ISSN : 0972-169X
Registered with the Registrar of Newspapers of India: R.N. 70269/98
Postal Registration No. : DL-SW-1/4082/2006

Monthly Newsletter of Vigyan Prasar

DREAM 2047

April 2006 | Vol. 8 | No. 7 | Price: Rs. 5.00

VP News

India and Pakistan agree for co-operation in Science and Technology

Talks in progress

The first meeting of Pakistan-India Joint Co-operation Technical Level Working Group on Science and Technology took place on 22 March 2006 at Islamabad. The Indian side was led by Shri Y.P. Kumar, Adviser & Head, International Division, Department of Science and Technology. Other members of the delegation included Dr. V.B. Kamble,

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Inside

Solar Eclipse

A total solar eclipse took place on 29 March 2006. Although it was not visible from India, a partial eclipse of the Sun was seen from several parts of the country. The totality was visible over a long stretch spanning several thousand kilometres across Brazil, Ghana, Nigeria, Georgia, Kazakhstan, and Mongolia. Eclipse enthusiasts in India will have to wait until 2009 to be able to see a total solar eclipse. As seen from Delhi, the eclipse started at 16.33 hrs in the afternoon and ended at 18.02 hrs. The maximum of the eclipse was seen at 17.19 hrs. The Capital witnessed about 17 per cent obscuration at the maximum of the eclipse as the Moon covered the face of Sun.

The partially eclipsed Sun as photographed through Quester $3^1/_2$"telescope of VP

People watching solar eclipse through telescope and solar filters on 29 March 2006 at Technology Bhavan

Vigyan Prasar organized a live show of the eclipse at Technology Bhawan, which houses the Department of Science and Technology, on 29 March. One telescope with solar filter was deployed for the people to watch the

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... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

Published and Printed by Dr. Subodh Mahanti on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 & Printed at S. Narayan & Sons, B-88, Okhla Indl. Area, Phase - II, New Delhi - 110 020
Editor : Dr. V.B. Kamble

Myths and Media

29 March 2006 was a memorable day. On that day, a total eclipse of the Sun was observed from within a narrow corridor that traversed half the Earth. The path of the Moon's umbral shadow began in Brazil and extended across the Atlantic, northern Africa, and central Asia, where it ended at sunset in northern Mongolia. A partial eclipse was seen within the much broader path of the Moon's penumbral shadow that included the northern two thirds of Africa, Europe, and Asia, including India. As it happens during every total solar eclipse, a large number of expeditions from all over the world were organised to the belt of totality – including a few from India – to carry out a variety of scientific experiments to understand the structure of the solar corona and related phenomena.

Despite the fact that a partial eclipse of the Sun is far from being a spectacular event like the total solar eclipse, hordes of curious children – many accompanied by their parents – thronged planetaria and schools where special arrangements were made for safe observation of the eclipse. What was most gratifying to watch was the sparkle in their eyes and the smile on their face after they had a look at the eclipsed Sun either through a telescope or through a safe solar filter.

But, many preferred to watch the eclipse in the safest manner – on their television sets in the cool comfort of their homes. With nearly twenty news channels available on the cable network, it was expected that there would be several educative and informative programmes on the television dealing with the scientific aspects of this awesome celestial phenomenon and interviews with scientists alongwith the live coverage of the eclipse. Alas! On most of the channels, the science got eclipsed and the myths prevailed!

Often I receive calls from television channels for live interviews on such special events. This time too I received a frantic call from one channel. I was to be in a live conversation for half an hour with an anchor. When I entered the studio, I discovered that I was not the only one invited. There was an astrologer already present! The pretty and petite anchor began conversation with the astrologer. At the outset the astrologer gave an interesting piece of information that this was the first day of the Vikram Samvat. The new year thus began with an eclipse and would also end with an eclipse – which does not augur well for the human beings! In particular, since the eclipse is taking place in the *Meena Rashi* (zodiacal sign Pisces), those who were born with this zodiacal sign may face the wrath of the evil forces. Then it was my turn. I was asked to explain how the eclipses took place and where this particular eclipse would be seen in the world. Later, the scene abruptly shifted to *Brahma Sarovar* at Kurukshetra where thousands were taking a holy dip to ward off the evil effects of the eclipse. The reporter there gave a running commentary of the rituals for nearly ten minutes! For about a minute the scene then shifted to Nehru Planetarium at New Delhi, and then once again to the astrologer in the studio. He talked at length about the rituals and ceremonies that must be performed before and after the eclipse with a special caution to pregnant women not to watch the eclipse at any cost, otherwise they may give birth to physically deformed or mentally retarded children! With this piece of profound advice from the astrologer the programme ended! I was never asked to give any further information – not even about safely observing the eclipse! I might have spoken for less than two minutes! The astrologer, obviously a VIP with that channel, continued to feature for the whole day, I was told!

I believe what I have described here is what we normally witness on any such occasion. I remember yet another instance. When the rare event of Venus Transit took place on 08 June 2004, almost all television channels were flooded with astrologers spreading myths and superstitions! The only scientific programme that was telecast was on Doordarshan by Vigyan Prasar. Why do the television channels vie with each other in spreading myths and superstitions? Is it because the myths and superstitions sell? Or is it just a survival tactics in the fierce war of channel supremacy? Perhaps yes. But, media are expected to be a mirror in which the true image of the society is reflected – without any distortion. In addition, they are also expected to raise issues that ail the society, suggest ways and means to address them rationally based on facts and figures. In fact their major responsibility is to build up an opinion through a scientific approach enabling people to make informed choices.

Vigyan Prasar and Development and Educational Communication Unit of ISRO have launched a massive

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Editor : **V.B. Kamble**

Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016; Tel : 26864157; Fax : 0120-2404437
e-mail : info@vigyanprasar.gov.in
website : http://www.vigyanprasar.gov.in

Leonhard Euler

"Master of All Mathematicians"

❑ Subodh Mahanti
e-mail : mahantisubodh@yahoo.com

"Liesez Euler, Liesez Euler, c'est notre maitre a tous (Read Euler, read Euler, he is our master in everything)"
The above testament to Euler's proficiency in all branches of mathematics was by Laplace.

"He (Euler) calculated just as men breathe, as eagles sustain themselves in the air."
Francois Arago

"Euler was the most prolific mathematician in history and contributed to all areas of pure and applied mathematics. In analysis he lacked Gauss's or Cauchy's rigour but he had a gift for deducing important results by intuition or by new ways of calculating quantities. He systematised much of analysis, cast calculus and trigonometry in its modern form and showed important role of e (Euler's number, 2.718 28…). Euler developed the use of series solutions, paying due regard to convergence; he solved linear differential calculus."
The Cambridge Dictionary of Scientists (2002)

"No other mathematician has published as much as Euler did. He wrote almost 900 papers, memoirs, books and other works. Of these almost half date from the second St. Petersburg period, when he was almost blind and everything had to be dictated to assistants. It is estimated that of all the pages published on mathematics, mathematical physics, astronomy, and engineering sciences during the last three-quarters of the eighteenth century, one third were written by Euler."
Ioan James in Remarkable Mathematicians: From Euler to von Neuman

Leonhard Euler was the greatest mathematician of the eighteenth century. His influence on the development of mathematics was not simply restricted to the eighteenth century. The work of many outstanding nineteenth-century mathematicians arose directly from Euler's work. He made numerous contributions to every branch of mathematics of his time, except probability. His major contributions were in the field of number theory. He founded the branch of mathematics known as graph theory. Euler introduced the symbols 'e' for the base of natural logs, 'i' for the square root of -1, 'f(x)' for 'f' a function of 'x', etc. The introduction of these symbols led to the systematisation of mathematics. It was Euler, who first represented trigonometric values as ratios. Euler made so many important contributions that the term like "Euler's formula" or "Euler's theorem" may mean different thing depending on the context in which it is used.

Leonhard Euler

Euler's contributions were not confined to the realm of pure mathematics. He made equally important contributions to the area of applied mathematics. Commenting on Euler's contributions to the area of applied mathematics, Ioan Jones wrote: "…Euler was remarkable for the skill with which he applied mathematics to practical problems. For example, he investigated the bending of beams and calculated the safety load of columns. He calculated the perturbative effect of celestial bodies on the orbits of planets. He calculated the paths of projectiles in resisting media. His three volumes on optical instruments contributed to the design of telescopes and microscopes. His work on the design of ships added to navigation. He produced a theory of the tides. Nor were his interests confined to subjects closely related to mathematics; he wrote about chemistry, geography, cartography, and much else."

Euler made significant contributions in optics, mechanics, electricity, and magnetism. He contributed to almost every branch of mechanics – the motion of mass points, celestial mechanics, the mechanics of continuous media, ballistics, acoustics, vibration theory, optics, and ship theory. He was also deeply interested in philosophy. He wrote 234 letters to the Princess of Anhalt-Dessau, the King's niece. The letters together presented a non-technical outline of the main physical theories of the time. They were among the most successful popularisations of science. These letters written during the period 1760-62 were published under the title *Lettres a une Princesse d'Allemagne* (*Letters to a German Princess*). Euler's letters to the Princess were translated into many languages.

Euler was the most prolific mathematician of all times. He found time to write over 800 papers in his lifetime. And what is remarkable is that Euler produced much of his work in the last two decades of his life when he was totally blind. His prolific output caused a tremendous problem of backlog. The St. Petersburg Academy continued publishing his work posthumously for more than 30 years! Euler's complete works fill about 90 volumes. John L. Greenberg wrote in *The Oxford Companion to the History of Modern Science*: "...Euler was the most productive mathematician of all time. The measure is not the number of papers, for which the current record holder is the Hungarian Paul Erdos, but the number of published pages. Yet productivity was perhaps least important of Euler's claims to mathematical distinction. One of his great contributions was his clarity, in contrast to French mathematicians of the time, who rarely expressed themselves so lucidly. The polishing that the savants of the previous century carried to extremes was almost wholly abandoned in the prolific eighteenth century."


Denis Diderot

Euler had a phenomenal memory. He could recite the entire *Aeneid* word-for-word. The mythological epic *Aneid*, which tells the story of the seven-year wanderings of Aeneas after the fall of Troy, was composed by Roman poet Virgil (70-19 BC). According to one story narrated by a contemporary French mathematician Condorcet, two students of Euler had independently summed seventeen terms of a complicated infinite series but their results differed at the fiftieth decimal place. This resulted in a minor dispute between the two, which was settled by Euler by re-computing the sum in his head.

Leonhard Euler was born in Basel, Switzerland, on April 15, 1707. His father Paul Euler, a Protestant minister, had studied theology at the University of Basel. As an undergraduate student of the Basel University, Paul Euler, not only attended lectures of Jacob Bernoulli I (1654-1705) but also lived in his house. It was here that he became a friend of Jacob's younger brother, Johann Bernoulli I (1667-1748), who was also an undergraduate student at the university. Euler's mother Margaret Brucker was the daughter of a Protestant minister. When Euler was one year old the family moved to a nearby village named Riehen. Euler spent his childhood at Riehen, where his father was a pastor. His father taught him elementary mathematics along with other subjects. Euler was sent to school at Basel where he lived with his maternal grandmother. The teaching in this school was far from satisfactory. He did not learn any mathematics from the school. However, he studied mathematical texts on his own and he also took some private tuitions. In 1720, Euler entered the Basel University. His father's friend Johann Bernoulli was professor of mathematics at the university. Bernoulli not only recognised Euler's great potential in mathematics but he also helped him develop his interest in the subject. Euler in his unpublished biographical writings wrote: "...I soon found an opportunity to be introduced to a famous professor Johann Bernoulli...True, he was very busy and so refused flatly to give me private lessons; but he gave me much more valuable advice to start reading more difficult mathematical books on my own and to study them as diligently as I could; if I came across some obstacle or difficulty, I was given permission to visit him freely every Sunday afternoon and he kindly explained to me everything I could not understand." Euler graduated in 1722.

Following his father's wishes, Euler's joined the faculty of theology. In 1724, Euler obtained his Master's degree in philosophy by writing a thesis comparing the natural philosophy of Descartes with that of Isaac Newton. But soon he realised that he had no interest in theology or subjects like Greek and Hebrew. He sought his father's consent to change to mathematics. He finally got the permission after his father was persuaded by his old friend Johann Bernoulli. Euler completed his mathematical studies at the Basel University in 1726. He studied the works of Varignon, Descartes, Newton, Galileo, van Schooten, Jacob Bernoulli, Hermann, Taylor and Wallis. In July 1726 he was offered a teaching assignment by St. Petersburg Academy of Sciences founded by Catherine I, the wife of Peter the Great. He was to teach applications of mathematics and physics to physiology. The post that was offered to Euler had become vacant after the death of Nicolas (II) Bernoulli. Euler did not accept the offer immediately. And even when he finally accepted it in November 1726 he was not prepared to travel to Russia until the spring of the following year. There were reasons for his delay. He needed time to prepare himself to study the topics of his teaching as-


Pierre Louis Moreau de Maupertuis

signment. They were new to him. He was also hoping to get the vacant post of the professor of physics at the University of Basel. To strengthen his claim for this post he wrote a treatise on acoustics, which became a classic on the subject. When Euler was not selected for the post at the Basel University, he finally decided to take up the assignment at St Petersburg Academy. He reached St Petersburg on 17 May 1727. He was appointed to the mathematical-physical division of the Academy rather than to the physiology post he had originally been offered. This was possible because of the recommendation of Daniel Bernoulli and Jakob Hermann. Euler served as a medical lieutenant in the Russian Navy from 1727 to 1730. When Daniell Bernoulli returned to Basel in 1733, the senior chair in mathematics at the academy held by him was offered to Euler. With this appointment Euler's financial situation improved considerably. In 1735, Euler was appointed Director of the Academy's geographic section. His task was to help the French astronomer Joseph Nicholas Delisle (1688-1768) in preparing a map of the whole Russian Empire. The result of this collaboration was the *Russian Atlas*, which first appeared in 1745. It consisted of 20 maps.

Voltair

Euler's first stint with the St. Petersburg Academy continued for 14 years. He was mainly engaged in mathematical research. During his first period of stay he completed about 90 works for publication. He also solved the problems of seven bridges of Konigsberg, which dated from 1736. This led to the establishment of a new branch of mathematics called graph theory. In his treatise *Mechanica* written during 1736-37, Euler for the first time presented Newtonian dynamics in the form of mathematical analysis. He regularly entered for the annual prize given by the Paris Academy. He won the award 12 times and thus made a record, which even surpassed that of Daniel Bernoulli. He also helped the Russian government by solving many practical problems brought to his attention. He also wrote elementary and advanced mathematical textbooks for use in school. It was during this period that Euler lost sight of his right eye. It is said that his loss of eyesight was due to looking at the Sun accidentally during astronomical studies.

Euler had no intention of leaving St Petersburg. However, political turmoil in Russia made it difficult for foreigners to stay there. Anna Ivanovna's reign (1730-40) was one of the bloodiest in Russian history. The situation was little better after the death of Ivanovna, but by that time Euler had made up his mind for leaving Russia. He accepted the invitation of the King of Prussia Frederick II (1712-1786), who was planning to establish an Academy of Science replacing the Society of Sciences. Under the political and military leadership of Frederick II, also known as Frederick the Great, Prussia doubled its size and became a major European power. Euler arrived at Berlin on 25 July 1741. The Berlin Academy was established in 1744 with French mathematician Pierre Louis Moreau de Maupertuis (1698-1759) as the President. Euler was appointed as Director of Mathematics. He undertook wide-ranging duties at the Academy. "...he supervised the observatory and the botanical gardens; selected the personnel; oversaw various financial matters; and, in particular, managed the publication of various calendars and geographical maps, the sale of which was a source of revenue for the Academy. The King also entrusted Euler with solving practical problems, such as the project in 1749 of correcting the level of the Finow Canal. At that time he also supervised the work on pumps and pipes of the hydraulic system at Sans Souci, the Royal summer residence." In addition to these duties he served on the committee of the Academy dealing with the library and of scientific publications. After the death of Maupertuis in 1759, Euler assumed the leadership of the Berlin Academy. However, he was not given the title of President. The King was in overall charge of the Academy. In 1763, the Presidency of the Academy was offered to Jean d'Alembert (1717-1783). Euler did not like this. There was too much French influence in the activities of the Berlin Academy. The members of the Berlin Academy were required to speak and write in French at the instance of Frederick II. However, he could not do much because by that time he had fallen out of favour of the King, who had no interest in Euler's mathematics. Though d'Alembert refused to accept the offer Euler's position did not improve. The King continued to interfering with the running of the Academy. As a result Euler decided to leave Berlin. During his 25 years' stay in Berlin Euler wrote 380 papers and books on a number of topics like calculus of variations, calculation of planetary orbits, artillery and ballistics, analysis, shipbuilding and navigation, motion of the Moon and others.

Frederick the Great

In 1766, Euler returned to St Petersburg at the invitation by Catherine II, the Great and stayed there till his death. He became the Director of the St. Petersburg Academy. Soon after his arrival in Russia he went completely blind. However, he continued his work on optics, algebra, and lunar motion. This he could do because of his remarkable memory. He produced almost half of his total works after he lost his eyesight.

Euler was very much interested in philosophy. However, his understanding of the subject was very limited. This did not deter him to get him engaged in philosophical debates, particularly with Voltair (1694-1778), the French writer, philosopher and historian and who is regarded as the embodiment of the 18th century enlightenment in Europe. Voltair's real name was Francois Marie Arouet. In these debates Euler often blundered to the amusement of the audience. There was an interesting episode about his philosophical debates. While he was in Russia for the second time, the Russian Czarina Catherine the Great invited to her court the French philosopher and writer Denis Diderot (1713-84). Diderot attempted to convert the Czarina's subjects to aetheism. The Czarina did not like this and so she asked Euler to quiet Diderot. One day in the court Diderot was informed that someone has proved mathematically the existence of god. Diderot, who had no knowledge in mathematics, wanted to know more about it. Euler then stated: "Sir, $a+b^n /n = x$, hence God exists; reply." Diderot had no idea of what Euler was talking about but he could realise by hearing the laughter in the court that he was made a fool. Afterwards he did not stay long in Russia.

Catherina the Great

While in Prussia (the former state and kingdom in Germany, its capital was Berlin), Euler's home was destroyed by the Russian army invading Prussia. However, as he was held in very high esteem in both Russia and Prussia, his loss was promptly compensated.

Euler did not have many disciples of his own. However, as French mathematician Pierre-Simon Laplace (1749-1827) said, Euler was considered as the teacher of all mathematicians of his time.

Euler died on 18 September 1783. Even on the last day of his life Euler worked as per his normal routine. He gave mathematics lesson to one of his grandchildren. He made some calculations with chalk on two boards on the motion of balloons. He discussed with others the planet Uranus, which was discovered in 1781 by the English astronomer William Herschel. About five o'clock in the afternoon he suffered a brain haemorrhage and died about eleven o'clock at night.

References

1. Heilbron, J. L. (Ed.), *The Oxford Companion to the History of Modern Science.* Oxford: Oxford University Press, 2003.
2. James, Ioan, *Remarkable Mathematicians: From Euler to von Neuman*, Cambridge: Cambridge University Press, 2002.
3. *Chambers Biographical Dictionary* (Centenary Edition), New York: Chambers Harrap Publishers Ltd., 1997.
4. *A Dictionary of Scientists*, Oxford: Oxford University Press, 1999.
5. *The Cambridge Dictionary of Scientists* (Second Edition), Cambridge: Cambridge University Press, 2002.
6. Available resources on the Internet.

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India and Pakistan agree for co-operation in Science and Technology

Director, Vigyan Prasar & Adviser, Department of Science and Technology, and Smt. Paramita Tripathi, Under Secretary, Ministry of External Affairs. Also present were officials from the Indian High Commission at Islamabad. Pakistani side was led by Mr. Ayaz Hamid, Joint Scientific Adviser, Ministry of Science and Technology, Government of Pakistan.

To begin with, both the sides briefed each other about the structure and functioning of their respective Ministries. The meeting, in particular, focussed on areas and possible modes of co-operation between the two countries. A few areas were identified, say, Medicinal Plants and Herbal Medicine, Biotechnology and Renewable Energy Sources. An important area identified for mutual co-operation was science popularization. The possibility of having a joint "Science Train" on the pattern of "Vigyan Rail – Science Exhibition on Wheels" depicting the progress made in the field of science and technology by both the countries was discussed. In this regard, Dr. Kamble made a presentation on "Vigyan Rail – The Indian Experience". The Pakistani side evinced keen interest in the possibility of launching the "Science Train" jointly that could travel in both the countries. The discussion in this regard would continue in the next meeting to be held in New Delhi.

The present initiative may help step up co-operation in science and technology with other SAARC countries, it is hoped.

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Solar Eclipse

eclipse. Over 100 people saw the eclipse through the telescope and also directly through solar filters. Photographs of the eclipse were taken through the telescope.

Crystal ball of Climatologists

❑ Dr T V Venkateswaran
e-mail : tvv@vigyanprasar.gov.in

Fairy tales conjure up a number of contraptions – a magic mirror that disclose the most beautiful lady of the world; a crystal ball that can predict the unfolding events. However, climatologists have no such magical privileges when they make the claim that Earth has had eight ice ages during the past 7,40,000 years, punctuated by rather brief warm spells. One of such interglacial – warm interlude between two freezing ice ages – we enjoy today being one such 'warm' spell. When the climate modellers claim that once there was ice – rather

Figure 1: Crystal ball with air bubbles

mountain-sized glaciers crawling and swarming what today is Sahara desert – indeed this sounds like a fabulous make-believe story straight out of a crystal ball gazing. How do we know that these claims are reasonable and not mere figments of imagination?

Sure enough climatologists consult crystal ball of their own, and to gain a gaze at it they would have to do penance, suffering in the freezing cold desert of Antarctica or Greenland. Each slice of chilly cold ice core drilled from the depth of Greenland or Antarctica's frigid snow tells tales about the distant world it came from. These ice cores, serving as favourite crystal balls of climatologists not only tell tales of the bygone era but also warn us of the ominous times to come.

Ice core as the crystal Ball

An ice core is a vertical cylinder of ice removed from a virgin, uncontaminated ice sheet. It is collected by driving a hollow tube or by core drilling deep into an ice sheet, most commonly in the polar ice caps of Antarctica, Greenland, or in high mountain glaciers elsewhere. As the ice sheet forms from the incremental buildup of annual layers of snow in the first place, it is evident that the lower layers are older than those on top. Just like the annual ring of the tree trunk, each layer of the ice core pertains to a particular year. Therefore an ice core, extracted from a glacier contains ice formed over a range of years. Plotting the depth against age creates an ice core chronology. The properties of the ice can then be used to reconstruct a climatic record over the age range of the core.

Ice cores contain an abundance of climate information, as almost everything that fell in the snow that year remains behind, including wind-blown dust, ash, atmospheric gases, and even radioactivity. From a careful study of the ice core it is possible to make a reasonable estimate of temperature, precipitation, chemistry and gas composition of the lower atmosphere, volcanic eruptions, solar variability, sea-surface productivity, and even forest fires. Ice core records are most applicable to the study of greenhouse gas concentrations. They are in fact the most detailed record available of the past climate. It is the simultaneous occurrence of these properties recorded in the ice that makes ice cores such a powerful tool in palaeoclimatological research.

The length of the record depends on the depth of the ice core and varies from a few years to as long as 8,00,000 years. Of course, the time resolution, i.e., the shortest time period that can be accurately distinguished depends on the amount of annual snowfall, and the depth as the ice compacts under the weight of layers accumulating on top of it. Upper layers of ice in a core may correspond to a single year or sometimes even a single season. However, deeper layers become thin and annual layers become indistinguishable and may be indicative of duration of, typically hundreds of years.

The cornerstone of the success achieved by ice core scientists in reconstructing climate change over many thousands of years is the ability to measure past changes in both atmospheric greenhouse gas concentrations and temperature. Layers can be measured in several ways to identify changes in composition. Small meteorites may be embedded in the ice. Volcanic eruptions leave identifiable ash layers. Dust in the core can be linked to increased desert area or high winds. The measurement of the gas composition is direct: trapped in deep ice cores are tiny bubbles of ancient air, which can be extracted and analysed using mass spectrometer. Temperature, in contrast, is not measured directly, but is instead inferred from the isotopic composition of the water molecules released by melting the ice cores. Isotopic analysis of the ice in the core can be linked to temperature and global sea level variations.

Burble from the air bubbles

As the snow falls, air is trapped between the snowflakes. As porous snow consolidates into ice, the air within it is confined in bubbles in the ice. Minute bubbles containing preserved air pockmark the core. This process continuously preserves samples of the atmospheric contents. Scientists 'read' such air bubbles in the ice core. Information latent in the air bubbles provide clue to the relative concentration of atmospheric gases. Just like a refrigerator keeps food fresh, the frigid ice sheet preserves air from three-quarters of a million years ago – locked in these bubbles! Analysis of the air contained in bubbles in the ice can reveal the composition of the atmosphere, in particular CO_2 variations, in the past. At the same time levels of ^{10}Be isotope are linked to cosmic ray intensity, which can indicate extent of solar activity.

Figure 2: Drill working at Dome- C

In order to retrieve these trapped samples of air the ice is first ground at low temperatures, allowing the trapped air to escape, which is carefully collected for analysis by gas chromatography or mass spectrometry. The studies reveals gas concentrations and their isotopic composition respectively. Apart from the intrinsic importance of knowing relative gas concentrations of, say CO_2, at times their isotopic composition can provide information on the sources of gases. For example, CO_2 from fossil fuel or biomass burning is relatively depleted in ^{13}C isotope. If the CO_2 level is high but low in ^{13}C, it implies that the source of the 'excess' CO_2 was biomass or fossil fuel burning.

The upper parts of ice cores are dated by counting annual layers, as with tree rings; by identification of annual layers scientists can ascertain the age of ice at a particular layer. While the lower parts of an ice core are dated using various indirect indicators. Specific events leave distinctive tracers that can be used to calibrate the ice core against another for which dates have already been established. Such markers are called "reference horizons." For example, the eruption of a volcano creates a reference horizon, and knowing the precise date of this eruption enables scientists to establish dates for bands above and below the eruption.

Tales told by isotopes

If one has to make an estimate of past global temperatures one cannot deploy a direct method. Reliable records of global temperature and other atmospheric data are available only for the past 100 years or so and they would be woefully inadequate to picture the changes in the climate of Earth over thousands of years. If a direct method is not feasible, then indirect methods can be used to ferret out reasonably reliable information; for instance, scientists can work out climatic conditions by looking at the ratio of different isotopes of hydrogen.

Water (H_2O), we know, is made up of molecules comprising two atoms of hydrogen and one atom of oxygen. We also know that there are several isotopes – chemically identical atoms with the same number of protons, but differing numbers of neutrons, and therefore differing masses – of oxygen, and hydrogen. The isotopes of particular interest for climate studies are ^{16}O (with 8 protons and 8 neutrons that makes up 99.76 percent of the oxygen in water) and ^{18}O (8 protons and 10 neutrons), together with ^{1}H (with one proton and no neutron, which is 99.985 percent of the hydrogen in water), and ^{2}H (also known as deuterium, D, which has one proton and one neutron). Deuterium is a stable atomic species that makes up 0.014 to 0.015 percent of hydrogen compounds. While many other isotopes are possible and feasible, these particular isotopes are of interest because they are 'stable' – they do not undergo radioactive decay.

Using sensitive mass spectrometers, scientists can measure the ratio of the isotopes of both oxygen and hydrogen in samples taken from ice cores, and compare the result with the standard isotopic ratio. The standard isotopic ratio of average ocean water is known as SMOW (Standard Mean Ocean Water). The water molecules in ice cores from cold periods are usually low in the heavier isotopes such as ^{18}O or ^{2}H. If a sample of ice has a lot of these, it points to a warmer climate. That is how scientists can tell how cold or warm it was in the distant past. In fact, by measuring the amount of heavy isotopes in the snowfall as compared to the temperature for past several years, scientists have confirmed that there is a near linear relationship between the ratio of heavy isotopes and the temperature in the polar regions. Analysis of ice cores from depths of more than three kilometres in the Antarctic ice sheet has shown a succession of ice ages, with warm interglacial periods, over a period of about 100,000 years.

Journey to the past

Ice core analysis is a fairly new science; the first deep cores were drilled in the 1960s. Though a fledging discipline, ice core studies have already yielded a wealth of information. Scientists turned to ice cores in earnest in the early 1980s, primarily to determine the effect of human activities on the Earth.

One of the earliest core drilling was conducted in Greenland around 1950s. Ice cores extracted from Greenland by US and European agencies yielded data for the past 100,000 years. In 2003, recovery of uninterrupted ice core of 2,917 m length from Greenland provided undisrupted data for past 500,000 years. Meanwhile, the Russians made substantial strides. Up to 2003, the longest core drilled was at Vostok station in Antarctica by the Soviets. It reached back 420,000 years and revealed four past glacial cycles. Another important site for cores drilling in Antarctica is the Byrd Station in western Antarctica. With each centimetre of depth achieved in ice core we make a trip back in time. Deeper we drill, farther back we can glimpse the past.

The latest 'time machine' for climatologists is 'Dome C' in Antarctica. Dome Concordia (or Dome C) is a broad topographic dome roughly centred at 75° 06′06 S, 123° 23′42 E on the polar plateau of East Antarctica (at 3,233 m elevation above sea level), and is more than 700 km from the coast and about 560 km from Vostok. Average temperatures at the site are minus 44ºCelsius. In summer, when the station is open, temperatures usually range from -20º up to -50ºCelsius. In winter, temperature drops as low as -86ºC. A large team of scientists, from 10 different countries, has spent more than a decade extracting the mammoth column of ice from this location. Dome C contains about 800,000 years' worth of snowfall, and the core was drilled to 3,190 m. The core went back 720,000 years and revealed 8 previous glacial cycles.

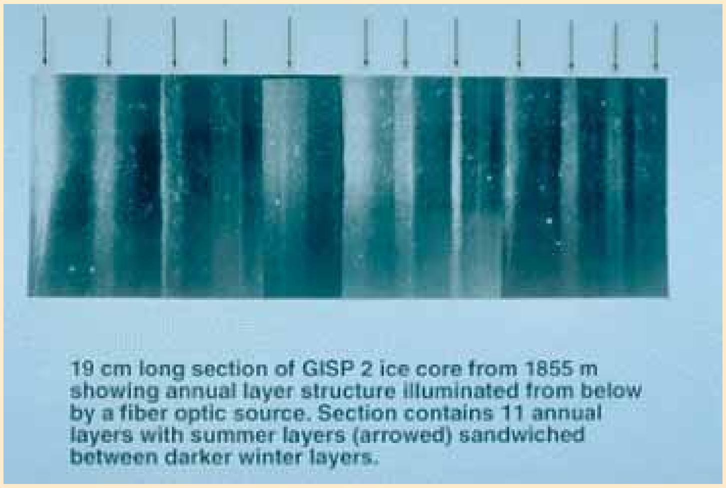


Figure 3: Like annual ring in the tree trunk each layer of snow pertains to a particular year

Cold lessons

Over the last 800,000 years the Earth has, on the whole, been a pretty chilly place. Interglacial – or warm spells – have come every 100,000 years, like pinpricks and have generally been short-lived. The current warm spell in which we live and thrive is expected to last for another 15,000 years, if the past records are anything to go by. However, the current period of interglacial may be shorter as human action pollutes the atmosphere and impact on the climate in unknown ways.

The Greenland cores best reflect the rapid temperature fluctuations of the last ice age, characterized by increases of up to 6ºC in a few years or decades. The discovery of these fluctuations, has given rise to intense interest in their causes. The affirmation from ice-core samples has fueled speculation that current-increasing levels of greenhouse gases in the atmosphere could trigger such rapid change in the coming decades dooming the world and our current civilization.

Of course the studies have indicated that there is a natural variation in the concentration of atmospheric CO_2. In the past the CO_2 level has shown natural fluctuation, but researchers hope a detailed picture of past fluctuations will give them a better idea. If past patterns are followed in the future, we can expect the current warm interlude to last another 15,000 years. The data may also help predict how greenhouse gases will affect climate.

Great floods in store?

Sediment cores drilled at the edge of Antarctica goes to show that the global sea levels rose and fell in a dramatic cycle 34 to 15 million years ago. The research suggests the oceans went up and down by between 50 and 65 metres, as the main ice sheet on the eastern side of Antarctica advanced and retreated in a climate that was 3-4°C warmer than today. Ice cores show alternating freezing ice conditions and open marine settings, implying changes in the sea level at the margins of Antarctica. Changes in global sea level, called 'Milankovitch cycles', are known to happen roughly every 20,000, 40,000, and 100,000 years, and are said to be occurring concomitant with "wobbles" in Earth's orbit. (see Box).

Milankovitch model

The astronomical theory of ice ages is usually based on the theory called as 'Milankovitch model', named after the Serbian scientist Milutin Milankovitch (1879-1958). The basis of the idea is much older, and is drawn from the ideas of Alfred Wegner, better known for his work on continental drift. The model assumes that the combined effect of three basic "wobbles" of Earth profoundly affect the climatic condition of the planet as a whole. These three separate, cyclic changes – changes in eccentricity, obliquity and precession – in the Earth's movements through space combine to produce the overall changes in the solar radiation falling on Earth.

The longest of these is a cycle of between 90,000 and 100,000 years, during which the shape of the Earth's orbit around the Sun stretches from almost circular to something more elliptical and back again; that is the eccentricity changes. When the orbit is nearly circular, there is a more even spread of solar heating over the year. When the orbit is elliptical, we are closer to the Sun at times that at others. This can increase the contrast between seasons, even though the total heat received by the whole Earth over an entire year may remain the same.

The second effect is a cycle some 40,000 years long, during which the tilt of the spinning Earth changes. This change is known technically as a change in the 'obliquity of the ecliptic', and it directly changes the contrast between seasons. When the tilt is more pronounced there are strong seasonal differences, and when the Earth is nearly 'upright' there is less difference between summer and winter.

Finally, the gravitational pull of the Sun and Moon on the bulging equatorial regions of our planet produces a wobble like that of a spinning top – but with a period of 26,000 years. This is the 'precession of the equinoxes'.

These effects combine to produce changes in the amount of heat received at different latitudes at different times of the year, but they do not change the total amount of heat received from the Sun by the whole planet over a whole year. It is very easy to see, in general terms, how this kind of change in seasonal heat could encourage ice to spread, given the present positions of the continents. Cool summers in the northern hemisphere might allow the snow that falls in winter on the land surrounding the polar sea to persist through the summers. Once some snow and ice fields become established in this way, we can imagine that, by reflecting away a good part of the weak summer Sun, they will encourage the rapid spread of glaciations through a feedback process.

On the other hand, the conditions we need to produce a spread of ice in the southern hemisphere are just the opposite. What is important there is to have very severe cold winters, in order to freeze more ice from the sea – snowfall alone would be of no use, since the southern hemisphere has little land for the snow to fall on. What we need for global ice age conditions, then, are cool northern summers plus cold southern winters, and, of course, the two go hand in hand. Since northern summers occur at the same time as southern winters, the astronomical effects that are needed to produce ice ages in both hemispheres also go hand in hand, as long as we have an arrangement of continents roughly like that of the present day.

Day after tomorrow

How long would humanity last before the next ice age engulfs and freezes it? Would the advance of next ice age be rapid or stretch over several thousand years? The ice cores reveal that not all ice ages are created equal. From the Vostok core, scientists deduced that those that occurred in the last 400,000 years were very intense, lasting around 80,000 to 100,000 years each.

Figure 4: Antarctica and Dome C

Therefore the interglacial – 'warm'— periods between two ice ages were short, lasting only for about 10,000 years. New data, from Dome C, suggest that prior to 400,000 years ice ages were shorter and the longer-lasting interglacial periods had lower temperatures, a finding that agrees with lower-resolution marine sediment cores. As they have not yet reached the bottom of the ice sheet at Dome C, the researchers hope that they will be able to extend the climate record even further back in time through continued drilling at the same site. With data on longer period one would be able to deduce better understanding of the dynamics of the Earth's global climate.

Back Care Basics

Nine steps to relief

❑ Dr. Yatish Agarwal
e-mail: dryatish@yahoo.com

Back pain can strike a person at any time. The good news is, most of acute backache attacks resolve without much fuss. However, it's only sensible that each of us should know the first aid measures to soothe the aching back.

The most common cause of a back pain is strained muscles or sprained ligaments. Several things could lead to that: improper lifting, a sudden, strenuous physical effort, an accident, injury or fall, lack of muscle tone, excess weight especially around your middle, your sleeping position especially if you sleep on your stomach, sitting in one position a long time, poor sitting and standing postures, holding the telephone under your shoulder, carrying a heavy briefcase, purse or shoulder bag, sitting with a thick wallet in your back pocket, holding a forward-bending position for a long time, and the daily stress and strain.

The effect may begin to show immediately after you have strained the muscles or it may be several hours before it hits you. The muscles knot up in spasm, and you can feel the pain. That's your body's way of signalling you to slow down and prevent further injury.

If you suffer a sudden attack of acute back pain, you might consider taking the following first-aid measures:

Rest

At the first signs of back pain, just lie down. Being in a horizontal position places the least strain on your spine. If you're at home, slip into your bed, provided it's not too soft or uneven. If you're out, don't worry, the floor should be fine, just ask somebody to make the surface comfortable so that it's firm – not hard – and doesn't dig into your spine and ribs. If possible, let somebody spread a few rugs or blankets evenly on the ground.

If your muscles are in spasm it may take you a while to ease yourself on to the bed or down on to the floor. Try sitting on the edge of the bed and then rolling slowly on to it, or use a support to help you get to the floor.

There is no right or wrong way to lie. You can lie on your back, on your front or on your side whichever is the least painful. Lying in a horizontal position will help relax muscles that are in spasm and you should find the pain slowly ease away.

If you are lying straight on your back, you might like to place a pillow or a rolled-up towel in the small of your back. This should make you more comfortable. If you are lying on your side, a pillow between your knees will support the upper leg and prevent it from folding over forward.

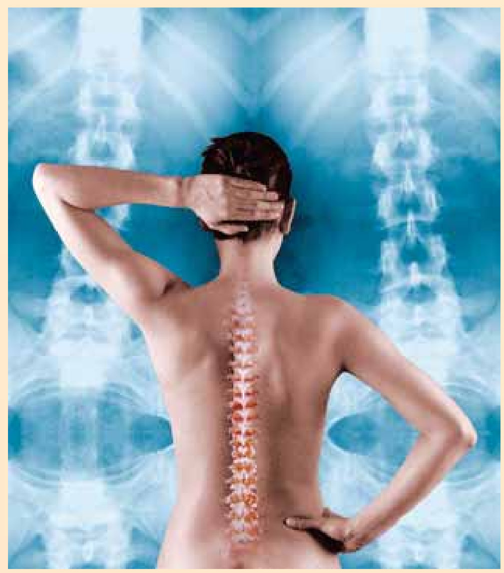
Whether you are on the bed or the floor, do not prop yourself up on pillows. That will put more strain on your back and worsen the pain.

Get plenty of rest, but avoid prolonged bed rest – more than a day, two or three may slow recovery. Moderate movement keeps your muscles strong and flexible. Avoid the activity that caused the sprain or strain. Avoid heavy lifting, pushing or pulling, repetitive bending and twisting.

Swallow a pain-relief tablet

Do not be afraid to take simple pain-relief tablets during an acute episode of back pain. Medicines such as paracetamol, ibuprofen, diclofenac, nimesulide or one of the other over-the-counter preparations can relieve your pain and ease you out of muscle spasm.

What works should simply guide the choice of the medication best for you. Just be careful that you don't add



insult to injury by swallowing a tablet that might worsen an existing illness. A person who has peptic ulcer, asthma or allergy should particularly be vigilant.

Use a cold pack

During the first 24 to 48 hours, applying a cold pack against your back may help relieve the pain. Wrap an ice pack or a bag of frozen peas in a piece of cloth. Hold it on the sore area for 15 minutes four times a day. To avoid frostbite, never place ice directly on your skin.

Heat treatments work wonders

After 48 hours, you may use heat to relax sore or knotted muscles. Use a hot water bottle wrapped in a towel, an electric

heating pad or a heat lamp. Spending a few minutes in a hot shower can also soothe a painful back. But be careful not to burn your skin with extreme heat. If you find that cold provides more relief than heat, you can continue using cold, or try a cold and hot combination.

A gentle massage can work magic

Ask your spouse, friend or a member of the family to give a gentle back rub. That can help to relax your muscles. Just make sure the room is warm, that you are lying on a comfortable surface, and the massage is gentle, not too vigorous. No pressure should be directly applied on your spine.

Try belladonna plaster

Provided the skin is intact, you may apply a strip of the good old porous belladonna plaster over the painful lumbo-sacral (near the small of the back and the back part of the pelvis between the hips) and sacroiliac area. The sacroiliac area lies next to the spine and connects the sacrum (the triangular bone at the bottom of the spine) with the pelvis (iliac crest). Keep it on for the next four or five days. It should diminish the inflammation within the muscle planes and together with its counter-irritant effect should help ease the discomfort and pain.

Just be careful that you don't develop an allergic rash. Some individuals do. Watch for redness at the edges of the tape. If that happens, remove the tape.

Use at-home traction

There is a simple way of applying traction at home to stretch the lower spine and relieve the pressure on the discs. Lie on your back on the floor, and ask a member of the family to lift your legs by the ankles, lean back slightly and gently swing your legs from side to side. This simple technique should help if you have pain in the lower back or down the back of the leg.

Warm up

Gradually begin gentle stretching exercises. Avoid jerking, bouncing or any movements that increase pain or require straining. Healing will occur most quickly if you can continue your usual activities in a gentle manner while avoiding what may have caused the pain in the first place. Avoid long periods of bed rest, which can worsen your pain and make you weaker.

The road ahead

Simple home remedies such as these generally suffice, and you should find that the pain has become much less acute within the next 48 to 72 hours. With proper care, you should notice a steady improvement. However, strenuous use of a strained muscle during the next few weeks may bring back the pain. Most back pain is gone in six weeks. Sprained ligaments or severe muscle strains may take up to 12 weeks to heal.

Once you have back pain, you're more prone to experience repeated bouts of such pain. Your best bet to keep your back pain-free relies on maintaining your flexibility and strength and keeping your abdominal muscles strong.

When to seek medical help

In case, your pain does not settle, or you have any of the following symptoms that suggests possible nerve damage from a prolapsed disc, you would do well to consult a doctor as soon as possible:

- When you start developing a problem with your bladder or bowel, seem to be losing control over them, or suffer any numbness or loss of feeling in the groin or rectal area.
- When your leg or foot feels weak and you experience difficulty in walking and you relate it to your back.
- When you have pain in your back that also radiates down the leg with numbness or loss of feeling in your leg.
- When you have pain down the leg and you experience repeated or prolonged 'pins and needles' in your leg.
- When your pain results from a fall or blow to your back.
- When your pain lasts longer than three or four days.

S. N. Bose National Centre for Basic Sciences, Kolkata

❑ Manas Pratim Das
e-mail :manaspratim_d@yahoo.com

The S. N. Bose National Centre for Basic Sciences was established in Kolkata in 1986. It is the youngest among scientific institutions in Kolkata. But, undoubtedly, it is one of the most promising scientific institutions in the city and the country. The major research areas of this institute are:

- Electronic structure and the physics of materials
- Soft condensed matter and complex systems
- Non-equilibrium statistical mechanics
- Physics of mesoscopic and nanoscopic systems
- Quantum optics and foundations of quantum mechanics
- Astrophysics
- Cosmology
- Chemical physics integrable systems, differential geometry and probability theory

It is worth taking a look at some of the recent research projects of the institute.

The astrophysics group is headed by Professor Sandip Kumar Chakrabarti, whose interest is in black holes – the invisible, voracious, matter guzzlers of the universe about which very little has been discovered. Prof. Chakrabarti and his students have been studying the astrophysical flows around black holes. Although black holes have a reputation for rapacity, not all objects from any distance fall into it. That way the universe would have vanished in moments. Objects that pass by them at a 'safe' distance are deflected in much the same way that they would be by an ordinary star and can proceed on their way. But objects that get too close – closer than what has been termed the black hole's *event horizon* – are doomed. They will be drawn inexorably toward the centre of the black hole and will be subject to an ever increasing and ultimately destructive gravitational strain. They form an accretion disk, which is a subject of intense study for black hole physicists. Prof. Chakrabarti's team has studied the solutions of advective accretion flows including viscous heating and radioactive cooling processes, general relativistic flows, and time-dependent solutions with oscillation. Some work on astrobiology has also been carried out, mainly to produce complex molecules using grain chemistry. The astrophysics group also participates in astrophysics related activities in the nearby Centre for Space Physics including Telescope Making Workshops and seminars and workshops on the progress in astrobiology. The head and members of the group have a good number of international publications to their credit.

Prof. Jaydeb Chakrabarti's area of research is soft condensed matter and complex systems. He has concerned himself with what can be called 'Biology inspired Physics'. In fact, the search for active part of a genome by signalling protein is the key to gene

S. N. Bose National Centre in full blossom

expression and its control. The kinetics of the search mechanism is still a big mystery to molecular biologists, despite the fact that a lot of progress has been achieved in understanding the equilibrium binding energy. Prof. Chakrabarti and his team are trying to shed light on these mechanisms in the context of a highly simplified model. Faculty from Bose Institute, Kolkata has participated in this project.

Some of the research projects in the institute are focussed on nanoparticles. For example, Surajit Sengupta, Reader, has been trying to model the dynamical response of nickel ferrite magnetic nanoparticles in silica-gel matrix. He is assisted by other scientists in this project. Pratip Kumar Mukhopadhyay, Reader, is also concentrating on preparation of soft nanoferrites in an externally funded project.

Post-B.Sc. Integrated PhD

The Post-B.Sc. Integrated PhD is a unique educational program of the Centre. A number of research institutions in Kolkata, together with faculty members from various universities and colleges in this region have come together to participate in this joint venture. The program started in August 2001. In this course, the students have the opportunity of working with one or several faculty members of the group of institutions involved in the program. The S. N. Bose National Centre for Basic Sciences is the nodal agency for this program. The degree is awarded by the West Bengal University of Technology.

C. K. Majumder Memorial Lecture

The S. N. Bose National Centre for Basic Sciences has already set up a tradition of rich scientific lectures under the C. K. Majumder Memorial Lecture scheme. Renowned scientists from different corners of the country and abroad have figured in the list of speakers for this annual lecture. The list includes C. N. R. Rao, R. A. Mashelkar, Jayant V. Narlikar, Martin Blume, H. E. Stanley, Kazuo Fujikawa, and other equally renowned scientists.

Though a very young institute compared to other national scientific institutions, the S. N. Bose National Centre for Basic Sciences is being increasingly recognized as one of the leading institutions of the country in the area of research, training, manpower development, and networking of activities. It has become a unique place where teaching and research have been synchronized into a holistic program with all-round benefits accruing to the academic community.

Interview with the Director, Dr. Avijit Mookerjee

Dr. Avijit Mokerjee

1. *With what purpose was this Centre set up?*

Ans: S.N. Bose National Centre for Basic Sciences was set up to do research in basic sciences namely physics, chemistry and mathematics and also in biological sciences, which is again considered to be a branch of basic sciences. But it would be wrong to assume that research in basic sciences means theoretical research only. We, in our institute, have set up experimental facilities that have enabled us to do crucial research in the application of basic sciences.

2. *Your institute maintains very good contact with the local universities in academic matters. What is the underlying reason?*

Ans: In fact, we do not believe that there should be any barrier between universities on the one hand and research institutions like ours on the other, as far as academic exchange is concerned. Thus we have built up a network with the University of Calcutta, Jadavpur University, etc., through which we have been benefited over the years. We go to teach at these universities and the faculties from these universities also come to our institute to share their experiences with the students.

3. *What was the purpose behind starting the integrated PhD course in your institute?*

Ans: We need young scientists to do cutting-edge research with us. Proper training is necessary for grooming the students so that they can fill the slots. The integrated PhD program was started with the aim of imparting training to the students, which they do not receive in the regular M.Sc. courses at the universities. The syllabus of this integrated PhD course at our institute keeps evolving in order to keep the students abreast with the latest developments in the world of scientific research.

4. *How do you rate the performance of your institute against that of other renowned institutes in the country and the world?*

Ans: Our research publications in reputed international journals speak for our performance. In the final analysis, that is the only criteria by which you judge the level of any institute.

Contd. from page 35

Myths and Media

campaign to enhance scientific content on television with emphasis on scientific method through various Doordarshan channels. We have been receiving overwhelming response to our efforts from all corners of the country. It is nearly twenty five years since we began concerted efforts in our country to communicate science and inculcate scientific attitude among the people. Indeed, our efforts have just begun to show signs of success. Still I often I feel we are like Abhimanyu fighting a valiant but losing battle against the mighty Kaurava Generals – the umpteen television channels that continue to spread myths and superstitions!

Television is undoubtedly the most powerful medium of all – in fact a double-edged sword – that can, if used judiciously, transform the people into rationally thinking individuals, or throw them into an infinite abyss of superstitions and unscientific beliefs. There is no gainsaying the fact that the media need to refrain from feeding the public with the opium of superstitions and unscientific beliefs. Instead they should question such beliefs and offer scientific explanations. Then science would not get eclipsed, nor would the myths prevail. The media would then become a veritable tool to transform our country into a nation of scientifically thinking people.

❒ **V. B. Kamble**

Beyond Electronics : Anyonics

❑ Dr. S. P. Gupta
e-mail : spkuk@rediffmail.com

Introduction

Quantum mechanics traditionally divide elementary particles into two types: fermions and bosons. Fermions such as electrons have antisymmetric wave functions, which means that a minus sign (i.e. a phase of π) is introduced into a system when two fermions in that system are interchanged. Bosons such as photons, on the other hand, have symmetric wave functions that do not change when two bosons are exchanged. Fermions and bosons also have different intrinsic angular momentum or spin: fermions have half-integer spins in quantum units, while bosons have integer spins.

But in 1977 a small band of theoretical physicists spearheaded by Jon Leinaas and Jan Myrheim at Oslo University, Norway realized that for particles living in two, rather than three, dimensions there are other mathematical possibilities. Among these are particles that introduce any phase when they are interchanged, not just 0 or π.

In the early 1980s Frank Wilczek named the hypothetical new particles “Anyons”, the idea being that ***any***thing goes – but he did not lose much sleep anticipating their discovery. Very soon afterwards, however, Bert Halperin at Harvard University found the concept of anyons useful in understanding certain aspects of the fractional quantum Hall effect, which describes the modifications that take place in electronics at low temperatures in strong magnetic fields. In 1985 Dan Arovas, Bob Schrieffer and Frank Wilczek, all of them then at the Kavli Institute for Theoretical Physics in USA, proved that a successful theory of the fractional quantum Hall effect does indeed require particles that are neither bosons nor fermions. These developments spawned a vast literature, featuring beautiful and elaborate mathematics.

Until very recently, however, the subject of anyons had been almost entirely theoretical. Suddenly, over the last few months, the scenario has changed with the appearance of serious – though not entirely uncontroversial – claims that anyons have been observed directly. Meanwhile, several groups have proposed a new generation of experiments that could be more decisive in proving that anyons exist.

Fractional Quantum Hall Fluids

Strange things happen in semiconductors that are very pure, very cold and subject to strong magnetic fields. In particular, a phase of matter called a ‘fractional quantum Hall effect fluid’ appears. In this state, electrons no longer carry discreet units of charge *e*, but fractions of that unit. If it could be proved that these fractional electronic charges are anyons it could lead to a new kind of semiconductor technology that goes beyond electronics. An “anionic” circuit would operate in ways that are impossible for conventional electronic circuits, and it is precisely this behaviour that physicists are ultimately hoping to exploit. Indeed, conceptual designs for anyonic quantum computers are already on the drawing board, such as those of Parsa Bonderson and others at California Institute of Technology in USA.

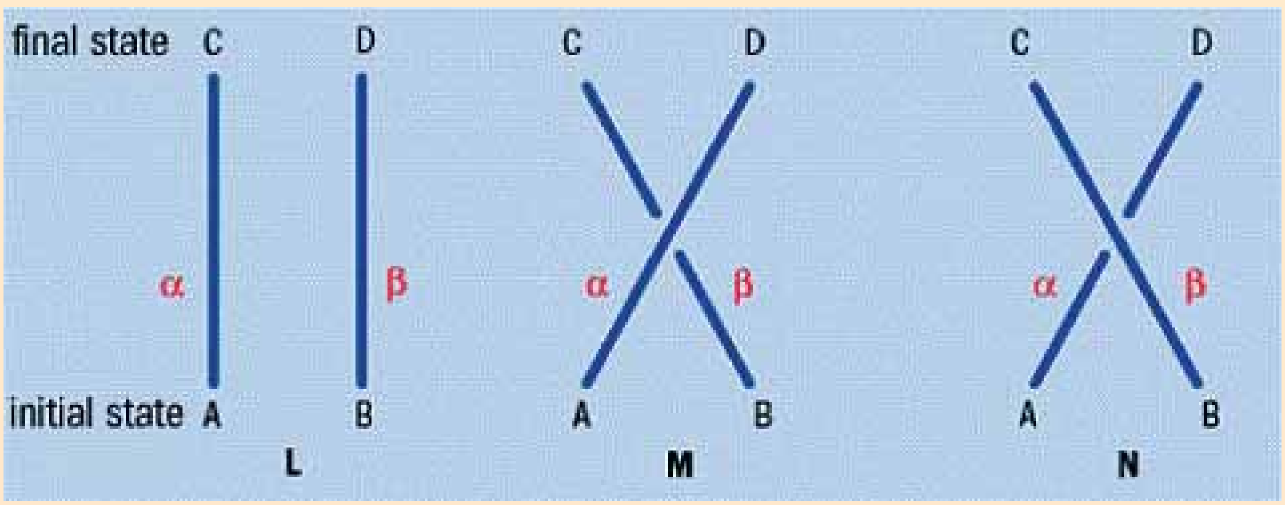


Figure 1

To understand how these applications arise, we first need to introduce the idea of quantum statistics. In everyday life, we think of sameness as a limiting case of similarity: there are subtle distinctions between “identical” twins, for example. In quantum mechanics, however, objects can be truly identical. This profound identity is the basis of quantum statistics, and the reason behind the distinction between fermions and bosons.

Suppose that we want to calculate the probability that two identical particles α and β, which are originally at points A and B, will arrive at points C and D a certain time later. According to the rules of quantum mechanics, we can get this probability by adding the so-called amplitudes of every possible route that the particles can take to get from the initial to the final state, and then take the square of that sum.

If α and β are truly identical, then each of these possible routes leads to the same final state. For example, one route will leave α at position D and β at C, while another will leave β at C and α at D. Although the final state is the same, there is a clear distinction between the two ways of getting there: one is a direct process and the other is an exchange process (Fig 1). We therefore need to supply a rule for how to properly combine the amplitudes of these topologically distinct processes. The simplest rule is to add them, and that rule defines bosons; the next simplest rule is to subtract them, and that defines fermions.

For many years, physicists thought that these two rules were the only consistent ones. In the case of particles moving in three (or more) dimensions, that is certainly the case. For particles confined to two dimensions, however, things are different. The reason is that there is no way to continuously deform the ‘Over’ process in which the path of particle α loops over particle β (path M in Fig 1) - to the ‘Under’ process denoted by N without the paths of the two particles crossing one another.

Similarly, in two dimensions it is no longer true that doubling the process M renders it trivial. Even though α and β will not have been interchanged, the doubled loop is even more entangled. This change opens up possibilities beyond the simple minus sign we had for fermions, and these possibilities essentially define anyons.

Reality of Anyons

Talking of particles confined to two dimensions might seem more than a little academic, but 2-D systems such as thin layers of semiconductors on insulating substrates are ubiquitous in microelectronics. The key insight is that quantum mechanics can suppress degrees of freedom. For instance, because atomic energy levels are discrete, the highest levels will not be accessible if a system is studied at sufficiently low energies and temperatures. As a result, certain kinds of motion cannot occur. If a semiconductor happens to be layered in such a way that the motion of electrons in the third dimension is quantised, then it can be rigorously considered as 2-D. Even to those of us who had been musing about the hypothetical possibility of anyons, their emergence as concrete physical realities in the theory of the quantum Hall effect in the mid-1980s came as something of a shock.

Although observable consequences of anyon behaviour are simple to sketch out, they are difficult to achieve experimentally. The latest experimental developments in the study of anyons are all based on the same theme: a circuit consisting of a drop of fractional quantum Hall fluid with an island in the middle. An electric current can flow from one side of the drop to the other via two different paths, but if there are anyons on the island they will affect the way we add the contributions of these paths together. By studying the net current in the circuit, such a device can therefore show the presence of different numbers of anyons on the island. Last year, Fernando Camino at Stony Brook University in USA were able to control the overall size of such an island using an applied voltage, which enabled them to create a quasi-particle interferometer. With it, the researchers detected the fringes that arise when particles with different fractional statistics interfere with one another, although the team did not attempt to introduce or resolve individual anyons.

That vital next step will be addressed by a new generation of experiments, such as those proposed by Sankar Sarma *et al.* at the University of Maryland, Eun-Ah Kim *el al.* at the University of Illinois and Nick Bonesteel *et al.* at Florida State University. The circuits in these experiments will contain several islands, allowing more intricate situations in which paths go over one island and under another. We can then imagine connecting islands together and moving anyons around, thus opening up the vast potential of anyonics.

References:

1. Parsa Bonderson *et al.* arxiv.org/abs/cond-mat/0508616
2. F. E. Camino *et al. Phys. Rev. B* **72** (2005) 075342
3. Sankar Das Sarma *et al. Phys. Rev. Lett.* **94** (2005) 166802
4. Eun-Ah Kim *et al. Phys. Rev. Lett.* **95** (2005) 176402
5. N. E. Bonesteel *et al. Phys. Rev. Lett.* **95** (2005) 140503

Dr S P Gupta, Physics Department, Kurukshetra University

Recent Developments in Science and Technology

Climate Model Predicts Greater Melting of Ice

Over the past 30 years, temperatures in the Arctic have been creeping up, rising half a degree Celsius with attendant increases in glacial melting and decreases in sea ice. Experts predict that at current levels of greenhouse gases – carbon dioxide alone is at 375 parts per million – the Earth may get warmer by as much as five degrees Celsius, matching conditions roughly 130,000 years ago. Now a refined climate model is predicting, among other things, sea level rises of as much as 6 metres, according to research results published in the journal *Science.*

Modeler Bette Otto-Bliesner of the National Center for Atmospheric Research in Boulder, Colorado, and paleoclimatologist Jonathan Overpeck of the University of Arizona matched results from the Community Climate System Model and climate records preserved in ice cores, exposed coral reefs, fossilized pollen and the chemical makeup of shells to determine the accuracy of the computer simulation. Roughly 130,000 years ago, the Arctic enjoyed higher levels of solar radiation, leading to increased warming in the summer and the retreat of glaciers worldwide.

But sea levels rose, by as much as 3 metres 130,000 years ago and scientists speculate that may have been the result of additional melting in Antarctica. After all, the ice there is not all landlocked; some rests in the ocean and a little warming in sea temperatures could melt it or pry it loose. And this time around, the warming is global, rather than concentrated in the Arctic. Scientists says "In the Antarctic, all you have to do is break up the ice sheet and float it away and that would raise sea level; it's just like throwing a bunch of ice cubes into a full glass of water and watching the water spill over the top."

Source: wwwsciam.com

Invention: Laser spark plugs

The spark plugs inside an internal combustion engine erode and need to be replaced regularly because high voltages are required to ignite the engine fuel. Scientists at Colorado State University in the US hopes to create longer-lasting plugs by replacing electrical ignition with pulsed laser light, fed into the cylinders by glass fibers.

But problem is that a lot of energy is needed to ionise gas and create a spark that disintegrates conventional optical fibres. So the university is patenting a new fibre that promises to be strong enough to feed laser power to spark plugs.

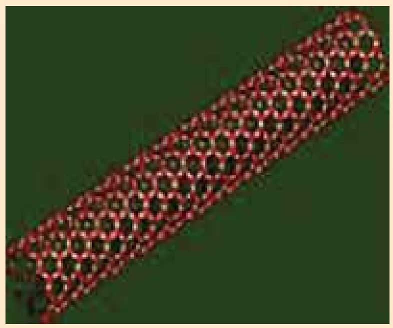
The fiber is hollow, 700 micrometres in diameter and filled with helium. The internal surface of the tube is coated with a 0.2-micrometre layer of reflective silver. The silver coating should stop light from escaping and the inert helium should prevent the creation of any sparks inside the fiber.

Infrared light from a neodymium-YAG laser is fired into the tube, which carries it round bends and into the engine cylinders where a lens focuses all the energy onto a fine spot. This triggers the electrical breakdown of gas inside the cylinder and generates a plasma spark that ignites the fuel.

Source: www.newscientist.com

Nanotube circuit could boost chip speeds

A single-molecule logic circuit has shown that using carbon nanotubes instead of silicon pathways could someday soup up integrated circuits to near terahertz processing, up from today's low gigahertz range.



Researchers at IBM's Thomas J. Watson Research Center used techniques similar to conventional chip-making technology to create field effect transistors along a carbon nanotube – one very large carbon molecule – that had been deposited onto a silicon wafer. Unlike conventional silicon circuits, the resulting logic circuit yielded virtually no electron flow impedance, meaning current flowed faster.

Idea of using nanotube isn't about making the circuits smaller but it's about making them faster because nanotubes have a characteristic of advance high-end processing.

Doping tracts of a silicon substrate with metals of different electronic properties make the components of today's computer chips. While this technique was the breakthrough technology behind the integrated circuit, it becomes increasingly problematic in the race for smaller and smaller components.

Source: www.newscientist.com

Compiled by : Kapil Tripathi

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We cannot prevent Earthquakes, however, we can significantly mitigate their effects by identifying their hazards, build safer structures and communicate information on Earthquake safety among people. Identifying this as a necessity, Vigyan Prasar has brought out an activity kit on Earthquake, with the central message of "Earthquakes; we cannot avoid them. Let preparedness protect us". Quite a few activities like Cutout of Interior of the Earth and Seismological observatory; How to locate an epicenter, Flip books on various types of fault, simple demonstration of seismic waves with a slinky, three dimensional model of Earthquake faults, global mosaic of tectonic plates and on activity to understand the principle of seisomograph, colour activity sheet for seismic zones of India; Do's and Don'ts during and after an Earthquake; mini book on Earthquake related terms and activities to understand resistant structures, are the highlights at the kit.

Besides being an activity package, the kit is also useful for training programmes on Earthquake awareness. A comprehensive book entitled "Earthquake" also accompanies the kit. The Kit is available both in English and Hindi. The cost of this kit is Rs. 100/- plus Rs. 50/- postal charges. For more details write to the: **Director, Vigyan Prasar, A-50, Institutional Area, Sector-62, Noida-201 307 (U.P.)**

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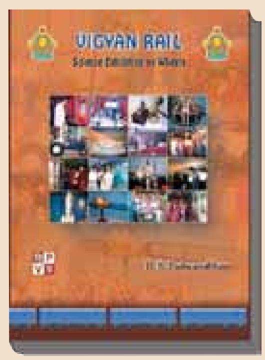

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