The Neutrino Journal

Club Neutrino

The Physics Club

Sanskriti School

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Letter to the reader

Dear Reader

It brings each one of us in Club Neutrino tremendous joy to see the release of the first issue of the Neutrino Journal. A reflection of the passion for Physics that is felt by each of us, we hope that it will be of interest to you, as well as provide an insight into the fascinating world of Physics.

The complex amalgamation of equations and theories that seek to explain the unimaginably diverse phenomena and the pure beauty in the symmetry of Physics make it one of the most fascinating subjects explored by humankind. This journal is our humble effort to bring to you a piece of this vast field of knowledge, in the hope that it will awaken in you a desire to be drawn further into the subject. From the Bose Einstein Condensate to the world of Cassini, from medical physics to a tribute to perhaps the greatest physicist of our times, we bring to you some of the most exciting and intriguing developments in Physics.

This year, Club Neutrino will be led forward by Chirag Wadhwa (Club President), Shreya Singh (Vice President) and Samiha Sehgal (Director) from the twelfth grade, along with a team of members ranging from grades nine to twelve. The teachers in charge of the club are Ms. Shampa Biswas and Ms. Ripple Mehta, without whose support and interest none of our work would have been possible.

Once again, we hope you shall enjoy this issue of our journal, and we extend a heartfelt thanks to each and every reader.

May the passion for learning stay eternal.

Warm regards

Niharika Mukherjee

(Editor, The Neutrino Journal)

Neutrino Focus: Stephen Hawking

By Ananya Sinha

"It matters if you just don't give up."

This combination of few words makes a statement with a deep meaning. It was very aptly quoted by a person who himself followed it in letter and spirit. Despite his physical limitations, he was a true fighter who proved to the world that IMPOSSIBLE actually meant I'M POSSIBLE. He had an unquenchable zest for life. He was an icon for many reasons, but as we remember him, his remarkable contribution to science is undoubtedly his greatest legacy.

We are talking about the blessing in the field of space travel, Mr. Stephen William Hawking CH CBE FRS FRSA. He was born on the 8th of January in 1942 to Frank and Isobel Eileen Hawking in Oxford. Hawking received his first schooling at the Bryon House School in Highgate, London. He had a close group of friends with whom he enjoyed the manufacture of fireworks, model aeroplanes and boats, and long discussions about the developments in science at that time. The formation of a computer from clock parts, an old telephone switch board and other recycled components, with the help of their mathematics teacher Tahta, was an amazing feat for teenagers in that era.

Hawking began his undergraduate education at University College, Oxford at the age of 17. Over there he developed into a popular, lively and witty college member, interested in science fiction and classical music too. After receiving a first-class (Hons.) degree in natural science, he began his graduate work at Trinity Hall, Cambridge in 1962. Some time later, after being diagnosed with motor neurone disease, he fell into a depression. His ailment progressed into the acute stage rather slowly than the doctors had predicted. However, Hawking still faced difficulty walking unsupported and his speech was almost incoherent. With the undying optimism shown by his fellow mates and encouragement by his supervisor, he returned to his work. Hawking started developing a reputation for brilliance, finesse and brashness when he publicly challenged the work of Hoyle (another supervisor) and his student.
In collaboration with Penrose*, Hawking extended the singularity theorem concepts first explored in his doctoral thesis.
[*-Penrose-Hawking Singularity Theorems are a set of results in general relativity that attempt to answer the question of when gravitation produces singularities.

Singularity solutions of the Einstein field equations is one of the two things:
i. A situation where matter is forced to be compressed to a point (a space-like singularity)
ii. A situation where certain light rays come from a region with infinite curvature (a time-like singularity)]
In 1970, they published a proof that if the entire universe obeys the general theory of relativity and fits any of the models of physical cosmology developed by Friedmann then it must have begun as a singularity.

Hawking postulated what later came to be known as the second law of black hole dynamics, that the event horizon of a black hole can never get smaller. Later, with James Barden and Brandon Carter, he proposed the four laws of black hole mechanics, drawing an analogy with thermodynamics. Hawking's first book, 'The Large Scale Structure of Space-Time' written with George Ellis was published in 1973. Hawking moved on further into the study of quantum gravity and quantum mechanics. In 1975, he was awarded both the Eddington Medal and the Pius XI Gold Medal, and in 1976 the Maxwell Prize and the Hughes Medal. The following year he received the Albert Einstein Medal and an honorary doctorate from the University of Oxford. Hawking co-edited a book on Euclidean quantum gravity with Gary Gibbons and published a collected edition of his own articles on black holes and the Big Bang, in 1993.
Along with Thomas Hertog at CERN, from 2006 Hawking developed a theory of 'top-down cosmology', which says that the universe had not one unique initial state but many different ones and therefore, that is inappropriate to formulate a theory that predicts the universe's current configuration from one particular initial state. Stephen Hawking was the laureate of the most reputed honor and every physicist's dream: the Nobel Prize for Physics (2013).

The death of Hawking on 14th of March at the age of 76, has not just deprived the world, of a great scientist, it has deprived science, of an effective ambassador to the non-scientific world.

Cassini, like a daydream

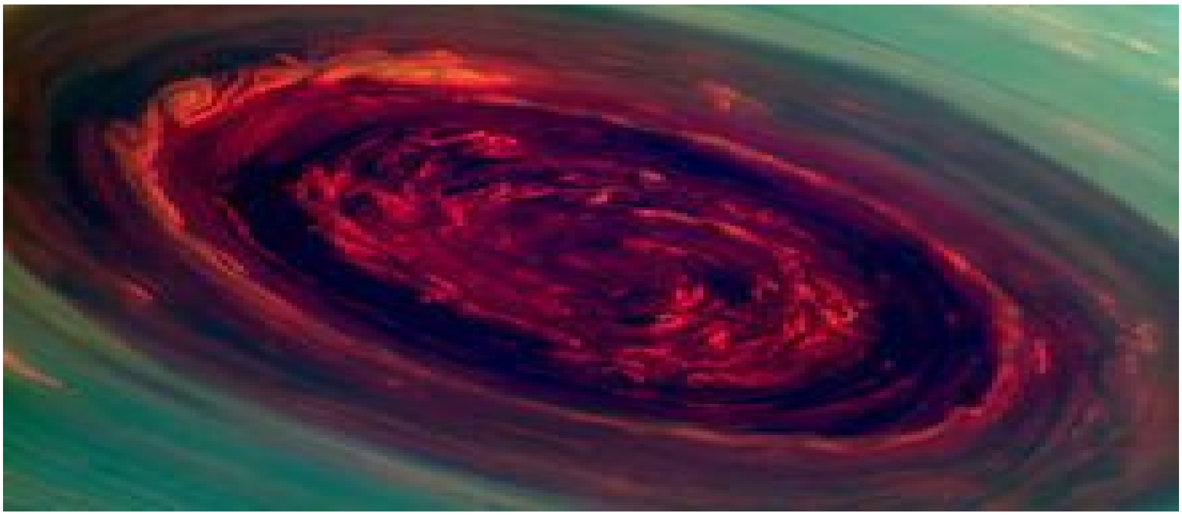
By Anushka Sanjay

If you are anything like me in life, you would be doing a nasty Math problem because you have a test tomorrow. But you hate areas of circles, if not Math in general, so you look around because your concentration levels are next to nothing. You spot your dad reading the paper across the table and a half page article on the Saturn Orbiter, Cassini catches your attention. Now that's something very interesting. So you ditch Math and excuse yourself to surf the internet. So you read about it and your mind is blown because you realise that your plans of space colonisation are closer than ever. But if you are less like me and more like my friend 'Bob' then before you hear my plans on taking over the universe, you might want to understand what a "Cassini" is.

Cassini or Cassini- Huygens, was a collaborative mission between NASA, the European Space Agency and the Italian Space Agency. The mission's objective was to study Saturn, its Rings and its Satellites. The mission lasted for 20 years from October 1997 and ended on September 15 2017 when it entered Saturn's atmosphere. It was named after two scientists of the 17th century, Jean Dominique Cassini, who discovered Rhea, Tethys, Lapetus, and Dione, all of which are satellites of Saturn, he was also the one who discovered the Cassini division (a narrow gap between Saturn's Rings) and Christiaan Huygens who discovered the giant of a moon, the mighty Titan. It took 7 years to reach Saturn. Once it reached Saturn it completed its 4 year long primary mission by 2008. But why a Saturn probe? It's unique and mysterious. Saturn's magnetic field and the planet appear to rotate about the same axis. This alignment is unique among all known planets and depending on Cassini's discoveries, scientists may have to rethink their theories of how planetary magnetic fields form. Plus Saturn is just infinitely cool with its unique shape and rings. For fuel and power, it was equipped with a radioisotope generator; it would have its own onboard power from nuclear decay that would last for decades, allowing for unprecedented analysation and calculations to be done from a distance. Cassini gave humankind a lot of new and surprising discoveries and information. But since I am on a word limit, I will talk about the cooler ones only.

On January 14 2005, the Huygens probe landed on Titan, the most distant in our galaxy. The probe's 2 hour and 27 minute descent revealed the moon to have similar conditions as Earth before life evolved. In fact Titan has been found to have similar geologic processes as Earth. It was found that it experienced methane rain and had liquid methane on its surface. In fact, it was the first

planet beside Earth to show signs of surface liquid. Plus complex hydrocarbons, were found in Titan’s atmosphere.
A surprise discovery made by Cassini was discovering ice and water vapor gushing out of the icy moon Enceladus. These gravity measurements suggests the existence of a large, regional ocean of water, that is about 10 kilometers deep under an ice shell of 30- 40 kilometers. The subsurface ocean evidence supports the inclusion of Enceladus among the most likely places in our solar system to host microbial life.
Scientists have stalked a new class of moons in the rings of Saturn that create distinctive propeller-shaped gaps in ring material. It marks the first time scientists have been able to track the orbits of individual objects in a debris disk. The propeller features are up to several thousand kilometers (miles) long and several kilometers (miles) wide. The moons embedded in the ring appear to kick up ring material as high as 0.5 kilometers (1,600 feet) above and below the ring plane, which is well beyond the typical ring thickness of about 10 meters (30 feet). Many believe this to be an example of moon formation in Saturn.
Saturn has a ridiculously beautiful pair of hexagonal storm systems at its poles. The driving forces of each remain a mystery.
Anyway, the Cassini mission was successful beyond expectation. A mission planned for 4 years, went on for 9 more and ended with a death fit for heroes (It dived into Saturns atmosphere and burned off, to prevent any damage to any of Saturn’s satellites). In every way, it was perfectly perfect. I guess we will have to talk about space colonisation another day.



Bose Einstein Condensate

By Abhayraj Samir palande

We were always told that everything around us is present in either of these 3 forms - solid , gaseous and liquid. But there even exists 2 unusual states in things or matter exist - plasma and Bose Einstein condensate (BEC).In this article we will be focusing on the latter one. Before jumping in to understand BEC , you first have to peep into the world of Quantum physics.

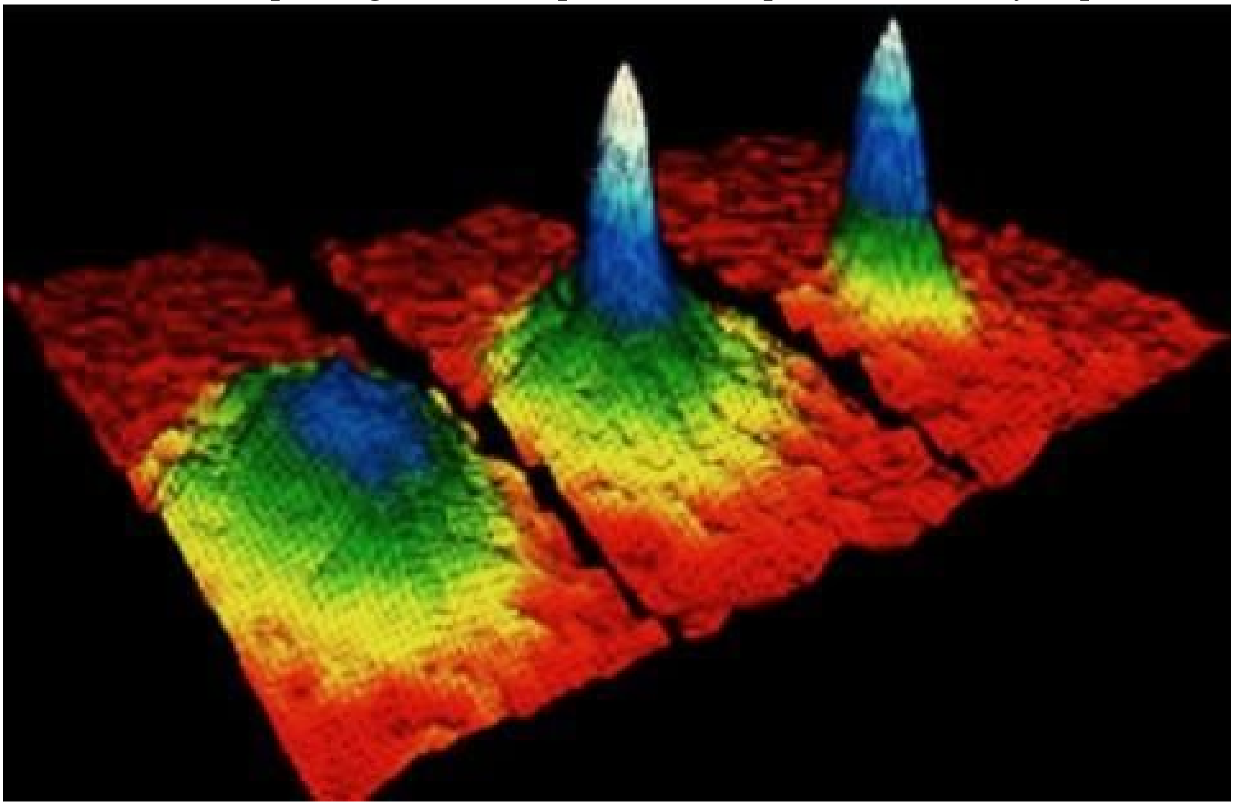
Not all elements can be converted into their BEC state. They have be an overall Boson. Boson and fermions are two groups in which elementary particles(they are even smaller than an electron or proton)are differentiated. Based upon their value of rotation(or spin) they are differentiated . Now the two groups obey and disobey respectively, ***THE PAULI EXCLUSION PRINCIPLE***.

Let's take two groups of two people each and label one fermion and other boson. In the fermion group , the two people don't want to be at the same place at the same time , while in the boson group , two people want to be at the same place at same time . In BEC bosons are present hence , they create a matter which has some crazy properties. BEC is made by exposing a group of bosons to an approximate temp of -459 Kelvin.

Through freezing it we are able to achieve a quantum state or 'the same place' mentioned before. On june 5 1995 , Carl wieman and Eric cornell were able to achieve the BEC state of 170 Rubidium atoms by freezing them to 117 nanokelvin.

Some interesting property of BEC are If we take BEC of helium-4 and keep it in a vesselthen it would crawl up the side of the vessel and seemingly escape the vessel, defying gravity!

It takes place because of its peculiar topology(study of geometrical shapes) of vortices present. Another interesting property is that, few elements like lithium, when their BEC are made they are stable only up to a critical number of atoms as when more are put together, an explosion takes place followed by implosion.



Pictorial representation of Bose Einstein Condensate

Medical physics
By Niharika Mukherjee

The term ‘medical physics’ nowadays generally brings to mind the work of physicists employed in hospitals, who are connected mainly with operating machines assisting diagnostic imaging and clinical measurement. This form of involvement of physics in clinical work began about a century back, but the relation between physics and medicine has a much longer history.

The origins of medical physics in history are traced from the first use of weighing as a means of monitoring health by Sanctorius, a medic in the seventeenth century. The emergence of radiology, phototherapy and electrotherapy, the forms of medical physics that we are more acquainted with today, emerged around the end of the nineteenth century.

Sanctorio Sanctorius was a Venetian physiologist and physician who introduced the quantitative approach into medicine, and is credited with the invention of several medical instruments including the thermometer.

Physics has influenced, in fact revolutionised, modern medicine with several contributions. Two perhaps most significant of these contributions are the use of particle accelerators to defeat cancer and Magnetic Resonance Imaging, more commonly known as MRI scans.

<u>Treating Cancer Using Particle Accelerators</u>

In the last 50 years, medical physicists have spearheaded the development and application of particle accelerators for treatment of cancer. Once confined only to physics laboratories, linear accelerators are high energy machines that can now deliver beams of energetic electrons or X rays to malignant tumours, kill the cancerous cells and stop the tumour’s growth.

How it works

The linear accelerator uses microwave technology (similar to that used for radar) to accelerate electrons in a part of the accelerator called the "wave guide," then allows these electrons to collide with a heavy metal target to produce high-energy x-rays. These high energy x-rays are shaped as they exit the machine to conform to the shape of the patient's tumour and the customized beam is directed to the patient's tumour. The beam is usually shaped such that it is contained within the head of the machine. The patient lies on a moveable treatment couch and lasers are used to make sure the patient is in the proper position. The treatment couch itself can move in many directions. The beam comes out of a part of the accelerator called a gantry, which can be rotated around the patient. Radiation can be delivered to the tumour from any angle by rotating the gantry and moving the treatment couch. This radiation is delivered at doses capable of killing cancerous cells and stopping the tumour's growth.

Advancement of Linear Accelerators

In recent years, an advanced treatment technique called intensity-modulated radiation therapy (IMRT) has enhanced the ability of radiation to control tumours.

Intensity-modulated radiation therapy (IMRT) is an advanced mode of high-precision radiotherapy that uses computer-controlled linear accelerators to deliver precise radiation doses to a malignant tumour or specific areas within the tumour. IMRT allows for the radiation dose to conform more precisely to the three-dimensional (3-D) shape of the tumour by modulating—or controlling—the intensity of the radiation beam in multiple small volumes. IMRT also allows higher radiation doses to be focused to regions within the tumour while minimizing the dose to surrounding normal critical structures.

Radiation therapy, including IMRT, stops cancer cells from dividing and growing, thus slowing tumour growth. In many cases, radiation therapy is capable of killing cancer cells, thus shrinking or eliminating tumours.

Magnetic Resonance Imaging

A magnetic resonance imaging (MRI) scan is a common procedure used by hospitals around the world. MRI uses a strong magnetic field and radio waves to create detailed images of the organs and tissues within the body.
The development of MRI revolutionized the medical world. Since its discovery, doctors and researchers have refined techniques to use MRI scans to assist in medical procedures and also help in research.

The scan uses a strong magnetic field and radio waves to generate images of parts of the body that can't be seen as well with X-rays, CT scans or ultrasound. For example, it can help doctors to see inside joints, cartilage, ligaments, muscles and tendons, which makes it helpful for detecting various sports injuries.

What it looks like

During an MRI, a person will be asked to lie on a movable table that will slide into a doughnut-shaped opening of the machine to scan a specific portion of the body. The machine itself will generate a strong magnetic field around the person and radio waves will be directed at the body.

A person will not feel the magnetic field or radio waves, so the procedure itself is painless. However, there may be a lot of loud hammering or tapping noises during the scan, so people are often given headphones to listen to music or earplugs to help block the sound.

How it works

The human body is mostly water. Water molecules (H_2O) contain hydrogen nuclei (protons), which become aligned in a magnetic field. An MRI scanner applies a very strong magnetic field (roughly a thousand times the strength of a typical fridge magnet), which aligns the proton "spins."

The scanner also produces a radio frequency current that creates a varying magnetic field. The protons absorb the energy from the magnetic field and flip their spins. When the field is turned off, the protons gradually return to their normal spin, a process called precession. The return process produces a radio signal that can be measured by receivers in the scanner and made into an image.

Magnetic resonance imaging is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body.

In conclusion, it is clear that medical physics has an important role in clinical medicine, and in biological and medical research. The entwining of these diverse disciplines has produced results that have allowed the treatment, diagnosis and cure of diseases in more effective measures than was imaginable even a century back. The way forward, therefore, promises to be startling, rewarding and intriguing like never before.

From the lab: Physics News

By Preksha keshri and kartikeya tomar

- On 14th march 2018, aged 76, the great English theoretical physicist, Stephen William Hawking died in Cambridge, England.

- In the latest experiment of its kind, researchers have captured the most compelling evidence to date that unusual particles lurk inside a special kind of superconductor. The results, which confirms theoretical predictions first made nearly a decade ago at the Joint Quantum Institute (JQI) and University of Maryland (UMD).

- The Physics of Finance helps to solve a century-old mystery

By unleashing the power of big data and statistical physics, researchers in Japan have developed a model that aids understanding of how and why Brownian motion arises.

- New Devices uses biochemistry techniques to detect rare radioactive decays

The researchers are taking advantage of a biochemistry technique that uses fluorescence to detect ions to identify the product of a radioactive decay called neutrino less double beta decay that would demonstrate that the neutrino is its own antiparticle.

- Theoretical physicists used stimulations to explain the unusual readings collected in 2009 by the Mercury Surface, Space environment, Geochemistry and Ranging mission. The origin of electrons detected in Mercury's magnetic tail has puzzled the scientists. This new study, appearing in Physics of Plasmas, provides a possible solution to how these energetic electrons form.

- (April 9th) theoretical physicists proposed a new state of matter called superfluid quasicrystal. According to them It is an exotic state of matter with zero viscosity

- (April 12th) Scientists have engineered a tiny guitar string that vibrates 1 billion times, when plucked.
  They would like to use it as a microphone for light

- (April 16th) US army funded researchers at the University of California in Los Angeles have found a proverbial smoking gun signature of the long sought after Majorana particle. The find could block intruders on sensitive communication network.

- (April 17th) At University of Bristol ,Scientists have discovered a new type of opal formed by common seaweed which harnessess technology by self -assembling a nanostructure of oil droplets to contol how light reflects from its cells to display shimmering array of colours.

- (April 20th)Researchers at the Institute of Photonic Sciences in Barcelona, Spain have been able to confine light down to a space an atom, the smallest possible. This will pave way to ultra- small optical switches, detectors and sensors.