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Monthly Newsletter of Vigyan Prasar

# DREAM 2047

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# VP News

## Release of Films on Professor A K Raychaudhuri and Professor P C Vaidya

As part of the activities of the World Year of Physics 2005, Vigyan Prasar and Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, have jointly produced two films on the life and work of renowned Indian astrophysicists Professor A K Raychaudhari and Professor P C Vaidya, whose contributions in the field of General Relativity and Gravitation have been fundamental. Both worked under most adverse conditions in pre-independence India, while teaching physics in colleges and universities.

*Professor P.C. Vaidya being felicitated by Professor Jayant Narlikar*

Professor Raychaudhuri's contribution relates to the further understanding of dynamics described by the Einstein's equation, and is recognized as the Raychaudhuri equation. It is that which governs the dynamics of the Universe on the one hand and that of the black holes on the other. The discovery of the Raychaudhuri equation will always stand so long as General Relativity stands. He discovered this equation in the mid-fifties while working all by himself in the Presidency College at Kolkata. It is a single handed work done in complete isolation. It is interesting to note that the famous cosmologist Professor Jayant Narlikar also derived inspiration from the great work of Professor Raychaudhuri while working on the structure of the Universe. The entire shooting of the film was completed in July 2005. However, it was tragic that Professor Raychaudhuri did not survive to see the completed version of the film. He passed away on June 8, 2004.

*Prof. A.K. Raychaudhuri*

The most famous solution of the Einstein's equation is the Schwarzschild solution which describes the gravitational field of a mass point or a black hole which was obtained soon after the equation was written. But, the stars do not remain inactive. They radiate. Professor P. C. Vaidya's work relates to such realistic situations. He is credited with

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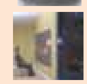

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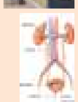

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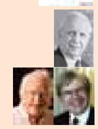

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... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

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Editor : Dr. V.B. Kamble

# Bird Flu: Scare on Wings

There does not seem to be a respite from calamities like tsunami, cyclones, floods, tidal waves, and earthquakes – even terrorism. They have brought with them poignant stories of devastation, of death, suffering and misery. They also brought with them stories of outrage at lack of preparedness to cope with these disasters. We are now faced with yet another threat, this time from the winged members of our biosphere - the birds. Migratory birds from colder reaches have already started descending on the tropical lands during their annual sojourn, including India. It is a pleasing sight to watch a flock of migratory birds flying over the horizon. But, may be they are carrying a virus - the lethal strain H5N1 of influenza - that might soon kill millions of people!

How is it that the flu (also called influenza) virus found in the birds could prove to be so dangerous to human beings? Flu pandemics spread when one of the many influenza strains that circulate in wild and domestic birds evolves into a form that infects humans as well. This virus then adapts further and can even exchange genes with a flu strain native to humans. This chain of events produces a novel germ that is highly contagious among human beings. Flu pandemics emerge unpredictably 3-4 times a century - that is almost every generation! The last three pandemics struck in 1918, 1957 and 1968.

Indeed, the influenza pandemic in 1918 (caused by the strain H1N1) killed nearly 40 million people worldwide! The pandemic in 1957 (strain H2N1) killed 1-4 million worldwide, while the one in 1968 (strain H3N2) killed I million. What makes influenza so dangerous? After an incubation period of just about two days, influenza virus affects primarily the upper respiratory tract and airways with body temperature rising to about 104 $^{0}$ F for 4-5 days. Influenza lowers the body's resistance to infections. Hence the patient may become vulnerable to infections by other organisms that could cause secondary infections of lungs, say pneumonia. Indeed, secondary pneumonia is the major cause of death related to influenza.

True, there is a genuine fear over the bird-flu spreading in Asia and Europe. However, at present the disease tends to make birds sick and rarely humans. The particular strain of bird flu – called H5N1 – currently circulating apparently originated in South Korea in 2003. So far, there have been just 64 confirmed human deaths from bird-flu. But, if the virus were to turn into something that humans could easily transmit to one another, it could cause widespread death and economic loss of billions of Rupees. It is, therefore, important to bring the H5N1 strain of bird-flu under control.

It is estimated that wild life is a reservoir that harbours nearly half of the pathogens that could jump from birds or animals to humans. Situation in which wild and domestic animals, birds and human beings mingle in unhygienic conditions could provide an ideal passage for a virus to jump from one species to another. A densely packed, mixed animal market could aggravate the situation. There is no reason why bird-flu virus cannot jump to humans under such conditions causing a pandemic.

What is causing the emergence and re-emergence of different viruses? A major reason is the change that is taking place when humans travel, or the change that takes place in land use, environment or agriculture. The world is changing very fast in ways that matter to pathogens and ways that give them new opportunities to infect new host species or get to new areas. Remember SARS (severe acute respiratory syndrome), a viral respiratory illness that apparently "jumped" from animals to humans and claimed 800 lives in 2003 in about two-dozen countries? Its fast spread was attributed to the widespread international travel. Factors like urbanization, over-crowding of humans in poor tropical countries like India and other developing countries, and movement and trade of birds and animals also are equally responsible for emergence and re-emergence of these viruses.

The bird-flu virus H5N1 is only one of the1400 pathogens that have been discovered till date affecting humans. Some 13% of these are regarded as emerging that are responsible for SARS or HIV, or re-emerging that are responsible for tuberculosis or malaria. However, what is worrying is the fact that the number of new pathogens emerging seems to be growing. The current research shows that human pathogens have emerged or re-emerged 409 times in the past 50 years. What is important is the fact that a large number of diseases come from animals and birds.

How could we reduce a possible threat of bird-flu pandemic, then? Closer monitoring of poultry stocks and steps to eradicate any avian influenza outbreak could prove to be quite cost-effective. Till date, millions of birds have caught the disease and 150 million poultry have been culled. Despite this action, the virus is now endemic in Indonesia, Vietnam, Cambodia, China, Thailand, and

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# Hendrik Antoon Lorentz

## The Most Revered Scientist of His Time

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

"Everybody felt his (Lorentz's) superiority, but nobody felt oppressed by it. Though he had no illusions about people and human affairs, he was full of kindness toward everybody and everything. Never did he give the impression of domineering, always of serving and helping. He was extremely conscientious, without allowing anything to assume undue importance; a subtle humour guarded him, which was reflected in his eyes and in his smile."

**Albert Einstein**

"…Lorentz was regarded by all theoretical physicists as the world's leading spirit, who completed what was left unfinished by his predecessors and prepared the ground for the fruitful reception of the new ideas… Lorentz was a man of immense personal charm. The very picture of unselfishness, full of genuine interest in whoever had the privilege of crossing his path, he endeared himself both to the leaders of his age and to the ordinary citizen."

**The Nobel Foundation**

"He (Lorentz) shaped his life like an exquisite work of art down to the smallest detail. His never-failing kindness and generosity and his sense of justice, coupled with a sure and intuitive understanding of people and human affairs, made him a leader in any sphere he entered. Everyone followed him gladly, for they felt that he never set out to dominate but only to serve. His work and his example will live on as an inspiration and a blessing to many generations."

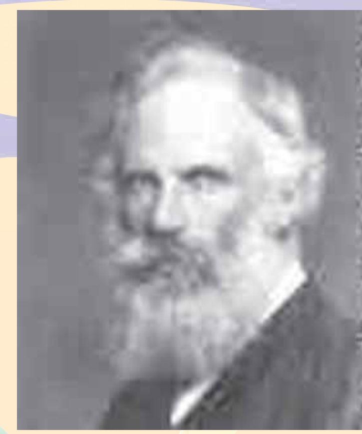
**Albert Einstein**

Hendrik Antoon Lorentz was one of the greatest scientists of his time. His work covered many fields of physics. However, his most outstanding contributions were to the theory of electromagnetism. Based on the Maxwellian framework, Lorentz proposed a universal theory of physics based purely on the concepts of electromagnetism. His fundamental postulates, which were independent of mechanical principles, were presented in "Inquiry into a Theory of Electrical and Optical Phenomena in Moving Bodies" published in 1895 in Dutch. Lorentz described the electromagnetic field in five equations for the first time in compact vector notation. The first four equations embodied the content of Maxwell's theory, while the fifth equation described, what was called Lorentz force, connected continuous field with electricity. His discoveries prepared the ground for many of the developments in modern physics. Lorentz was one of the first to predict the existence of electrons. He explained the Zeeman effect, a change in spectral lines in a magnetic field. Lorentz further advanced the hypothesis of George Francis FitzGerald (1851-1901) that the length of a body contracts in the direction of its motion when it is moving. This phenomenon is now called Lorentz contraction. Lorentz is also well-known for Lorentz transformations which he introduced in 1904. Lorentz transformations are a set of mathematical equations that correlate space and time coordinates of one moving system to known space and time of another system. Lorentz transformations explained the experiment of Michelson and Morley and described the shortening of length the increase in mass and dilation of time of a moving body moving at a speed close to the velocity of light. This work influenced, and was confirmed by Einstein's special theory of relativity. Lorentz did a great deal to found theoretical physics as an academic discipline in Europe. Lorentz was much influenced by Augustin Jean Fresnel's (1788-1827) work. He admitted that it was through Fresnel's work that he acquired clarity in thought and insight.

*Hendrik Antoon Lorentz*

After the First World War, Lorentz strived hard towards reorganisation of international co-operations especially among scientists. He largely succeeded in his endeavours because of the undisputed prestige and respect that he enjoyed among scientists all over the world. Towards the end of his life he served as Chairman of the League of Nations' Committee of Intellectual Co-operation. Lorentz was the President of the first Solvay Conference for Physics held in Brussels and he continued to be president of Solvay Conferences until his death.

Owen Williams Richardson (1879-1959) described Lorentz as "[A] man of remarkable intellectual powers…Although steeped in his own investigation of the moment, he always seemed to have in his immediate grasp its ramifications into every corner of the universe…The singular clearness of his writings provides a striking reflection of his wonderful powers in this respect…He possessed and successfully employed the mental vivacity which is necessary to follow the interplay of discussion, the insight which is required to extract these statements which illuminate the real difficulties and the wisdom to lead discussion among fruitful channels, and he did this so skilfully that the process was hardly perceptible."


George Francis FitzGerald

Lorentz was born on July 18, 1853 at Arnhem, the Netherlands. His parents were Gerrit Frederik Lorentz and Geeruide. Till the age of 13 he attended the Mr. Timmer's Primary School in Arnhem. He then entered the first High School to be opened at Arnhem in 1866. In 1870, Lorentz entered the University of Leiden. He obtained his BSc degree in mathematics and physics in 1872 and then he returned to his native place Arnhem where he started teaching evening classes. Though he left the university but he continued to work for his doctorate degree.

In 1875, Lorentz obtained his PhD degree from the Leiden University. At the time of his getting PhD, he was just 22 years old. In his research work for his PhD dissertation, Lorentz refined the electromagnetic theory of Clerk Maxwell. Lorentz could provide better explanation for reflection and refraction of light. His doctoral dissertation was titled "The theory of the reflection and refraction of light."

Lorentz remained at his home without taking any permanent profession even after receiving his doctoral degree. This was due to the fact that he was in dilemma over the choice of a career in physics or mathematics. In those days theoretical physics was an isolated academic pursuit. It was yet to emerge as a distinct scientific discipline of its own. In 1878, at the early age of 25, Lorentz was appointed Professor of Mathematical Physics at the Leiden University. The post, the first chair of theoretical physics in Holland, was newly created for him. He remained at the Leiden University till his retirement in 1912. This was in spite of the fact that he received offers of many academic appointments abroad. Lorentz engaged himself in developing a single theory to explain the relationship of electricity, magnetism and light. His main objective in developing such a unified theory was to refine the electromagnetic theory of Clerk Maxwell so that the relationship between electromagnetism and light can be explained. He proposed that the atoms might consist of charged particles (later termed as electrons) and the oscillations of these charged particles were the source of light. A consequence of Lorentz's electron theory was that a magnetic field would affect the electron oscillations, and thereby the frequencies of the light emitted. Lorentz adopted the term 'electron' in 1899 and identified electrons with cathode rays. He showed how vibrations of electron give rise to Maxwell's electromagnetic waves. In 1896, Lorentz jointly with Pieter Zeeman (1865-1943) explained the Zeeman effect whereby atomic spectral lines are split in the presence of magnetic fields. For this work they were jointly awarded the 1902 Nobel Prize in Physics. Lorentz's 'electron theory' proved to be so successful that its failure to explain the photoelectric effect was a major clue to the need for quantum theory.

Lorentz is well-known for his suggested method of resolving the problems raised by the results of the experiments conducted by Albert Abraham Michelson (1852-1931) and Edward Williams Morley (1838-1923) in the 1880s to demonstrate the existence of hypothetical ether. Michelson-Morley experiment gave no indication that the Earth was moving through the hypothetical ether. He showed that if it was assumed that moving bodies contracted very slightly in direction of their motion then the observed results of Michelson-Morley experiment could be accounted for. FitzGerald also derived it independent of Lorentz. This phenomenon is now known as Lorentz-FitzGerald contraction. In 1904, Lorentz developed a firm mathematical description of this, the Lorentz transformation. Einstein later showed that this emerges naturally out of his special theory of relativity.


Augustin Jean Fresnel

Lorentz presided over the first Solvay Conference in Brussels in 1911. The main objective of this conference was to look at the problems of having two different approaches in physics—classical physics and quantum physics. In his Presidential address at the opening ceremony of the conference, Lorentz observed: "In this stage of affairs there appeared to us like a wonderful ray of light the beautiful hypothesis of energy elements which was first expounded by Planck and then extended by Einstein and Nernst and others to many phenomena. It has opened for us unexpected vistas, even those, who consider it with a certain suspicion, must admit its importance and fruitfulness." Lorentz himself never fully accepted the quantum theory. He believed that eventually the new theory would be fitted into the classical approach.

In 1912, Lorentz became the Director of research at the Teyler Institute at Haarlem. However, he remained honorary professor at Leiden and gave weekly lectures there.

Lorentz was elected a Fellow of the Royal Society in 1905. He was also the recipient of the Rumford Medal (1908) and Copley Medal (1918) of the Royal Society. In 1923, he was elected to the membership of the "International Committee of Intellectual Co-operations" of the League of Nations. Lorentz became its President in 1925.

*Pieter Zeeman*

Lorentz died on February 04, 1928. He was the most revered scientist of his time in the Netherlands. The Nobel Laureate Owen W Richardson, while describing Lorentz's funeral, wrote: "The funeral took place at Haarlem at noon on Friday, February 10. At the stroke of twelve the state telegraph and telephone services of Holland were suspended for three minutes as the revered tribute to the greatest man Holland has produced in our time. It was attended by many colleagues and distinguished physicists from foreign countries. The President, Sir Ernest Rutherford, represented the Royal Society and made an appreciative oration by the graveside." This description gives an indication the respect that Lorentz held in the Netherlands.

*Paul Ehrenfest*

Lorentz's contributions to the growth of physics and his greatness as a human being were beautifully summarised by Albert Einstein in his message delivered at Leiden in 1953 on the occasion of commemorating of the one hundredth anniversary of the birth of Lorentz. We quote here from this Einstein's message: "At the turn of the century the theoretical physicists of all nations considered H. A. Lorentz as the leading mind among them, and rightly so. The physicists of our time are mostly not fully aware of the decisive part which H. A. Lorentz played in shaping the fundamental ideas in theoretical physics. The reason for this strange fact is that Lorentz's basic ideas have become so much a part of them that they are hardly able to realise quite how daring these ideas have been and to what extent they have simplified the foundations of physics...Thanks to the generosity of the Leiden University, I frequently spent some time there staying with my dear and unforgettable friend, Paul Ehrenfest. Thus I had often the opportunity to attend Lorentz's lectures which he gave regularly to a small circle of young colleagues after he had already retired from his professorship. Whatever came from this supreme mind was as lucid and beautiful as a good work of art and was presented with such facility and easy as I have never experienced in anybody else. If we younger people had known H. A. Lorentz only as a sublime mind, our admiration and respect for him would have been unique. But what I feel when I think of H. A. Lorentz is far more than that. He meant more to me personally than anybody else I have met in my lifetime."

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## Bird Flu: Scare on Wings

possibly Laos. Surely, improvements in surveillance of the viral strain, veterinary health care and laboratory services could go a long way in reducing this threat.

Unfortunately, our defences today are extremely weak to face up to the possible H5N1 pandemic, should it strike. We probably have had a good vaccine for H5N1 for more than a year. Yet it has not been properly tested till now. Nor is the best drug, Tamiflu, being stocked by governments of various countries as fast as they could, partly because the patent holder, Swiss-based Roche, till recently refused to let anyone else make it. This despite the fact that Roche could not have fulfilled the orders even of rich countries till 2007! The Indian company Cipla says that it will begin marketing the generic version of the drug by December 2005 and make a million 10-capsule courses of treatment per month by July 2006.

Unlike in the past, probably it is for the first time that we can "see" a flu pandemic on the horizon. Indeed we are much better placed today compared to the earlier pandemics - we have several tools to minimize its impact if it does arrive. Even if the dreaded H5N1 virus does not evolve into a form that can spread easily among the people, some other flu virus certainly will. The stronger our defences, the better we shall be able to face up to the challenge. We cannot afford to be complacent any more.

❐ **V. B. Kamble**

# The Strange World of Quantum Physics

❑ P. K. Mukherjee

Relativity theory and quantum mechanics may be regarded as the twin pillars of the modern twentieth century physics. While the relativity theory governs the properties of matter travelling at extremely high speeds, quantum theory regulates the behaviour of the microscopic system, namely, the small bits of matter called sub-atomic particles.

Quantum mechanics is unique because of its profoundly radical quality. It forced physicists to reshape their ideas of reality, to rethink the nature of things at the deepest level and to revise their concepts of position and speed, as well as their notion of cause and effect. Quantum theory is perhaps the most precisely tested and most successful theory in the history of science. Yet, the conceptual foundation of this theory is mysterious. Not only was quantum mechanics deeply disturbing to its founders, even to date no consensus has been reached on some aspects of the theory. While acknowledging its stunning power some of the luminaries of science are still dissatisfied with its foundations and its interpretation. In a letter addressed to Max Born in December 1926 Einstein wrote : "Quantum mechanics is very impressive. But an inner voice tells me that it is not yet the real thing. The theory produces a good deal but hardly brings us closer to the secret of the Old one. I am at all events convinced that He (God) does not play dice."

*IS QUANTUM MECHANICS a façade? Einstein believed that behind the bizarre results apparent to us, the universe ultimately worked according to the intuitive principles of classical physics.*

In fact, Einstein never accepted quantum theory. He made several ingenious attempts to demonstrate that quantum mechanics is inconsistent and presented it informally at the famous Solvay conferences. Bohr was the principal defender of what was by then the standard or Copenhagen interpretation. In fact, the debate between Bohr and Einstein regarding inconsistencies in and/or incompleteness of quantum mechanics continued until Einstein's death in 1955.

## Quantum : the beginning

The clue that triggered the quantum revolution came not from studies of matter but from a problem in radiation. The specific challenge was to understand the spectrum of light emitted by hot bodies, dubbed by the physicists as 'blackbody radiation' (a black body is an ideal body that absorbs all radiations incident upon it regardless of frequency and also emits all radiations. The spectrum of absorbed or emitted radiation, however, depends on its temperature). The phenomenon is familiar to anyone who has stared at a fire. Hot matter glows and the hotter it becomes the brighter it glows. The spectrum of the light is broad, with a peak that shifts from red to yellow and finally to blue, that is, towards the shorter wavelength side, as the temperature is raised.

Attempts were made to explain the shape of the experimental curves, that is, the blackbody spectrum by combining concepts from thermodynamics to electromagnetic theory. While many scientists failed, Wien, and Rayleig and Jeans independently, met with only partial success. Wien's energy distribution formula, called Wien's displacement law, was found to agree with the experimental curves for black body radiation for short wavelengths and not for long wavelengths. Rayleigh–Jeans distribution formula, on the other hand, could give a good fit to the experimental curves in the region of long wavelength but not of short wavelength. This formula showed that as the frequency increased (or wavelength decreased) the energy density increased and became infinite in the limit of infinitely high frequency. In reality, of course, the energy density falls to zero in the limit of the frequency approaching infinity ($\nu \rightarrow \infty$). This discrepancy came to be known as Ultraviolet/ Catastrophe.

Where did Wien and Rayleigh-Jeans, after all, go wrong? It occurred to the German physicist Max Planck that the fundamental assumptions of the classical theory on which Wien's and Rayleigh-Jeans' laws were based might be at fault. Planck assumed that a blackbody radiation chamber (or cavity) was filled up not only with radiation (which existed in the form of standing electromagnetic waves) but also with simple harmonic oscillators of molecular dimensions (called Planck's oscillators) which could vibrate with all possible frequencies. However, an oscillator of frequency could not have a continuous distribution of possible energies but must have only some discrete or specific values which are an integral multiple of

$h\nu$ where h is a universal constant called "quantum of action" (which later became known as Planck's constant) having value $6.626 \times 10^{-34}$ Joule-second. This is called Planck's quantum hypothesis according to which the emission and absorption of energy by matter can take place only in certain discrete chunks or "quanta". Each discrete bundle or chunk of energy ($h\nu$) is called a quantum (plural quanta) from the Latin for "how much".

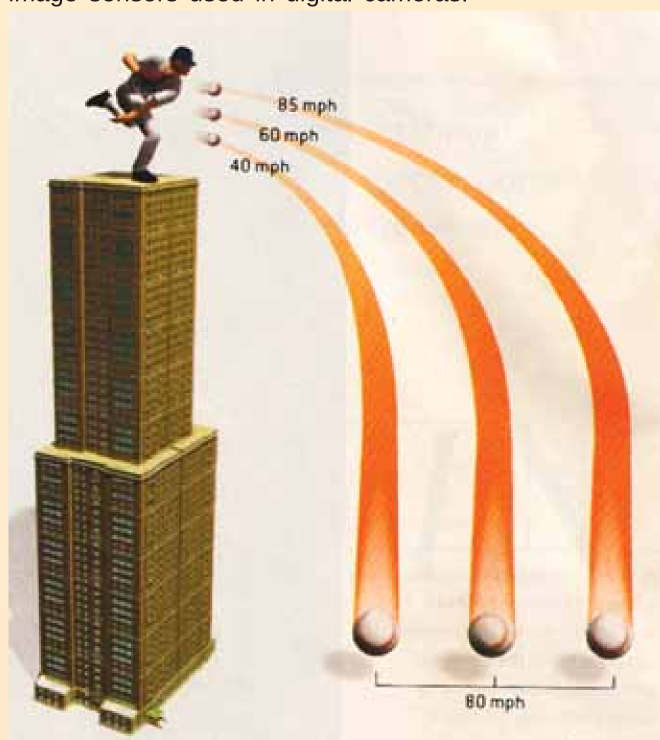
Planck was to make one more hypothesis to account for the true nature of the bell-shaped experimental curves. He had to assume that his 'energy quanta' were distributed over the discrete energy states in a peculiar non-classical way, that is, unlike how ordinary balls would be randomly distributed among a certain number of boxes.

Indeed, Max Planck started the quantum mechanical snowball. His two hypotheses, with no other supporting evidence at that time, were to truly revolutionize our understanding of the atomic world. For his work, which is now considered to mark the start of modern physics, Planck was awarded Nobel Prize in Physics in 1918.

Although, Planck's quantum hypothesis resolved the radiation problem but he himself was not satisfied with the theory. He regarded his quantum hypothesis as an "act of desperation" and remained sceptical for a long time of the physical reality of quanta. As he later wrote", My vain attempts to somehow reconcile the elementary quantum with classical theory continued for many years and cost me great effort.. Now I know for certain that the quantum of action (energy x time)has a much more fundamental significance than I originally suspected."

In 1905, Albert Einstein took Planck's quantum idea one step further. He assumed that the radiation or light itself is quantized ; and the energy absorbed by radiation arrived in discrete packets or bundles, now called photons (the term photon was coined much later by the chemist Gilbert Lewis in 1926). It is significant to note that Einstein's break with classical physics was more drastic than Planck's. Planck had assumed that although energy from an oscillator apparently had to be given to radiation (or standing waves in the cavity) in separate quanta (of energy $h\nu$ each), the radiation or waves themselves behaved exactly as in conventional wave theory. But according to Einstein, energy was not only given to radiation (or waves) in separate quanta but was also carried by the radiation in separate quanta. On the basis of the concept of light-quantum or photon Einstein was able to explain the phenomenon of emission of electrons from metal surfaces due to the light falling on them, called photoelectric effect. He gave his famous photoelectric equation which could explain all the experimental observations. Although the increased intensity of light sent more electrons shooting off the metal, the velocity of the liberated electrons remained the same no matter how dim or bright the light was. The only way to change the velocity of electrons was to use a different wavelength of incident radiation. This could be explained on the basis of Einstein's photoelectric equation. This equation could also explain why below a critical frequency (also called threshold frequency) no photoelectrons were emitted. In fact, there must be a minimum energy for an electron to escape from a particular metal surface or else electrons would pour out all the time. This energy is called the work function of metal; it is h times the critical frequency. The greater the work function of metal, the more energy is needed to leave its surface, and higher the critical frequency for photoelectric emission to occur. For his explanation of photoelectric effect, Einstein won the 1921 Nobel Prize in Physics.

The Photoelectric effect led to the invention of photoelectric cells and photomultipliers; the latter are used to channel light in astronomical detectors and television cameras. This phenomenon is also related to the processes used in present-day solar, or photovoltaic, cells and the image sensors used in digital cameras.

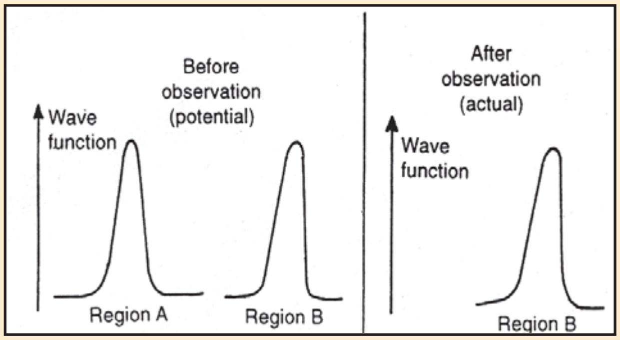



*FRICTION AND INFORMATION LOSS offer one explanation for quantum mechanics in classical terms. Because of air friction, balls falling from a skyscraper all reach the same terminal velocity. To an observer on the ground, any differences in the balls, initial velocities are lost. Similarly, if the universe in affected by some unknown type of friction, quantum mechanics may reflect the fact that outcomes of events collapse to discrete values rather than the full range of possibilities.*

Einstein's explanation of the photoelectric effect lent credence to the fact that besides behaving like waves the (electromagnetic) radiation could also show particle-like behaviour. The Compton effect also provided evidence that electromagnetic radiation could behave like particles. In 1923, A.H. Compton observed that when X-rays were scattered by a graphite block the scattered radiation contained greater wavelength in addition to the original wavelength. Compton was able to explain the phenomenon in terms of light quanta or photons.

## Bohr's ad hoc quantum condition

In 1911, Lord Rutherford proposed an atomic model in which electrons orbit a positively charged nucleus much like a miniature solar system. This 'solar system' model of the atom looked attractive, but it had a fatal flaw.




*The act of observation leads to the 'Collapse' of one of the two (potential) wave function, that is why superposition of states in not observed with layer objects e.g. Schroedinger's cat*

According to the classical electromagnetic theory, the orbiting electrons would continuously radiate away their energy and spiral into the nucleus in about a trillionth of a second. The Rutherford model, therefore, failed to account for the observed stability of atoms.

At about the same time, the scientists working in the field of atomic spectroscopy observed sharp bright lines against a dark background in the emission spectra of hydrogen-like atoms. Balmer, a Swiss physicist, gave a simple empirical formula relating the wavelength of various spectral lines in the visible spectrum of hydrogen. However, he failed to explain the theoretical basis of his formula. In 1913, a Danish physicist Niels Bohr, who had come to the University of Manchester to work with Rutherford, imposed an ad hoc quantum condition on the orbits of electrons. Not all orbits of electrons are allowed, said Bohr. Only those orbits are allowed for which the angular momentum (L) of the electron is an integral multiple of Planck's constant divided by $2\pi$:

$$L=nh \quad = n\ (h/2\pi)$$

Using this quantum condition, Bohr was able to salvage the Rutherford model. This way Bohr swept away the problem of atomic stability and was instrumental in ushering quantum physics into the world of atoms. Bohr could also explain the spectral lines in the emission spectrum of hydrogen. The stable electronic orbits satisfying his quantum condition, according to Bohr, exist with discrete or quantized energy levels. When electrons execute 'quantum jumps' between these allowed orbits of precisely defined energy, light with sharply defined frequencies or wavelengths are emitted or absorbed giving rise to the observed emission and absorption line spectra.

Bohr's theory worked for helium atom as well, but only if the atom was deprived of one of its two electrons. His theory reproduced the empirically observed existence of new spectra such as the one in the ultraviolet region for the hydrogen atom. These predictions were confirmed later.

Bohr's theory was remarkably successful in accounting for phenomena related to single hydrogen-like atoms and radiation, yet there were many unanswered questions. For example, some of the spectral lines were shown to possess fine structures. At first, it was thought that some refinements made in the Bohr's theory would be able to account for such results. However, the relative intensity or brightness of spectral lines remained inexplicable. Also, attempts at extending the hydrogen theory to more complex atoms exposed new difficulties. Soon, it became clear that Bohr's theory was not the whole story and a 'paradigm shift' was called for. A basic change in the worldview was needed, felt the scientists.

## Wave -particle duality

In 1923, Louis de Broglie, in his Ph.D. thesis, proposed that the particle behaviour of light should have a counterpart in the wave behaviour of particles. He assumed a wavelength with the momentum of a particle, the former being inversely proportional to the latter :

$$\lambda \alpha\ 1/p$$
$$\text{or } \lambda = h/p$$

The idea that waves could be associated with moving particles (such waves are called "matter waves") was intriguing. The de Broglie's hypothesis was confirmed by experiments performed by Davisson and Germer and independently by G.P. Thomson.

Broglie's formula has found may applications. Electrons at high speed or hih energy have associated wavelengths much smaller than those of visible light. This is why electron microscopes have much higher resolutions than those attainable in optical microscopes. The de Broglie waves also clarify the ad hoc quantum condition of Bohr's atom. Allowed orbits are only those for which the orbital length equals an integral multiple of electron wavelengths. All other orbits disappear due to destructive interference.

For large objects, such as balls and bullets, the associated de Broglie wavelengths are so small that quantum effects are completely negligible, and the laws of classical mechanics are valid.

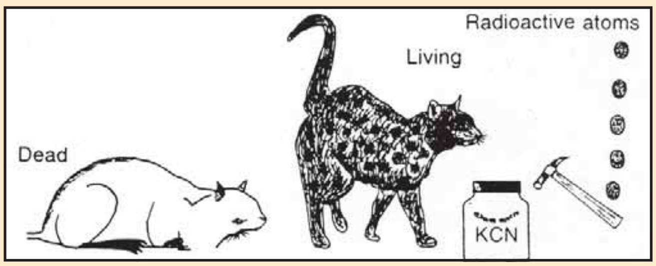
## Bose-Einstein statistics : a quantum concept

In the summer of 1924, S.N. Bose proposed a totally new way to explain the Planck's radiation law. He treated light as if it were a gas of massless particles (now called photon gas). Bose was able to demonstrate that the particles do not obey the classical laws of Boltzmann statistics but behave according to a new type of statistics based on particles' indistinguishable nature. But, Bose work was not accepted for publication. Therefore, he sent his paper to Einstein. Einstein immediately realized the importance of Bose's work. He translated the articles into

German and arranged its publication in a reputed German journal. Applying Bose's reasoning to particles other than photons, Einstein was able to show that they obey the statistics evolved by Bose. With both names attached, this is now called Bose-Einstein statistics.

### Spates of discovery in the quantum field

Suddenly, in the three-year period from January 1925 to January 1928, a tumultuous series of events occurred in the field of quantum theory culminating in a scientific revolution. In 1925, Woflgang Pauli proposed the exclusion principle according to which no two electrons can be in the same quantum state. Pauli's principle also provided a theoretical basis for the Periodic Table. In the same year, Werner Heisenberg with Max Born and Pascual Jordan discovered matrix mechanics. In 1926, Erwin Schrodinger proposed an alternative theory of the quantum world called




*The paradox of Schroedinger's cat. A quantum event, suitably amplified, may trigger poison release. For an external observer, with on observation, the probability has an interference between a living and a dead cat!*

wave mechanics. Influenced by de Broglie's work on wave-particle duality, Schrodinger in his work explored the consequences of matter waves and proposed a wave equation for them. Dubbed as Schrodinger equation this was analogous to the known equations for other wave motions in nature. Although Shrodinger's wave mechanics and Heisenberg's matrix mechanics seemed quite different to begin with, but they subsequently proved to be exactly equivalent, being two alternative ways of describing quantum mechanics.

In 1926, Enrico Fermi and Paul Dirac proposed that electrons obey a new kind of statistics. This was dubbed as Fermi-Dirac statistics. Electrons belong to a class of particles called fermions (building blocks of matter e.g. electrons, protons, neutrons etc. are all fermions) which have half-integral spin. Bosons (photons, helium atoms, alpha-particles, mesons, gravitons etc. are all bosons), on the other hand have integral spin (including zero) and obey Bose-Einstein statistics.

In 1927, Werner Heisenberg enunciated the Uncertainty Principle that it is impossible to exactly measure the position and momentum of a particle at the same time. According to the uncertainty principle, the measurements in the atomic world are inherently indeterministic which is a fundamental aspect of quantum mechanics. This is in stark contrast to the worldview of classical mechanics where the position and momentum of a particle can be simultaneously measured with complete precision.

### Prediction of antimatter and quantum field theory

In 1928, P.A.M. Dirac developed a relativistic wave equation for the electron. This equation was successful in explaining the electron spin and predicted the existence of antimatter. In 1932, Carl David Anderson discovered an antiparticle of electron called positron. Thus, quantum mechanics was instrumental in providing the first evidence for the existence of antimatter in the universe.

Dirac laid the foundation of quantum field theory in 1926 by providing a quantum description of the electromagnetic field. However, there were discrepancies and inconsistencies in his theory. In 1948, Richard Feynman, Julian Schwinger and Sin-Itiro Tomonaga removed the discrepancies in the Dirac's theory and laid the firm foundation for quantum electrodynamics (QED).

Quantum electrodynamics is able to explain the behaviour of leptons (class of particles that describe electrons, muons, tau mesons and their antiparticles) but it cannot describe more complex particles called hadrons, which are composed of either two or three quarks. Hadrons (e.g. protons, neutrons etc.) that consist of three quarks are called baryons while those consisting of two quarks are called mesons. For hadrons a new theory had to be developed. This theory, which is a generalization of QED, is called quantum chromodynamics (QCD).

In QED, the force between charged particles in mediated by the photon while in QCD the force between quarks is mediated by the gluon. In spite of the parallels, there is a crucial difference between QED and QCD. Unlike leptons and photons, quarks and gluons are forever confined within the hadron. They cannot be liberated and studied in isolation.

QED and QCD are the cornerstones for a grand synthesis known as the Standard Model which forms the foundation of elementary particle physics. Today, in the quest to understand the ultimate nature of matter, physicists are looking for theories that allow quantum description of gravity. String theories (there are at least five of them), often collectively called M-theory, are viewed by many physicists as promising approach to marrying quantum mechanics with gravity.

### Quantum Physics : varied applications

Besides predicting antimatter, quantum mechanics was also instrumental in understanding radioactivity and describing interactions such as those between light and matter (leading to the invention of laser) and of radio waves and nuclei (leading to magnetic resonance imaging). Quantum theory permits the quantitative understanding of molecules, of solids and liquids, and of conductors and semiconductors. It explains bizarre phenomena such as superconductivity and super fluidity, and exotic forms of matter such as the stuff of neutron stars and Bose-Einstein condensates, in which all the atoms in a gas behave like a single superatom. Superconducting Quantum Interference Device (SQUID), as the name implies, is a device that demonstrates quantum properties. Capable of measuring very weak magnetic fields, it has wide-ranging applications from medicine (checking abnormalities in tiny magnetic fields produced by the brain and/or the heart) to geology. SQUID furnishes a practical example that even large objects, under certain circumstances, may demonstrate quantum behaviour. Hence, the assumption that large or macroscopic devices must be entirely described by classical physics may not always be valid. Quantum mechanics has also opened up new areas of technology such as electron microscopes, photomultipliers, solar cells, and the microprocessor –based electronic revolution. In short, quantum mechanics allows us to understand and manipulate the material world; it provides essential tools for all the sciences and for every advanced technology.

## Controversies and paradoxes

In spite of its varied applications, quantum mechanics is not free from controversies. Also, interpretation of some aspects of quantum mechanics has given rise to certain paradoxes. In passing, let us mention that of the two approaches of quantum mechanics, namely, matrix mechanics and wave mechanics, it is easier to deal with the formalism of wave mechanics. In this approach one solves the Schrodinger equation which describes the behaviour of a quantum system. The solution to the Schrodinger equation is known as wave function. The complete knowledge of a quantum system is thus described by its wave function; and from the wave function one can calculate the possible values of every observable quantity.

In the beginning, the nature of Schrodinger's waves was unclear. A wave is generally thought of as a disturbance in a medium. In quantum mechanics, however, there is no medium; and in a sense there is no wave, as the wave function is fundamentally a statement of our knowledge of a system. Then, what is the correct interpretation of wave function? Max Born had the insight that the wave function should be interpreted in terms of probabilities. As suggested by Born, the probability of finding an electron in a given volume of space depends on the square of magnitude or the absolute square of its wave function. This indicated that the simple interpretation of wave function as a description of the physical matter waves in ordinary space, as was originally assumed by Schrodinger himself, is incorrect. This interpretation suggested that a fundamental randomness was built into the laws of nature. Einstein was deeply unhappy with this conclusion and expressed his preference for a deterministic universe with his oft-quoted remark, referred to already, that 'God doesn't play dice'.

Schrodinger too was uneasy. Wave functions could describe combinations of different states, so–called superpositions. For example, an electron could be in a superposition of several different locations. Schrodinger pointed out that if microscopic objects such as atoms could be in strange superpostions, so could macroscopic objects because they are made up of atoms. This quantum superposition could lead to paradoxes. The most dramatic of these paradoxes was described in 1935 by Schrodinger in a thought experiment involving a cat.

## Schrondinger's cat paradox

Imaging a perfectly sealed box containing a cat and a device with a deadly poison, say, potassium cyanide, inside. A quantum event, for example, the disintegration of a uranium atom, triggers the device. This releases the cyanide and the cat is killed; otherwise, the car remains alive. The radioactive atom, obviously, is in a superposition of two states-disintegrated and not disintegrated. In this scenario, the quantum process is amplified to affect the state of the cat. The superposition of the two potential states of the radioactive atom is translated to a superposition of two possible states of the cat, dead or alive. In other words, it produces a cat that is both dead and alive in superposition.

Now, if the box and its contents be treated as a quantum system this would evolve in time maintaining linear superposition of the two alternatives. To an observer outside the box, who does not observe the interior, the cat is in a linear combination of being dead and alive. To find the probability of the observable states, we must form the absolute square of this amplitude. Two main terms are the expected states of a dead cat and a living cat. The interference term corresponds to a situation of a combination of a dead and a living cat ! But such interference is never observed; when the box is opened, the cat is found to be either alive or dead. This is the famous Schrodinger cat paradox !

Lying at the heart of the paradox is the superposition or interference term, namely, the combination of a dead and a living cat. While such superpositions have been demonstrated innumerable times with electrons, atoms etc. we never see them in the everyday world around us. This seeming contradiction has been an enduring mystery at the very heart of quantum mechanics. Over the decades, physicists have developed several ideas to resolve the mystery including the Copenghagen and many-worlds interpretation of the wave function, and the theory of decoherence.

According to Copenhagen interpretation, an unobserved system evolves intrinsically in a probabilistic and deterministic manner governed by the Schrodinger equation. However, the act of observation triggers an abrupt change in the wave function of the system; the observer sees the system in one definite (classical) state, and from then onwards only that part of the wave function survives; the other part of the wave function vanishes or collapses and plays no role in the subsequent development of the system.

The "collapse" hypothesis associated with the act of observation is, therefore, able to explain why the superposition of states is not observed with objects in everyday world, for instance, the Schrodinger's cat. The paradox, therefore, gets resolved.

The collapse postulate was not accepted to many including H.Everett of Princeton University who decided to revisit this postulate in his doctoral thesis. He theorized that instead of being collapsed by measurements, microscopic superpositions would rapidly get amplified into byzantine macroscopic superpositions. Considering the case of the cat, it would either be dead or alive. A person would enter a superposition of two different mental states, each perceiving one of the two outcomes-one in which the cat is dead and the other in which it is alive. These two parts of the total wave function carry on completely independently, like two parallel worlds. Everett's viewpoint became popularly known as the many-worlds interpretation of quantum mechanics, because each component of one's superposition perceives its own world.

Everett's many-worlds interpretation had left a basic question unanswered, namely, if the world actually contains bizarre macroscopic superpositions, why don't we perceive them? The answer came in 1970 by H. Dieter Zeh of the University of Heidelberg and subsequently by the Los Alamos scientists Wojciech M. Zurek and others. They found that coerent superpositions persists only as long as they remain secret from the rest of the world. However, when an object (e.g., cat) cannot be isolated from its surrounding environemt, its interaction with the latter would act to destroy the superposition making it unobservable. This effect is known as decoherence because an ideal pristine superposition is said to be coherent. Thus, even a tiniest interaction of the object with the environment, such as a single photon or an air molecule bouncing off the object, would cause rapid decoherence making this superposition unobservable.It is almost as if the environment acts as an observer, collapsing the wave function. In other words, the decoherence produces an effect that looks and smells like a collapse.

Decoherence explains why we do not routinely see quantum superpositions in the world around us. It is not because quantum mechanics intrinsically stops working for objects larger than some magic size. Instead, macroscopic objects, such as cats, are almost impossible to keep isolated to the extent needed to prevent decoherence. In contrast, microscopic objects, for example, electrons, atoms etc. are more easily isolated from their surroundings so that they restore their quantum behaviour.

### The ticklish issue of "hidden variables"

Many physicists also started debating on the issue whether the wave functrion contains all possible information about a system or if there might be underlying factors, so-called hidden variables, that determine the outcome of a particular measurement. In the mid 1960s, John S. Bell showed that if hidden variables existed, experimentally observed probabilities would have to fall down below certain limits, dubbed as "Bell's inequalities." Experiments were carried out by a number of groups, which found that the inequalities were violated. Their collective data came down decisively against the possibility of hidden variables. For most scientists, this resolved any doubt about the validity of quantum mechanics.

However, over the past few years, hidden variables have come back from the dead, thanks largely to Gerard 't Hooft of the University of Utrecht in the Netherlands, a Nobel laureate quantum mechanician known for toying with radical hypotheses. He argues that the salient difference between quantum and classical mechanics is information loss. A classical system contains more information than a quantum one does, because classical variables can take on any value whereas quantum ones are discrets. So, for a classical system to give rise to a quantum one, it must lose information and that can happen naturally because of friction or other dissipative forces.

If balls are dropped from a skyseraper at different speeds, the air friction causes them to attain the same terminal velocity. An observer on the ground can scarcely tell the initial velocities of the balls; any differences in the balls' initial velocities are lost. The information regarding the balls' initial velocity is, therefore, a hidden variable. Similarly if the universe is affected by some unknown type of friction, quantum mechanics may reflect the fact that outcomes of events collapse to discrete values rather than filing the full range of possibilities. Therefore, asserts 't Hooft, nature could be classical at its most detailed level yet look quantum mechanical. Does it mean that quantum mechanics is a façade; for, as Einstein believed, behind the bizarre results apparent to us, the universe ultimately works according to the intuitive principles of classical physics? According to Carsten van de Bruck of the University of Sheffield in England, the particles behave in funky quantum ways simply because we don't, or can't see, the underlying order. Gerard 't Hooft says that the nature looks quantum mechanical because of friction or dissipation. As for the source of friction that turns classical systems into quantum ones, van de Bruck thinks it may have to do with gravity. Bruck has even gone one step further to suggest that strong gravitational field could change the laws of quantum mechanics.

All that said, something seems to be bizarre or weird in the quatnumland. As Fuchs has written, "There is no one way the world is because the world is still in creation, still being hammered out." The same thing can clearly be said of our understanding of the quantum world.

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# Checkmate – Urinary Tract Infection!

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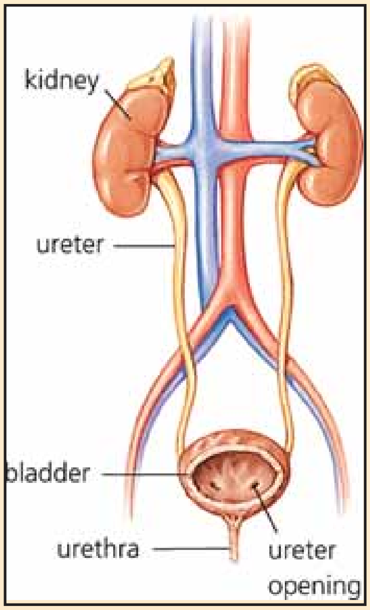
You wake up one morning with a strong urge to pee, and you rush to the bathroom. During passage of the urine, you feel a painful burning sensation low in the pelvis. The urine is cloudy, and has a foul odour. The situation is repeated several times during the morning, and on the last occasion the urine has a pinkish tinge. You feel alarmed, and just cannot figure what's going wrong.




This sequence of events is the most typical presentation of a urinary tract infection (UTI). A painful and annoying condition, it can affect any part of your urinary system—bladder, urethra, ureters, or kidneys. However, infection of the bladder or urethra is much more common. In fact, if the infection spreads to the kidneys, it can turn into a serious health problem.

Being of the fair sex, puts you at a special risk. As many as one in five women suffer a UTI during her lifetime, and many endure it more than once. Men run a considerably smaller risk, but may suffer in special circumstances. Children, especially girls, can also suffer.

You must seek medical attention as soon as you recognize its first symptoms. Timely antibiotic treatment can clean the infection, and set you free of any risks.

## What is UTI?

Urinary tract infection is the presence of a significant number of bacteria in one or more portions of the urinary tract. The bacteria may only lodge in the lower urinary tract. If they swarm the bladder, it leads to a condition called *cystitis*. If the urethra takes the brunt, *urethritis* results.

At other times, the bacteria may raid the upper urinary tract. An infection of the kidneys is called *pyelonephritis*, while that of a ureter is called *ureteritis.*

Generally a lower tract infection is less serious than one involving the upper tract, in which a loss of kidney function is a possible outcome.

## Causes

Bacteria may enter the urinary tract by three routes:

- By far the most common cause for infection in women is the ascent of bacteria from the outside of the body through the urethral opening. The location of the urethral opening close to the vagina and the anus allows organisms from these areas to mix with urine droplets and flow backward into the urinary tract. It is presumed that bacteria then multiply to large numbers and make their way up to the bladder, through the ureters, and eventually to the kidneys. About 90 per cent of UTI are caused by the organism *Escherichia coli (E. coli),* a bacterium that normally and harmlessly inhabits the bowel and faeces.
- The blood supplying the kidney may bring infecting organisms from other places in the body, such as infected areas of bone. The kidney, however, is not a very good trap for these bacteria and this pathway of infection is therefore not common.
- Infection carried through the lymph channels is possible, but this is also unusual.

## Why women run a higher risk?

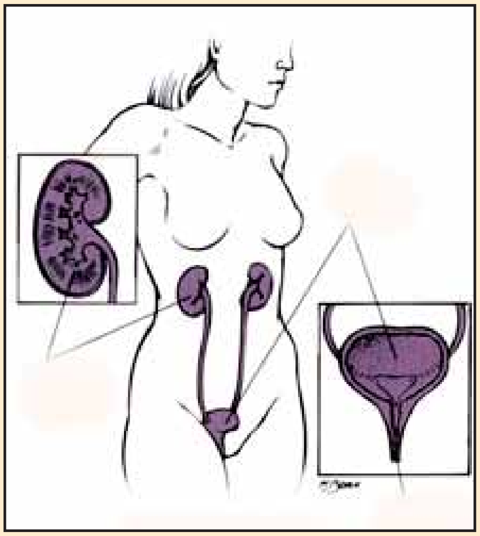
Some people appear to be more likely than others to develop UTI. Why women are at a higher risk of developing a urinary tract infection relates to their anatomy. Since the urethra of a woman is much shorter than men, being about one and one-half inches from the outside to the bladder, bacteria have easy access to the bladder. The warm, moist area between the genital folds makes the survival of bacteria likely, and incorrect toilet habits can play a significant role in causing infection. If cleansing of the anus is done from back to front, bacteria are swept up into the urethral opening, increasing the likelihood of infection.

The onset of sexual activity in women is also associated with an increased incidence of urinary tract infection. The bladder, which lies next to the vagina, is often mildly traumatized during sexual relations, and the motions of intercourse can transport bacteria up into the urethra. The term *honeymoon cystitis* has been coined to describe the onset of bladder infection in a woman during a period of frequent sexual relations.

Pregnancy can also initiate UTI. The hormonal changes of pregnancy alter the normal functioning of the urinary tract, and mechanical obstruction to urine flow occurs as the enlarged womb presses against the ureters and bladder. Many women require catheterisation during childbirth. Anytime an instrument is passed into the bladder, such as a small rubber tube or catheter for drainage, there exists the possibility of bacteria being transported from the outside of the body to the inside. The slight trauma of the procedure itself may be enough to encourage infection. Single catheterisation of the bladder in relatively healthy women carries a risk of infection of 1-3 per cent, but if the woman is pregnant or elderly and debilitated, this risk rises to 10-15 per cent.

Women who use diaphragm for birth control also may be at higher risk.

After menopause, UTI may become more common because tissues of the vagina, urethra and the base of the bladder become thinner and more fragile due to loss of oestrogen.



### Other risk factors

Several other conditions also increase the risk of UTI, and some of them operate equally for men and women. They include:

- *Prolonged use of tubes (catheters) in the bladder.*
- *Abnormally structured urinary tract*: Some people have a defect in the urinary tract since birth, because of which the urinary flow slows down or is obstructed. These conditions also predispose a person to suffer from a UTI.
- *Kidney stones*: Infection can follow a blockage of the urinary tract by a kidney stone; when the protective mechanism of flushing out the tract is lost and a stagnant pool of urine forms behind the stone, the conditions whereby urinary tract infection can flourish are enhanced. *Neurological abnormality of the bladder*: A paralysed bladder from stroke or injury also becomes a cesspool, where bacteria can grow and multiply, causing UTI.
- *Enlarged prostate in men*: Just as a kidney stone, an enlarged prostate also impedes the flow of urine, and increases the risk of UTI.
- *Diabetes and other chronic illnesses* that may impair the immune system
- *Medications that lower immunity*, such as cortisone in higher doses

### Signs and symptoms

The symptoms of a urinary tract infection can vary widely. In most adults, acute uncomplicated UTI is much easier to recognize. Women usually first notice symptoms of lower urinary tract involvement by the need for frequent urination. Symptoms are usually of sudden onset and may be accompanied by a mildly elevated temperature. There is discomfort during voiding, which may take the form of an intense burning sensation, a pain in the lower abdomen, or a vague feeling of irritation in the area of the opening of the urethra. Since the tissues are inflamed, there is often a sensation that the bladder does not completely empty, but when urination again seems to be necessary only a few drops of urine can be passed.

Normal urine is straw yellow in colour and clearly translucent. In UTI, the urine becomes dark in colour, cloudy, foul smelling, and may have debris floating in it. This debris is composed of strands of mucous, cells shed from the inflamed tissues, bacteria, and pus cells. It is not unusual to see red, brownish, or pink urine caused by red blood cells leaking from the inflamed lining of the urinary tract.

A lower tract infection usually precedes upper tract involvement. In up to 50 per cent of cases, untreated bladder infections are followed by kidney infections. When the kidneys are also infected, the temperature elevation is more pronounced and may be accompanied by shaking chills. General body symptoms are likely and include fatigue, nausea, and flank pain. The kidney becomes very tender, and a gentle blow to the back over the last rib often produces exquisite pain. Women with pyelonephritis are quite ill, frequently to the point of requiring hospitalisation.

### Symptoms and signs of a bladder infection

• A burning sensation when you pass urine • Feeling like you need to urinate more often than usual • Feeling the urge to urinate but *not* being able to • Leaking a little urine • Urine that smells bad • Cloudy, dark or bloody urine.

### Diagnosis

The diagnosis of urinary tract infection must depend on the examination and culture of the urine. Essential to an accurate diagnosis is the collection of a urine sample that is free from contamination by organisms from the surrounding skin, vagina/prepuce, and anus.

The best way to collect urine is to follow the clean catch midstream method. You should clean the surrounding skin, vagina/prepuce and collect the specimen after discarding the first few drops. A urine sample collected at home may be acceptable if transported immediately to the lab. If that is impossible, the sample should be refrigerated until delivered for analysis, as urine at room temperature will double its bacteria count every 30 minutes, giving a false positive diagnosis of infection.

Bacteria must be present in significant numbers before infection is diagnosed. The generally accepted criterion for infection is the existence of 100,000 or more bacteria per millilitre of urine. Even the specific infecting organism and the antibiotic that will kill it can be established from culture of the urine. Although the urine culture raises the expense of treatment, it is a necessary procedure.

A urinalysis gives further support to the culture diagnosis and is positive evidence if there is protein present, and if microscopic examination reveals the presence of blood, pus, and bacteria. Together with a clinical history of the typical symptoms, a positive urinalysis is often used as presumptive evidence for infection, and treatment can be started before the culture has completed its growth.

## Possible complications

Urinary tract infection should never be left untreated. An irreversible damage to the kidneys is always a possibility. A persistent infection, even if quiescent, may cause kidney scarring, stunted growth of the kidney, and occasionally renal failure, a very serious condition in which the kidney is unable to rid the body of nitrogen wastes. For this reason, it is very

important to seek medical advice, even when a urinary infection has seemingly gone away of its own accord.

Pregnant women with significant bacteria in the urine pose a special problem, in that an upper tract infection presents an increased risk for premature delivery.

## Treatment

The mainstay of treatment involves the use of an antibacterial medication directed at eliminating the offending organism. These antibiotics are either given orally or intravenously. A known allergy to any of these drugs should be called to the physician's attention before the treatment starts. Antibacterial drugs work promptly to relieve symptoms but may take 7-14 days to entirely eradicate infection. It is extremely important to follow the whole course of treatment and take the medication for as long as the physician has indicated, even if the symptoms disappear. A urine culture at the end of treatment that shows no growth of bacteria is conclusive evidence that the urinary infection has been cured.

An adequate intake of fluids is important in fighting a urinary tract infection. Forcing water through the urinary tract creates a constant flushing-out action that helps to eliminate large numbers of bacteria. A good rule to follow is to drink a glass of water with each dose of medication and another glass between each dose.

When UTI causes severe and toxic symptoms, as may be the case in upper tract infection, more active treatment is warranted. Again, antibacterial medication and extra fluids is the mainstay of treatment, but often they must be given by infusion into the bloodstream by way of an intravenous drip. When the severity of infection subsides, treatment is switched to medication that may be taken by mouth.

## Prevention

You can take steps to reduce your chance of getting a UTI. Women in particular may benefit from the following:

*Drink plenty of liquids.* Drink at least 8-10 glasses of liquids, especially water, daily. This will help wash out bacteria and keep the urinary tract clean.

*Go to the bathroom frequently.* The bladder should be emptied promptly whenever the urge to urinate occurs; bacteria are thereby flushed out of the urinary tract before their numbers can increase.

*Wipe from front to back.* Beginning in childhood, a young girl should be instructed by her parents in proper personal hygiene. The one rule to remember is to always use toilet paper in a single stroke to wipe the genital area from front to back, *never* back to front. The same rule applies to ablution. Doing so after urinating and after a bowel movement helps prevent bacteria in the anal region from spreading to the vagina and urethra.

*Take a shower.* Showering is preferable to taking bathtubs, as it carries the bacteria away immediately whereas prolonged sitting in a bathtub may leave the urethra in contact with organisms from the anus.

*Avoid potentially irritating feminine products.* Using deodorant sprays or toiletries such as bubble bath and feminine hygiene sprays, in the genital area, can irritate the delicate genital tissues in some women. This inflamed area then becomes more susceptible to infection. If you are sensitive to any of these agents, avoid them.

*Wear cotton.* Cotton underwear is much more effective than nylon at soaking up the normal moisture and secretions in the genital area and restricts development of the type of environment that encourages bacterial growth.

*Practise bladder hygiene before and after intercourse.* Since sexual intercourse can be a factor in urinary infections, it is good practice for a couple to shower prior to intercourse so that the number of potential infecting organisms is decreased. Immediately following intercourse, a woman should empty her bladder to flush out of the urethra any bacteria that have entered.

*Swallow an antibiotic.* If urinary infection always seems to be coincident with sexual intercourse and simple hygienic measures do not help, the use of a single dose of an antibacterial medication immediately after intercourse has been shown to prevent infection. A woman should not hesitate to bring this problem to her physician's attention. Medical intervention can usually resolve the difficulty with little or no effect on the pleasure of sexual relations.

## Self care

Urinary tract infections can be painful, but you can take steps to ease your discomfort until antibiotics clear the infection. Follow these tips:

*Use a heating pad.* Sometimes a heating pad placed over the abdomen can help minimize feelings of bladder pressure or pain.

*Drink plenty of fluids.* Take lots of water and liquids. However, avoid coffee, alcohol, and soft drinks containing citrus juices and caffeine until your infection has cleared, because these things can irritate your bladder and tend to aggravate your frequent or urgent need to urinate.

*Let your doctor know.* If you have recurrent bladder infections, consult your doctor. Together you can determine a strategy to reduce recurrences.

• • •

# Measuring Light Precisely

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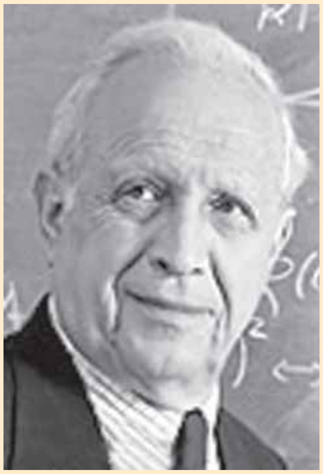
More than 150 years ago it was established by the English physicist James Clerk Maxwell that light is a form of electromagnetic radiation that travels as waves. This oscillatory property of light served to verify the electromagnetic theory of Maxwell. Then, in 1905, the German-born American physicist Albert Einstein through his explanation of photoelectric effect proved that light also behaved as particles. This dual nature of light signalled the dawn of modern quantum theory. To explain this dual nature of light we need both a macroscopic theory to account for the phase properties and a microscopic theory to account for the interaction between the photons and the material absorbing them. The former is given by Maxwell's theory and the latter by quantum electrodynamics. The Nobel Prize in Physics for 2005 is shared by two American physicists Roy J. Glauber of Harvard University, Cambridge, Massachussetts and John L. Hall of JILA, University of Colorado and National Institute of Standards and Technology, Boulder, Colorado, and one German physicist Theodor W. Hänsch of Max-Planck-Institut für Quantenoptik, Garching and Ludwig-Maximilians-Universität, Munich for their contribution to better understanding of optical phenomena. Glauber will receive half the prize money "for his contribution to the quantum theory of optical coherence", while the other half will be shared by Hall and Hänsch "for their contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique".


*Roy J. Glauber*

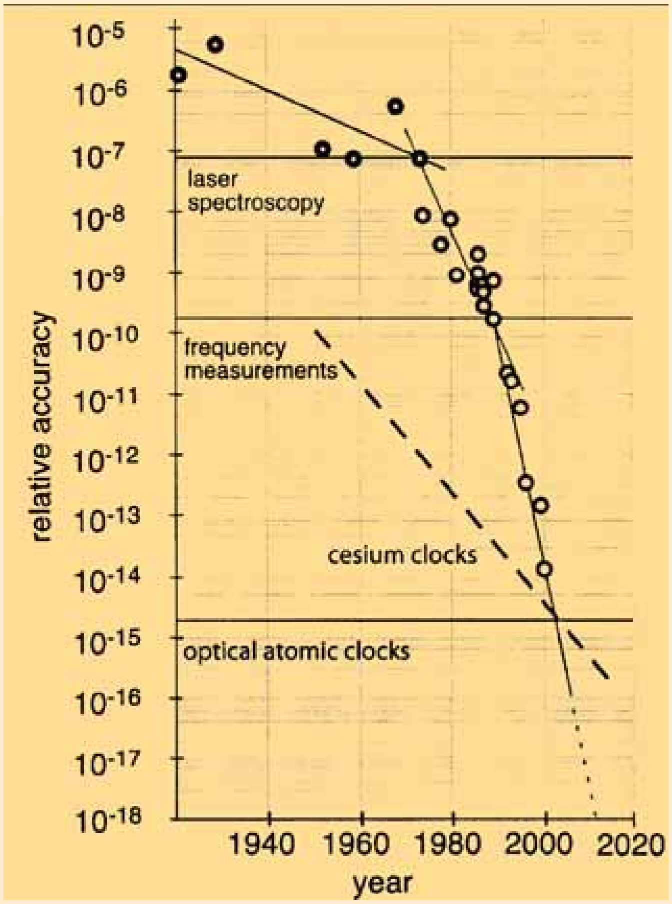
The electromagnetic phenomena form an integral part of modern technology. They are at work in all electrical motors, and our communication devices utilize their oscillatory behaviour in essential ways. Our radio and TV receivers and mobile phones are all based on the ability of the radiation to sustain well-defined frequency and phase properties. On the other hand, devices that detect electromagnetic radiation must be based on the absorption of radiation energy into the material medium. This energy is known to propagate in packets, called photons. Absorption of a single photon of radiation causes the creation of an excitation and leads to the release of one and only one photoemission electron from a solid, which may be amplified and detected. Thus the detector counts photoelectrons and not photons, and our information about the behaviour of photons is always indirect. In the process of observation, the photon must be absorbed, and thus it is no longer available afterwards. All photoelectric devices work on this principle.

But how the photon is absorbed in the detector was not adequately explained till 1963 when Glauber in a series of papers published in *Phys. Rev. Letters* showed how the quantum theory has to be formulated in order to describe the detection process. Glauber also presented the basic features of his quantum theory of optical coherence. His work served to bring out the distinction between the behaviour of thermal light sources and presently common coherent sources such as lasers and quantum amplifiers. His theory uses the formalism of quantum electrodynamics to describe the absorption of a photon in a detector. Glauber further showed that by correlating several such detectors, one may obtain higher order correlations, which can display clearly the characteristic features of quantum radiation. After the initial contributions, many authors applied Glauber's results to the rapidly evolving experimental situation in optical physics, thus creating the field today called "Quantum optics", which has since developed into a multifarious and challenging field of research. The experiments have brought measurements down to the level of single photons in the field and a few atoms, also allowing devices of ultimate stability.


*John L. Hall*


*Theodor W. Hansch*

In the limit of low intensity, only a few photons are involved, and this can be applied in secure quantum communications – the topical field of quantum computing




*Developments in relative accuracy in precision spectroscopy achieved with advances in measurement techniques.*

and the recording of ultra-weak signals in high-precision experiments. In all these situations, a good understanding of the basic theory is required, as quantum effects set the fundamental limit to what can be achieved; technical noise can be eliminated, quantum noise cannot. Another field of applications of the quantum approach to optics is offered by the possibilities to test fundamental aspects of quantum theory.

Many advances in spectroscopy have been spurred by measurements of unprecedented precision revealing new structures and phenomena. This is particularly true in atomic spectroscopy, where increasing spectral resolution led to the observation of atomic fine structure (due to the electronic spin), hyperfine structure (due to the nuclear spin), and volume isotopic shifts (due to the different charge distributions of the nuclei of isotopic species of an element). Pushing to ever higher precision and resolution may ultimately reveal new phenomena. The possibility to determine optical transition frequencies very accurately may lead to better atomic clocks, which in turn would allow better GPS systems, better space navigation and improved control of astronomical telescope arrays. The work of Hall and Hänsch relate to developments in these areas.

## Laser-based precision spectroscopy and optical frequency comb techniques

The definitions of the units for length and time have undergone a continuous development, once having been coupled to the size of the Earth and its motion. In 1960 the metre was defined as a certain number of wavelengths of a spectral line in $^{86}$Kr, and in 1967 the second obtained its present definition as being 9,192,631,770 oscillations of the radiation inducing the hyperfine transition in $^{133}$Cs. With improved measurement methods, the velocity of light could now be determined with even better precision by multiplication of frequency and wavelength for a stable radiation source. The definition of the metre, unfortunately being based on a slightly asymmetric spectral line, quickly became the limitation. The work of Hall and others led to the redefinition of the metre through coupling it to the second. The metre was defined as the distance light travels in 1/299,792,458s. But measuring optical frequencies accurately turned out to be a big hurdle and the new definition of the meter became unusable for most practical purposes. A new way to accurately measure optical frequencies was essential.

New high-precision measurement techniques known as "optical frequency comb techniques" solved the mounting problems in an ingenious way. The new measurement methods developed by Hall and Hänsch used lasers and were based on fundamental relations between cavity modes in a continuously operating laser and their interference, which led to a repetitive train of short pulses. At the end of the 1990s Hänsch and collaborators started to use the frequency comb structure of the mode-locked titanium sapphire lasers to bridge large frequency intervals in a simplified frequency chain to relate optical frequencies ultimately to the caesium clock. Through the work of Hall and Hänsch, the precision of optical laser spectroscopy could be stretched to the level of $10^{-15}$.

The techniques developed by Hall and Hänsch, which allow extremely precise spectroscopy and optical frequency standards, have many applications of both a fundamental and a practical nature. Using these techniques tests of fundamental theories can be made at an ever higher level of precision, regarding relativistic effects, the isotropy of space, possible asymmetries between matter and anti-matter (hydrogen and anti-hydrogen), and possible drifts in the fundamental constants. The techniques would also help refine global positioning systems, accurately synchronize very large astronomical telescope arrays, and make deep space navigation more accurate.

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# Recent Developments in Science &Technology

### Malaria Vaccine Proves Effective in Clinical Trial

A new vaccine stimulated human immune cells to recognize and kill malaria parasites in a recent clinical trial. The vaccine proved effective in both infected human blood samples and mice.

"This is the first malaria vaccine clinical trial to clearly demonstrate antiparasitic activity by vaccine-induced antibodies," writes Pierre Druilhe of the Pasteur Institute in Paris, who led the study. Malaria—a parasite carried by certain mosquitoes—sickens more than 300 million people worldwide every year and causes at least one million deaths, primarily of young children, according to the World Health Organization. Vaccine development has been hindered by the microscopic parasites adaptability and complexity.

In the new work, described in a report published in Public Library of Science,the team injected an MSP-3-based vaccine into 30 European volunteers who had never had malaria, read ministering it after one month and again after four months. Blood samples were taken one month after each injection. These blood samples were then compared to French blood samples from individuals with no immunity to malaria and African blood samples from people with immunity Nearly every vaccinated sample produced an immune response to malaria when it was introduced in vitro and 77 percent produced anti-MSP-3 antibodies.

*Source: Scientific American.com*

### Titan Found to Be Rather Like Early Earth

A frigid globe covered in a wet sand of organic compounds and sculpted by a liquid, most likely methane—that is the picture of Saturn's moon Titan emerging from data collected by the Huygens probe, which touched down on its surface in January2005. Nature published the first analyses in a series of papers.

Although conditions on Titan's surface are a frosty -179 degrees Celsius, it is the only body in the solar system other than Earth that has a nitrogen-rich atmosphere. The second largest moon in the solar system—behind only Jupiter's Ganymede—Titan also resembles Earth in having a complex weather cycle, landscapes carved by liquid flow, and volcanic activity, albeit of a freezing cold variety. It may in fact resemble our planet in the earliest stages of its existence. Data's also shows that the surface of titan is covered with dence layer of smog.

The methane and nitrogen that constitute its atmosphere form various aerosols in the sunlight—giving the moon its orange aspect.

Huygens collected data throughout its two-and-a-half-hour descent to the surface and for more than an hour after it landed. The probe's various systems included ice instead of rocks. instruments to measure the atmosphere, wind, aerosols, gases and the surface itself.

*Source: Scientific American*

### Immunise your computer

Malicious computer viruses could be stopped in their tracks by immunity software that spreads faster than the virus itself.

This system works on setting up a network of shortcuts through the Internet that only antiviral programs can use, allowing them to immunize computers before a virus arrives.

Eran Shir of Tel Aviv University Israel began working about the problem when the infamous Blaster worm spread across the Internet in 2003

Antivirus software aims to stop attacks on healthy computers, and to clean up those already infected. Teams work around the clock to look for new viruses and build software 'patches'. These patches are distributed to computer users to install on their machines, hopefully before the virus arrives. But the strategy means that some viruses stay one step ahead for days, wreaking havoc as they spread.

*Source: Nature.com*

### First-ever face transplant surgery is completed

Surgeons in France claim to have performed the world's first face transplant, although not of a whole face. A 38-year-old woman severely disfigured in by a dog attack received a "partial" triangular graft, consisting of the chin, lips and nose from a dead woman donor.

Today, the patient is in excellent general condition, and the graft is normal. The surgery was performed by Jean-Michel Dubernard of the Edouard Herriot Hospital in Lyon.

The woman's injuries were so severe that she could scarcely speak or chew. This type of injury is extremely difficult, if not impossible, to repair by the usual maxillofacial surgical techniques. The breakthrough ends a race between teams in France, the US and Britain to perform the procedure first.

Source: Newscientist.com

**Compiled by : Kapil Tripathi**

(Contd. from page 36)

## Release of Films of Professor A K Raychaudhuri and Professor P C Vaidya

the beautiful solution to Einstein's equation for a radiating star which he discovered in the mid-forties while working at the Banaras Hindu University with Professor V. V. Narlikar. It describes gravitational field of a star which is radiating out its energy. It is remarkably simple and elegant, and is extensively used in astrophysical study of gravitational collapse in the context of formation of black hole or naked singularity. Indeed, there are very few solutions to Einstein's equation that describe a pertinent physical situation. Professor Vaidya is known as a teacher par excellence and an educationist. He initiated a movement for mathematics education in Gujarat by founding the Gujarat Ganit Mandal.

*(from left to right) Dr. V.B. Kamble, Prof. C.V. Vishveshwara, Smt. Namita Raychaudhuri, Prof. P.C. Vaidya & Prof. Jayant Narlikar seated on the dais.*

In the global perspective of the work on General Relativity and Gravitation, these two are the shining examples of deep and lasting contributions. Both the films would serve as a source of inspiration to our youth for taking up a career in science, and for the coming generations of scientists.

The films were released at IUCAA on November 16, 2005. Professor Naresh Dadhich, Director, IUCAA, in his welcome address gave a brief background about the films. Dr. V B Kamble, Director, Vigyan Prasar, talked about the collaboration between Vigyan Prasar and IUCAA on this joint effort and programmes of VP. Professor Vishveshwara, Director, Bangalore Planetarium, spoke on the life and work of Professor P C Vaidya, while Professor Jayant Narlikar spoke on the life and work of Professor A K Roychaudhuri. Professor P C Vaidya had specially travelled from Ahmedabad to Pune for the release function. So did Smt. Namita Raychaudhuri, Professor A. K. Raychaudhuri's wife, from Kolkata. Both Professor P. C. Vaidya and Smt. Namita Raychaudhari were felicitated during the function. Surely, everybody missed the presence of Professor A. K. Raychaudhuri. Shri Sunil Shanbhag, the producer of both the films and Shri Sudhir Palsane, the cameraman, were also felicitated on this occasion. Later both the films were screened to the great applause of a very appreciative audience. Indeed, both the films are a tribute to the two great scientists and teachers that this country has produced.

Vigyan Prasar plans to telecast these films on Doordarshan and other channels in near future, and also bring out CDs / DVDs for dissemination in schools and colleges. It is hoped that both the films would inspire our youth by exposing them to the thrill and challenges that a career in science can offer.

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# International Conference on Distance Education (ICDE)

Indira Gandhi National Open University (IGNOU), organized International Conference on Distance Education (ICDE) at its new academic campus at Maidan Garhi, New Delhi, during 18-23 November, 2005. The conference included four pre-conference workshops on different aspects of Distance Learning Technologies (DLTs) and parallel sessions with emphasis on ICT enabled education. The conference was inaugurated by Shri Arjun Singh, Hon'ble Minister for Human Resource Development. During a session on PANdora DLTs in Asia (a research programme initiated by the International Development Research Centre, Canada) papers based on the ongoing projects in Asia were presented. A paper based on the project entitled "ICT enabled learning technologies in South Asia" - in which Vigyan Prasar and IGNOU (India), UCSC (Sri Lanka), and AIOU (Pakistan) are partners - was presented by Dr. V B Kamble and Dr. Zeba Khan (IGNOU). Professor S.K. Panda, IGNOU, also a team member of the project, co-ordinated the session. Incidentally, Vigyan Prasar and IGNOU are the Indian partners of the three nation joint project. Professor Nazir Sangi, Dean, Allama Iqbal Open University of Pakistan – representing Pakistan in this project - also participated in the conference. Shri Rintu Nath, Scientist 'D', Vigyan Prasar, made a presentation on DLTs undertaken by Vigyan Prasar in one of the sessions.


*(From L to R) Dr. Zeba Khan, Dr. Kamble, Professor Nazir Sangi and Professor S.K. Panda*

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