discovery of the atomic nucleus. He was captivated by the brilliance of Rutherford and decided to move to Manchester to work under hm. Rutherford showed interest in Bohr and accepted him as his student. Here, he worked on improving on the model proposed by Rutherford and recognized that it did not satisfy the laws of classical physics. Rutherford's model described that the structure of the atom was similar to the solar system with the nucleus at the centre and electrons revolving around it. But, an accelerated electron was supposed to radiate energy according to Maxwell's equations causing the electron to collapse into the nucleus and therefore the atom would be non-existent.

Bohr brought in the newly formulated quantum theory into this atomic model and introduced the concept of stationary states which resolved the drawbacks of the Rutherford atomic model. This work of Bohr came out in the form of three papers that are today famous as the '1913 Bohr Trilogy'. He sent these to his mentor Ernest Rutherford who was apprehensive about certain parts of the papers. Rutherford wrote back to Bohr informing that he would edit certain parts of the paper according to his discretion and would forward it to the philosophical magazine. But Bohr, who was very particular about publishing the work as it is, came down to Manchester and convinced Rutherford to publish them with only corrections to his English. Rutherford and Bohr developed a deep appreciation for each other during this time. Bohr in his frequent letters to his brother Harald has stated about his lik-

ing for Rutherford's style of research, enthusiasm and friendly nature. Rutherford was an outright experimental physicist who disliked a pure theoretical approach to any problem. On being asked about what led him to encourage Bohr, he replied "Bohr is different. He is a soccer player!"

During 1913-1914 Bohr held a lectureship at the University of Copenhagen. He had written to the authorities to establish a theoretical physics chair and to possibly give it to him. At the same time, Rutherford offered him a readership at Manchester which Bohr found it impossible to deny owing to the better facilities and research atmosphere at Rutherford's laboratory. Due to administrative delay, the chair for theoretical physics at the University of Copenhagen could be established only in 1916 and Bohr was appointed as the Professor. Working conditions at the university were rather poor. The place lacked good classrooms and laboratories. But Bohr being a highly patriotic person returned to Denmark and dreamt of establishing an institute dedicated to theoretical physics at Copenhagen. He succeeded in raising enough funds and in 1920 the Institute of Theoretical Physics was established under the University of Copenhagen and Bohr became its first Director which he continued to be until his demise in 1962. This institute became the heart of Quantum physics in the following years under the able leadership of Bohr and was renamed later in his honour.

Guiding light

Neils Bohr attracted the attention of many researchers by his theory of atomic structure which at that moment of time was brash as he did not base his concept of stationary states on any existing theory. Though agreement with Balmer's spectral line formula gave his research work some experimental proof, his theory was widely debated in the physics circles. He himself said that his theory was just like a pencil sketch of a human face and was just an attempt in understanding the theory of atomic structure. This broad mentality and a ready-to-learn attitude of his took him great distances in his life. Because of this nature of his, he won the confidence of brilliant young minds such as Heisenberg, Pauli, Dirac and many others who went on to improve his theory.

He invited Heisenberg to his institute to develop on the matrix equations that he had proposed to describe atomic theory. As a result, Heisenberg came up with the famous uncertainty principle which today bears his name. At around the same time, Schrodinger published his theory that had been improvised on the work of Louis de Broglie which described the electron by a wave function. Thus a debate regarding the validity of Schrodinger's wave mechanics and Heisenberg's matrix mechanics ensued. Bohr's institute played host to these debates and many great physicists regularly visited the institute to participate in the debates. The discussions started yielding and at the end of two years physicists came to conclusion that both described the same phenomena and yielded the same result differing only in their mathematical approach. Bohr gave the finishing touch to this debate by formulating the complementary principle which states that any event can be described by two mutually exclusive theories and still give the same result.

The uncertainty principle said that the position and momentum of a particle cannot be exactly determined at the same time, and that the state of a particle could be determined only probabilistically. This departure from mechanical determinism was not appreciated by many physicists including Einstein who believed that everything in na-

ture is bound by cause-and-effect relation and that events could always be accounted for precisely. This led to the famous 'Bohr-Einstein' debates. Bohr strongly advocated the uncertainty principle and was of the opinion that it was but inevitable to accept a probabilistic model. This debate reached its peak at the sixth Solvay congress in 1930. Einstein argued persuasively defending his stance on the uncertainty principle. It is said that Bohr was shocked as he could not come with an answer to the question Einstein posed and spent that entire night formulating his defence for the uncertainty principle. The next morning, a jubilant Bohr proved Einstein wrong by making use of relativity proposed by Einstein himself. Quantum mechanics grew with vigour due to Bohr's open mind and conviction. Neils Bohr also developed the liquid drop model of the nucleus in order to explain nuclear fission.

The difficult times

It is interesting to note that Bohr's research career reached its zenith during the time of the world wars. He came up with his celebrated atomic model during the First World War. During the Second World War, when Denmark succumbed to the Germans without any fight, Bohr had to face a lot of problems due to his Jewish descent. He showed exemplary humanity by helping scientists who wanted to escape from Europe by influencing the Swedish government. He himself escaped in a fishing boat to Sweden when he came to know about threat to his life through reliable sources. He along with his son Aage Bohr were flown by a British Military plane and they ultimately reached the USA to work on the Manhattan project. He worked under a false name of Nicholas Baker and did not actually take a major role in the development of the atomic bomb as he was mainly seen as a resource person. He angered both Roosevelt and Churchill by advocating sharing of information with the Soviet Union for the sake of safe use of atomic weapons. After the war, he returned to Denmark and took up major expansion of the institute. He also organized the Atoms for Peace conference in Geneva in 1955. He remained a strong advocate of nuclear disarmament and usage of nuclear energy only to solve energy crisis.

Post war and the last moments

Bohr was a driving force for the establishment of CERN at Geneva. For five years he organized and hosted CERN's theoretical department at his institute, until it was transferred to Geneva in 1957. After this, he helped establishing Nordita (Nordisk Institute Theoretisk Atomfysik) which was a joint venture of Sweden, Denmark, Norway and Finland. He was also actively associated with the Denmark atomic energy commission since its inception. Until his death, Bohr remained active in his research and in his later years showed interest in the field of Quantum Electrodynamics and Molecular biology. One of the most controversial and noteworthy event after the war was the historical meeting of Neils Bohr and Werner Heisenberg at Copenhagen. Heisenberg had worked with the Germans during the World war and naturally Bohr did not approve this decision of his colleague. The details of the discussion between them is not clear and Bohr was upset after this incident. This clash of emotions and ideologies lead to the famous play 'Copenhagen' by Michael Frayn. Neils Bohr passed away on November 18 at the age of 77 in Copenhagen.

A few anecdotes

Bohr had an inhibition for writing and he disliked being formal. He usually dictated his papers to someone and hence it was common for him to run into seven or eight

drafts. After his brother left to pursue research in mathematics, he took the help of Margherita Norlund — a friend of his brother to write down his works. This association with her went on to become a successful married life of about five decades. She was a loving wife and also played his secretary. They had six children and four of them survived past childhood. He lost one son at a very young age and his eldest son in a boat accident. It should be noted that these tragedies occurred during a time when his research was at its peak and only his strong commitment to science could have propelled him further. His son Aage Bohr went on to become a famous physicist like his father and received the Nobel Prize for his work concerning the structure of atomic nucleus.

It is said that Bohr loved watching Hollywood movies and usually coaxed one of the reluctant researchers to join him and explain him the plot of the movie!

Once when Bohr and fellow researchers went out for a stroll in Copenhagen, Casimir (an eminent physicist who became famous for an effect named after him), who was an expert climber, raced up three floors of a bank building. Bohr, inexperienced as he was, wanted to equal the feat and started climbing. He climbed till the second floor and lay gasping there in difficulty. Upon seeing them racing up a bank building, two policemen suspected robbery, and rushed to the spot armed with guns. Upon reaching the second floor they recognized Bohr and realized that it was only one of his childish antics.

Bohr disliked the concept of a formal conclusion in an essay and in one essay on metals he had mockingly added "In conclusion, I would like to mention Aluminium."

Bohr played a major role in the development of physics in the twentieth century and served as a guiding force for numerous young physicists. It is important for us to remember him and his contributions in the wake of the hundredth year (2013) of the formulation of his atomic model. If researches today were to adopt his scientific attitude and broad mind to encourage youngsters, scientific progress will gallop to reach new heights to be as prolific as it was during the golden era of quantum mechanics. □

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MARS ORBITER MISSION — AN APPRAISAL

Rajani K. S. *

ON NOV 5, 2013, the Indian space endeavour shot to fame! The entire world looked up to the Indian Space Research Organisation (ISRO), as it launched the Mars Orbiter into space from the Satish Dhawan Space Centre, Sriharikota. The Mars Orbiter Mission (MOM) is also popularly called 'Mangalyaan'. It is India's first interplanetary (Earth to Mars) mission. The orbiter is designed to orbit Mars in an elliptical orbit and, if successful, India would be the fourth space agency to reach Mars after the Soviet Space Programme, NASA, and the European Space Agency (ESA). Indeed, India has already achieved quite a feat as the spacecraft successfully crossed the first few hurdles of the interplanetary mission. The Breakthrough Science Society congratulates all the science personnel involved in the project.

Since August 2012, there have been 7 active missions surveying the Martian environment, its surface and other details. There are two rovers (robots) namely 'Opportunity' and 'Curiosity'(both by NASA), which landed on the Martian surface and are surveying the ground and the atmosphere of Mars. Three orbiters — 'Mars Odyssey' (by NASA), 'Mars Express' (by ESA), and Mars Reconnaissance Orbiter (by NASA) — are circling the planet. Two orbiters launched in November 2013 — Mars Orbiter Mission (by ISRO) and MAVEN (by NASA) are on their way to Mars.

*Ms. Rajani is the Bangalore District President of BSS, ex-HoD of Biology, Presidency College, Hebbal, and a member of the Editorial Board, Breakthrough.

It is noteworthy that around two thirds of the Mars missions have ended in failure! Hence it indeed will be a rejoicing moment for Indian Space Exploration if the Mars Orbiter Mission becomes successful.

History of Mars Missions

There have been 44 Mars missions across the globe since the 1960s, of which only 18 missions have been successful. Though the first attempt in interplanetary space missions was led by the erstwhile USSR way back in 1960 (Korabl 4), the first successful Mars mission was from the USA in 1964 (Mariner-4). Mariner-4 returned 21 images of Mars to Earth. The 1971 Mars-3 orbiter/lander of the USSR was the first successful space exploration mission for the USSR. It orbited Mars successfully for 8 months and flashed 20 seconds of data of the Martian surface before crashing on it. Hence if we credit the USA for achieving success in orbiting Mars, we should credit the USSR for pioneering the interplanetary space missions and achieving success in probing the Martian surface (though very short time duration–20secs). The US and the USSR have to their credit some successful missions. Japan (Nozomi-1998), Russia (Mars 96 – 1996), China and Russia together (Phobos - Grunt / Yinghuo 1 – 2011) have tried their hand in interplanetary missions but none of them have been successful. The European Space Agency has tried once and has been successful in its very first attempt (Mars Express Orbiter/ Beagle lander).

Objectives of the Mars orbiter mission

One of the main objectives of the first Indian mission to Mars, as stated by ISRO, is to develop the technologies required for design, planning, management and operations of an interplanetary mission.

Following are the major objectives of the mission:

A. *Technological Objectives:*

- Design and realisation of a Mars orbiter with a capability to survive and perform Earth bound manoeuvres, cruise phase of 300 days, Mars orbit insertion / capture, and on-orbit phase around Mars.
- Deep space communication, navigation, mission planning and management.
- Incorporate autonomous features to handle contingency situations.

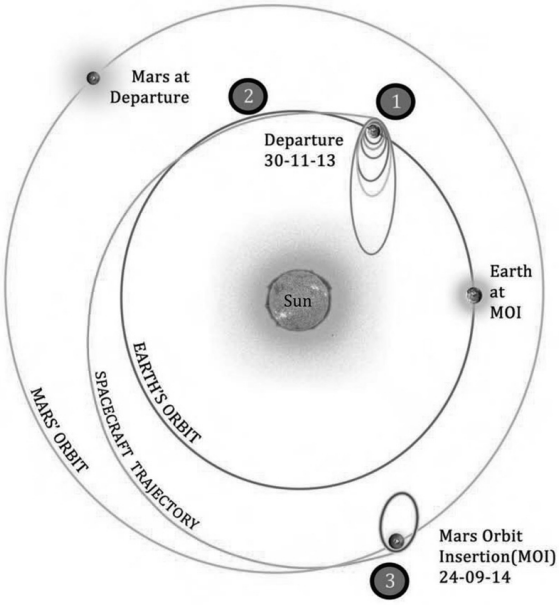
B. *Scientific Objectives:*

- Exploration of Mars surface features, morphology, mineralogy and Martian atmosphere by indigenous scientific instruments.

Current status of the Mars orbiter mission

From the day the orbiter was launched, the space craft has successfully completed five orbit raising maneouvers, crossed the moon's orbit around the Earth (mean distance 3,85,000 km) on December 2nd, 2013, and according to recent updates from ISRO (as on 11 December 2013), it is travelling at 29 lakh km away from the Earth.

While we laud the feat, we intend to draw the attention of our readers to a few issues raised by critics in order to appreciate the endeavour in its correct perspective.



The trajectory to be followed by the spacecraft to reach Mars.

Is the Mars orbiter mission a complete success?

Till now the going is great, though with a few hitches. For example, the flow to the liquid fuel to the engine stopped during the fourth orbit-raising manoeuvre, as a result of which the velocity could not be increased as expected. However the shortcoming has been corrected by performing an unscheduled burn on 12th November, 2013 raising the apogee to 1,18,642 kms, a slightly higher altitude than originally intended.

Following the orbit raising manoeuvres, there are three more stages before the Mars orbiter reaches the planet:

1. Trans-Mars injection that has resulted in the transfer of MOM away from earth's orbit and on a heliocentric trajectory towards Mars;
2. Trajectory correction manoeuvres — four were planned, one has been performed on December 11, 2013, and the

other three are scheduled in April 2014, August 2014, and Sept 2014;

3. The last stage is the Mars Orbit Insertion, scheduled on 24th September 2014, approximately two days after the arrival of NASA's MAVEN orbiter.

In the background of two thirds of the Mars missions being failure, we must keep our fingers crossed till the Mars orbiter reaches the Martian orbit. Mangalyaan will be placed in a 366 km $\times$ 80,000 km orbit which is quite distant from Mars. In an article titled Martian 'prestige' by Praful Bidwai, the writer argues that "even if the Mangalyaan is a successful, it can observe very little, not even a fraction of what US and European Mars Global Surveyor and Mars Express did. The 1,350 kg Mangalyaan only carries a small 13-kg scientific payload, compared to the Mars Express's 116 kg. This means Mangalyaan cannot add significantly to what's already known about Martian topography or atmosphere. The US' Curiosity—which roved on Mars' surface—couldn't find methane even in the parts-per-million range. It would be a miracle if Mangalyaan, a distant orbiter, finds methane traces, which would possibly but not necessarily, suggest the existence of life." Agreed, the payload is a meagre 13kg, the Mars Orbiter will orbit in a distant orbit, the technology may not be new or innovative, but many of us will understand that every new initiative will have limitations, but it is indeed a feat. India has attempted an advanced space travel dared only by 6 countries. However, there are further dimensions to the fame that ISRO is presently enjoying. Let us now delve into them.

The ISRO claims that the MOM is a 'technology demonstrator' project aiming to develop the technologies required for design, planning, management and operation of an interplanetary mission. Well, the MOM is a Rs. 454 crore project. The MOM was launched using the Polar Satellite Launching Vehicle (PSLV). If the Mangalyaan could be launched using the Geosynchronous Satellite Launching Vehicle (GSLV), it could place heavy (2000kg-plus) satellites into high orbits. Despite working on the GSLV for 15 years, ISRO has not succeeded in operationalising it. Former ISRO chairman G. Madhavan Nair has criticised the Mars mission as "useless" and a "showpiece event" that hides the GSLV programme's failure. According to him "no new technology is involved" in Mangalyaan. Probably this makes a little sense. When the country is spending such a huge amount on a mission which is a high risk project in terms of success, if it is sure of reaching close to Mars with PSLV itself, then why not work on GSLV and send bigger probes? ISRO will indeed gain some familiarity with deep space communication technology, but that does not explain the hurry. The partially failed 2008-09 Chandraayan moon mission showed that ISRO has not yet mastered the technology involved in such complex manoeuvres. Why the hurry?

Are there defence dimensions to these projects?

There are reports about a military angle to ISRO's seemingly scientific and technological projects. India's space and missile programmes are Siamese twins. ISRO's SLV rockets form the first stage of the Agni series of nuclear-capable missiles. Both shared a propellant factory. ISRO has launched a number of communication and spy satellites for the armed forces as well.

To quote from the Martian 'prestige' article of Praful Bidwai, "Spectacular missions like Mangalyaan and India's recent launches of military and surveillance satellites have another negative consequence.

They raise concerns in China about India's 'ambitions', and prompt a competitive response. It would be unwise for India to get into a space and anti-satellite (ASAT) missile race with China."

"The danger is real. In 2007, China destroyed an old satellite with ASAT. India too has since tried to develop ASAT, according to Defence Research and Development Organisation chief V.K. Saraswat. In April 2012, he said the Agni-V missile delivers the boosting capability needed for ASAT weapons. "

"India is trying to integrate a Ballistic Missile Defence (BMD) kill vehicle into its missiles to develop a space-based ASAT capacity. It has conducted several test-flights of its BMD system wherein an 'attacker' missile at an altitude of 120 km was destroyed with an interceptor."

"An India-China rivalry will further militarise space, a process recklessly begun by the US, which unilaterally abrogated the Anti-Ballistic Missile Treaty of 1972 to develop BMDs which can kill a missile in space before it re-enters Earth's atmosphere. India for decades opposed the militarisation of space. It is now silent on this, and is and trying to get BMD technology from the US and Israel."

Question of funding science and technological innovations

If ISRO gets a large funding, there is absolutely no problem. But then, the funding to science and technology in general, especially the investment in research initiatives in the basic sciences, should reflect that sense of priority. But in fact India spends only 0.9% of the GDP on basic R&D, while the US spends 2.7% and China spends 1.84%.

In 2003, India set itself a goal: To increase its research and development investment from under 1% of its GDP to 2% by 2007. Ten years later in 2013, India's targets are the same. So is the language of its national science policy.

The country's new "Science, Technology and Innovation Policy" unveiled by Prime Minister Manmohan Singh in Kolkata during the Indian Science Congress to claps and flashbulbs, is largely a mix and match of India's 2003 policy and a June 2012 government report, a close look at these documents shows. "It's a joke that's being played on the nation," a senior scientist at the Council for Scientific and Industrial Research (CSIR) said, requesting anonymity because he works for the government. "This joke will unfortunately rebound on the country."

Ten years after the 2003 policy, India's research and development investment remains under 1% of its GDP, and in absolute terms just a fifth of China's and one-twentieth of the US's funding for science and technology. India's investment in R&D in 2010 was 24.8 billion USD, well below the US (398 billion), Japan (148 billion), China (102 billion), Germany (72 billion), Mexico (56 billion), France (43 billion), and South Korea and the UK (both 41 billion), according to a report commissioned by the department of science and technology. Russia, Canada and Brazil are snapping at India's heels, threatening to overtake the country's R&D investment.

But while the new science policy recognizes that increasing the gross expenditure in research and development to 2% of the GDP has "been a national goal for some time," it suggests a blueprint similar to the failed charter of 2003.

Like the 2003 policy, the 2013 one argues that India can only achieve a target of 2% GDP spending on research if the private sector expands its investment and points to a need to create an environment conducive to private R&D investments. But it is silent

on why India has failed—since the 2003 policy—to attract enough private sector investment to allow the country's research investment to touch 2% of the GDP.

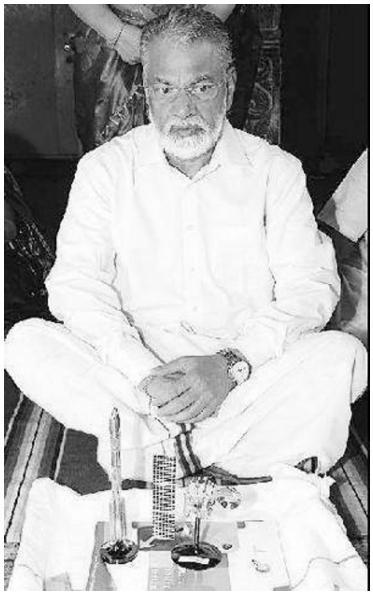
The ISRO, the Dept of Atomic Energy (DAE), and the Defense research and Development Organization (DRDO) together soak up two thirds of India's spending on science and technology. Therefore, we demand that the government should adequately fund not only the defence-related science and technology but all basic sciences and technological developments needed for the people.

Science institution upholding science or superstition?

And finally, even as we uphold the Mars Orbiter Mission while raising some critical questions, we cannot but take note of a matter of serious concern for the science loving people. It was flashed in newspaper reports that the ISRO top brass have publicly sought the intervention of the gods in making the Mission successful. We condemn the act of offering prayers to the deities and conducting rituals praying for the success of such scientific endeavours.

On earlier occasions, the heads of ISRO like Dr. Madhavan Nair and Dr. K. Radhakrishnan have offered prayers at Tirumala. This time, just before the launch, Dr. K. Radhakrishnan performed special poojas to the prototype of PSLV-C 25 rocket at the temple of Sullurpet village deity, Changala Parameshwari, located in Sullurpet town, after which he flew to Tirumala.

Such acts send the wrong signals to the people. While the need of the hour is that the people should have confidence in science, the prayers by the ISRO chiefs convey the message that—not science and technology—but only supernatural entities can make the Mars Mission successful. This will erode people's confidence in science and will fuel superstitious beliefs. People will find justification in not going to a doctor and to take recourse to black magic when someone falls ill. It is a shame on the scientific tradition, scientific temper, scientific ethics and scientific bent of mind.



ISRO Chairman Dr. K. Radhakrishnan praying to the gods before the launch of Mars Orbiter.

Conclusion

The Mars Orbiter Mission is definitely a bold step in the country's scientific endeavours. While we hail the ISRO's initiatives, we also sound a note of caution for reasons mentioned above. If these initiatives turn out to be the grim precursors of space wars as reported by a section of the science circles and media, we would not hesitate to condemn it. Funding to research in basic sciences must become the prerogative of the government and must be on par with the funding to defence based research. We condemn the act of the head of ISRO in publicly offering prayers wishing success of the project, as it goes against the basic temperament of science. □

Organizational News

Uttar Pradesh

Allahabad

On 17th October, 2014, an anti-superstition show was organized at Utraula, Balarampur, UP in presence of nearly 400 students, teachers and professors. The BSS activist Mr. Rajnish Sharma conducted the program. The show has become so popular that several schools and colleges have invited BSS to perform the show and to spread in the other parts of the district.

On 14th December, the BSS-Allahabad Chapter organized a seminar on mathematics at Ewing Christian College, Allahabad, with the title: "Cryptography — The Science of Secret Code and Information Security," on the occasion of 126th birth anniversary of great mathematician Srinivasa Ramanujan. The eminent mathematician Prof. Kalyan Chakrabarty from Harish-Chandra Reserach Institute was the speaker. About 150 students and teachers participated in the seminar.

On 21st December, the BSS organized a seminar on "Higgs boson or God particle?" at Tilak Dhari College, Jaunpur, UP. Dr. Manabendra Nath Bera was the speaker. There were about 120 students present in the seminar.

Lucknow district conference of BSS

On 3rd of October 2013, the Lucknow District Unit of Breakthrough Science Society held its first District Conference in Rai Umanath Bali Auditorium at Quaiserbagh, Lucknow. The conference comprised three sessions. First session was presided over by Dr. Nitya Anand (Padmashree Awardee Scientist). Other dignitaries present on the dais were Prof. Dr. V.D. Gupta (Senior Scientist and Ex-VC of Gorakhpur and Allahabad Universities), Dr. Rakesh Avasthi (Ex-Director of Geological Survey of India), Prof. Dr. Sudha Jain (Department of Chemistry, Lucknow University) and Mr. Sunil Gopal (State Co-ordinator of BSS in Madhya Pradesh).

In the second session of the conference, a Miracle Busting show was performed by BSS activists led by Mr. Ramashish Maurya, District Convenor of Jaunpur District Chapter of BSS.

In the third session there was a Panel Discussion on Science, Pseudo-Science and Society. As experts present on the dais were Dr. V.D. Gupta, Dr. P.K.Seth (Director, Biotech Park, Lucknow), Dr. Rakesh Avasthy, Dr. C.M.Nautiyal (Scientist, Birbal Sahni Institute of Paleo-Botany, Lucknow), Dr. Sarjitsen Sarma (Assistant Professor, Geology Department, Lucknow University), Dr. Naresh Kumar (Assistant Professor at Central Institute of Plastic Engineering and Technology), Dr. Manabendra Nath Bera (Research Scholar, Harishchandra Research Institute, Allahabad) and Mr. Sunil Gopal.

The conference unanimously resolved to oppose all such designs and attempts to misguide people under the disguise of science and urged upon the scientific community to lead people out of this ignorance and darkness which is prevailing due to the si-

lence of the right and logical thinking of the people.

An eight-member district committee was formed with Mr. Dhananjay Singh (Assistant Professor, Institute of Engineering & Technology, Lucknow) as President, Dr. Naresh Kumar as Vice-president, Mr. Shailesh Rao (Engineer) as Secretary, Mr. Durgesh Pratap Singh (Lecturer, Institute of Engineering & Technology, Lucknow) as Joint-secretary, Mr. Yadvendra Pal (Engineer) as Treaurer, Dr. Parvez Ali (Fellow Researcher in Chemistry), Shivani Tripathi (Research Scholar at Lucknow University) and Jai Prakash Maurya (Engineer & Science Activist), all three as Executive Body Members. The Board of Advisors has Dr. Nitya Anand as Chief, Dr. P.K.Seth, Dr. Rakesh Avasthy and Dr. Sudha Jain as members. The Board of Patrons is comprised of Dr. V.D. Gupta as Chief, Dr. Sarjitsen Sarma, Dr. Alka Mishra (Department of Mathematics, Lucknow University) and Dr. Poonam Tandon (Department of Physics, Lucknow University). The committee resolved to advance the cause of science and scientific attitude in Lucknow and adjoining districts.

Madhya Pradesh

First District Science Conference held in Guna

The BSS Guna chapter has organized the first district conference on 10th Dec 2013 at Modern Children H.S. school, Guna. More than 275 students, teachers, and other eminent persons of the Guna were present in the conference.

In the beginning, the senior member of BSS Guna chapter Mr. Pradeep Sen delivered his introductory speech. After that, a report was presented by Mr. Vikas Bansal.

The All India Convener of BSS and main speaker of this conference Dr. Soumitro Bennerjee addressed the conference. A resolution on the different issues in science was passed in the conference. Many students participated in the discussion on the resolution. In the end, a District Advisory Board was formed. The members of this board are Mr. S.P.jain (famous doctor), Mr. Ghanshyam Shrivastava (retired Lecturer and science activist), Mr. Manoj Bhiroria (Prof. of botany P.G. College Guna), Mr. S. N. Jha (senior Professor, Polytechnic College Ashoknagar), Mr. Anoop Kausik (Prof. Ghandhi vocational College Guna), Mr. S. K. Vashishta and Mr. Harish Goyal from H.S. School, Mrs. Preeti Patwardhan (Save education committee), and Mr. Pradeep Sen.

The new distrist committee was also formed. Mr. Vikas Bansal and Mrs. Suman Kirar were elected as the President and Secretary. In addition, it was decided that Mr. Yogesh Dhaked will represent Guna in the State Conference Organizing Committee.

Kerala

Kottayam disctrict chapter

24 November 2013: Workshop on Comet ISON at Jawahar Balbhavan, Kottayam. Prof. K.R.Somanathapillai (DB College, Parumala), Dr.C.S. Menon (Rtd. Director, SPAP, MG University), amateur astronomer Sri. K Thankappan and Prof. P.N. Thankachan were the resource persons.

2 December 2013: Talk on *Madhav Gadgil Committee Report* by Prof. P.N. Thankachan at Mundakayam, Kottayam.

4 January 2014: Sky Watch Program at Model Residential School, Ettumanoor. Prof. P.N.Thankachan took class. Sri. A.G. Sumesh and Master Yadukrishnan conducted the skywatch.

12 January 2014: Sky Watch Program at Govt. UP School, Periyappuram jointly organized by Galileo Science Club, Periyappu-

View of the exhibition on Pokkali rice.

ram. Prof. P.N.Thankachan took class. Sri. George and Sri. A.G. Sumesh conducted the skywatch.

14 January 2014: Sky Watch Program at Thoothootty, Thiruvanchoor jointly organized by Pulary Balavedi, Thriuvanchoor. Prof. P.N.Thankachan took class. Sri. P.G. Sasikumar and Sri. A.G. Sumesh conducted the skywatch.

KOTTAYAM ASTRONOMY CLUB.

11 January 2014: Class on Physical and Psychological effect of Liquor abuse. Dr. Sandeep Alex and Sri. Jomon of Psychiatry Department, Medical Collage Hospital, Kottayam, took Classes.

Thiruvananthapuram district chapter

23 December 2013: Workshop on "Gadgil Committee Report" in Science and Technology Museum Hall Thiruvanathapurm. Benny Joseph and Dr. P. P. Rajeevan took classes. Arul Jerald Prakash, Director, Science and Technology Museum also spoke on the occasion.

11 January 2014: Talk on GM seeds by Benny Joseph in Science and Technology Museum Hall, Thiruvanathapurm.

Alappuzha district chapter

6 November 2013: Workshop on Comet ISON at Netaji Study Centre Muttom, Harippad for the activists of different districts. Dr.K.R. Somanathapillai (DB College, Parumala), Dr.C.S. Menon (Rtd. Director, SPAP, MG University), amateur astronomer Sri. K. Thankappan took the classes.

16 November 2013: Workshop on ISON Comet at Netaji Study Centre Muttom, Harippad. Benny Joseph Prof. P.N.Thankachan Dr. K. Hariprasad and K.Sivankutty took the classes

Report on Pokkali rice cultivation

It was reported in the last issue that in the district of Alleppey, prawn is cultivated in large tracts of land by letting in saline water. This practice has caused serious environmental damage in the locality. This degradation can be controlled to a great extant if paddy crop cultivation is alternated with saline prawn culture as has been the practise down the ages. With this objective, the cultivation of a salt-tolerant, indegenous, and highly nutritious paddy species, called Pokkali, was started at the initiative

of our organization.

The district collector Shri N Padmakumar, former judge of Kerala and Bombay High Courts along with Dr. Sreekumar, senior scientist of Rice Research Station Vytilla, and Dr. Manoj Mathew of Kerala Agriculture University visited Puthenkari Pokkali field as part of a pre-harvest evaluation. This exercise was undertaken as per the request of Pokkali Protection Struggle Forum, which has been spearheading the agitation to restore pokkali paddy crop cultivation in these fields.

Succumbing to the pressure of people's struggle and heeding to the report drafted by a twelve-member expert committee headed by Dr. Madhu Soodhana Kurup, Vice-chancellor of Kerala University of Fisheries and Oceanic Studies, the government proclaimed "one paddy – one fish" as its declared policy. Based on this policy the district magistrates of Ernakulam and Alleppey, which have nearly 25000 hectares of pokkali fields, proscribed prawn culture in these fields during the rice crop season from late March to early Movember. In spite of this order the prawn lobby, with the support of the mainstream political forces and corrupt officials, continued to flout it with impunity. As the movement gathered strength, scientists and researchers who have been witnessing the near extinction of the rare paddy species came forward to lend their support.

Harvesting of paddy in 140 acres of water logged field is a stupendous task, especially when one considers the fact the whole operation has to be carried out with manual labour.

Andhra Pradesh

The BSS Hyderabad district chapter organized a series of discussions on comet ISON to the high school students at the Master Talent Institute on 11-10-2013 and at the Vidyarthi Educational Institute, Khairathabad, on 18-10-2013. R. Gangadhara and L. Sarath delivered the talks.

Breakthrough science society organized a memorial meeting of the great scientist and humanist Madame Marie Curie on her 146th birth anniversary in the Stanley College of Engineering and Technology for Women, Hyderabad. The Principal of the College Dr. Anuradha, AIMSS State Secretary Smt. Prameela, and BSS state convener Mr. R. Gangadhara addressed the meeting.

Hyderabad District Science Conference

The first Hyderabad District Science Conference was organised on 26th September 2013 at the Stanley Collage of Engineering and Technology for Women, Hyderabad. The conference started with inauguration of photo and quotation exhibition by Prof. Y. Arun Kumar.

Mr. G. Satish Kumar, Convenor, BSS Karnataka State Unit, was the main speaker of the first session of the conference, dedicated to Ishwar Chandra Vidyasagar. Other speakers of the session were Dr. Y. Arun Kumar (as chief guest), and Dr. M. Rajitha. Mr. R. Gangadhara convenor BSS AP unit, presided over the session.

Apart from the main resolution, a resolution condemning the brutal killing of Dr. Narendra Dabholkar, and another on nuclear energy were proposed and unanimously accepted in the conference.

In the second session, delegates presented their view on different scientific subjects. Dr. Rama Sharma, Head of the Department of Electronics, Osmania University, and Mr. Jani Basha also spoke in this session.

Finally a new Hydrabad District Committee was elected with M. Charan Sagar as President, Mudgala as Vice President, Vijay

A view of the audience at the Hyderabad district science conference.

as Secretary, and Sarath as treasurer. An Advisory Board was also constituted with Dr. Parimal Mishra, R. Gagadhara, Jani Basha, Dr. M. Rajitha, Prof. Sharma, and Dr. V. Anuradha as members.

Karnataka

Chitradurga district

Science competitions for PU students were organised on 11th Jan, 2014 at Vidya Vikas PU College. 57 participants from 9 colleges participated. Three competitions — essay, collage and speech competitions were organised.

Bangalore district

A two day science competition was organised for high school and college students on Dec 21-22, 2013 at KLE College, Rajajinagar, Bangalore. Around 1000 students participated in the five events, namely, essay contest, collage, chart design, written quiz and speech contest. The topics on which the students reflected upon are as follows: Towards improving science teaching in curriculum, Science and its ethics, Science can solve social problems, Conserving planet earth, Science and superstition, Managing natural disasters, Solution to power crisis, anti-superstition bill, science and media.

A prize distribution ceremony to felicitate the prize winners in the five competitions was held on Jan 18th, 2014, at the Sharada Sabhangana (Auditorium), at KLE College, Bangalore. Sri Vinaya Kumar, Principal, KLE PU College, Sri. Suresh Hegadi, Principal, KLE degree college, Dr. N.S Shashidhara, Head of media relations, Vishweshwaraiah Museum, Mr. G. Sathish Kumar, State Convenor, Breakthrough Science Society, Karnataka, gave away prizes.

The prize distribution ceremony was followed by a day long science experiments demonstration and model making workshop. Around 200 students from 15 schools participated in the model making workshop.

Bihar

The Einstein Science Club, Jamalpur, organized a programme on the life struggle and contribution of Madame Curie on 16th November at the Barobari Talla, Jamalpur. BSS organizer Dr. Radhakanta Koner was the main speaker. State organizer Mr. Suryakar Jitendra also spoke on the occasion.

The new body of Einstein Science Club was formed, with Kamal Kishore as Pres-

Participants at the Science Competition in Bangalore.

ident, Rupesh Roshan as Vice President, Rahul Kumar as Secretary, Amit Kumar as Joint Secretary, and Paritosh Kumar as Office Secretary. In the evening a sky-watching programme was organized.

West Bengal

Science competitions in memory of Prof. Sushil Kumar Mukherjee

A state-wide science competition was organized in memory of the legendary scientist and humanist Prof. Sushil Kumar Mukherjee. It was conducted first at the local/subdivision level, then at the district level, and finally at the state level.

In the Kolkata district, the local competitions were held in Calcutta University (21-22 Sept.), Garia (29 Sept.), Chetla (4 Oct.), Nimta (11 Jan.), Dumdum Cantonment (12 Jan.), Naktala (18 Jan.), Rashbehari (5 Oct.), and Behala (5 Oct.). In the East Midnapur district, the local competitions were held in Mahisadal (6 Oct.), Haldia (6 Oct.), Bajkul (10 Nov.), Pratapdihi (6 Oct.), Deulia (22 Oct), Tamluk (22 Oct.), Contai (21 Dec.), and Panskura (22 Dec.). In the Howrah district, the competition was held in Howrah town (5 Oct.), Andul (12Jan.), Makardah (19 Jan.) In the Burdwan district, the competition was held in Durgapur (9 Nov.). In the West Midnapur district, the local competitions were held in, Pingla (12 Dec.), Belda (18 Dec.), Narayangarh (15 Dec.), Midnapur town (14 Jan.), Sabang (14 Jan.), Gopiballavpur (15 Dec.) and Kharagpur (15 Dec.). The district level competitions were held in East Midnapur district (Mecheda, 26 Dec.), Kolkata district (19 Jan.), South 24 Parganas district (12 Jan.), West Midnapur district (19 Jan.), Hooghly (19 Jan.), and Howrah (23 Jan.).

Finally, on 26th January the state level competition was held at the Rajabazar Science College Kolkata. After the competition, there was a programme in memory of Prof. Mukherjee. Prof. Saroj Sanyal, former Vice Chancellor of Bidhan Chandra Krishi Vishwavidyalaya, Dr. Dulal Chandra Mukherjee, honorary secretary of the Indian Chemical Society, Prof. Sukumar Aditya, one of the early students of Prof. Sushil Kumar Mukherjee, and Mr. Debasis Ray, one of the Vice Presidents of BSS, spoke on the occa-

A view of the programme in memory of Madame Curie at Jamalpur, Bihar.

sion. It was followed by a prize distribution ceremony. The programme was presided over by Prof. P. K. Ray, retired Professor, BESU.

Programmes on the Comet Ison

This year a comet called ISON visited the inner solar system, which created a lot of excitement in the scientific circles. It was a sun-grazing comet which was expected to be very bright during its passage close to the sun. The science clubs associated with the BSS took up large scale astronomy popularization programme taking advantage of its visit.

In West Bengal, discussion on the comet was organized in Kakdwip (4 Sept.), University Institute Annex Hall (27 Oct.), Mugberia College, Brajakishor High School, Chakarsul High School (2 Nov.), IIT Kharagpur, Jainagar (4 Nov.), Duttapukur (16 Nov.), Mecheda (17 Nov.), Brajalalchawk, Mahisadal (21 Nov.), Naihati (22 Nov.), Jainagar (23 Nov.), Purulia, Sabang, Baharampur (24 Nov.), Behala, Howrah (24 Nov.), Tamluk (26 Nov.), Behala (26 Nov.), Garia (27 Nov.), Nimta (27 Nov.), Basirhat, Raghunathpur (25 Nov.), Burdwan (30 Nov.), Nistarini College (2 Dec.), Adra (3 Dec.), Garbeta (4th Dec.), South Kasidia School (5 Dec.), Midnapur town (12 Dec.).

Other programmes

14 Sept: The BSS organizes the Acharya Prafulla Chandra Ray memorial lecture every year. This year the topic was the foundation of quantum mechanics in commemoration of the 100 years of the Bohr atom. The talk was delivered by Dr Partha Ghosh, retired Professor of the Satyendranath Bose National Center for Basic Sciences, on 14th September at the Darbhanda Hall of the Calcutta University.

7-8 Sept: Medical camp of flood victims organized by Panskura Science Center

7 Sept: Anti Superstation show organized by Kakdip Science Forum

15 Sept: Discussion on 'Science & Ethics' at Durgapur by Dr Soumitro Banerjee.

5-6 Oct: Science Fair organized by Anneshan Vigan Sanstha, Garia

24 Oct: Discussion on Historical Evidence preservation and Scientific Outlook, at Chandraketugarh, by Radhakanta Konar.

27 Oct: Discussion, Quiz, Prize distribution organized by Madam Curie Science Center and Newton Science Association, Behala.
23 Nov: Discussion on "Atomic model of Niels Bohr," at Young Scientist Forum, Kolkata, by Dr. Soumitro Banerjee.
24 Nov: Medical camp organized by Newton Science Association, Behala
1st Dec: Discussion on Human chimerism, Dr. Pulakesh Aich
15 Dec: Discussion on Uttarakhand Disaster, Geological View, by Dr. Sarifa Khatun
22 Dec: Excursion to BITM organized by Newton Science Association and Madam Curie Science Society, Behala.

IIT Kharagpur Chapter

The committee of the Breakthrough Science Society, IIT Kharagpur Chapter has been formed, with Prof. Damodar Maity as the President, Dr. Radhakanta Koner as the Vice President, Mr. Tapas Dey as the Secretary, Ms. Sangita Singh as Assistant Secretary, and Mr. Biswajit Manna as the Treasurer. In addition, the following students have taken specific responsibilities: Mainak Mandal (astronomy), Tamoghna Ojha and Sneha Rani (seminar), Jit Mukherjee (nature study), Dipak Giri and Sudhansi Billoria (membership).

Tamil Nadu

ISON awareness programs:

A Theme meeting on ISON was organized jointly by the Chemistry Association, A.M.Jain College, Chennai and BSS TN on Oct 19, 2013. Dr.S.P.Balaji, Principal, delivered the inaugural address. Dr.Venkatesan made a presentation on the science and astronomy of comets. Prof. Elangovan, Dept of Chemistry, conducted the proceedings. Ms. Vaishnavidevi, a student from the Chemistry Dept made a presentation on Astrochemistry.

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In a students' camp (Oct 12-13) near Vaigai Dam, Theni, BSS organizers Venkatesan and George Joseph made presentations on the formation of solar system and the science and astronomy of comets. A sky-watching program was also conducted. The moons of Jupiter, phase of Venus and the craters of Moon were viewed through telescope.

Sethupathy School, Madurai, Nov 29: Prof. Krishnakumar, Dept of Physics, Tyagaraja College, Madurai conducted a talk on ISON.

Neyveli: Dr. R.Venkatesan gave a talk on comet ISON in NLC Hr. Sec. School, Neyveli on Nov. 23, 2013. On the same day in the evening, a lecture programme was organised jointly with the Institution of Engineers, Neyveli and Engineers and Scientists Association, Neyveli on the topic "Comet ISON — a rare visitor in the sky". The lecture was conducted by Dr. R.Venkatesan.

A booklet in Tamil on Comet ISON was prepared and circulated among students.

Jharkhand

10 Nov 2013, Saraikela Kharsavan Jharkhand — A discussion on comet ISON and a sky watching program were organized at nucleus science classes at Adityapur.

11 Nov 2013, West Singhbhum Jharkhand — Two programmes were orgranised: in Chakradharpur there was a discussion on Comet Ison, and in Chaibasa there was an anti-superstitions program.

In both the programmes, Yudhisthir Kumar, member of Einstein Club Ghatshila, and Vijay Kumar, Discovery of Science Society, Bokaro, gave the demonstrations.