DIMENSIONS

2014-15

Department of Physics, Miranda House,
University of Delhi

FROM THE EDITORIAL BOARD

The miracle of the Universe has amazed, intrigued, intimidated and humbled us for centuries. How many times have we looked at the stars and questioned our own significance in this highly complex, highly mysterious world? Then again, how many times have our curiosity led us to make an attempt to understand the complexities of this Universe and make sense of our own place within the Cosmos?

We here at Vidyut, wanted to throw in our two cents on the workings of the law of physics. And so the idea of a magazine was born. Through this magazine we hope to unravel the many dimensions of physics. We present articles from undergraduate students on a wide range of topics, in an attempt to display the elegance of physics. But these articles are only a small fragment of the magazine. Interspersed throughout are various facets of physics in the form of comic strips and physics trivia, to name some.

Dimensions also shows the various sides of being a Physics undergraduate at Miranda House. Some of our best times in college have been spent involved in various departmental activities. We hope that we can convey some of that vigor, enthusiasm and joy through his magazine.

We would like to thank our principal, our professors and all the contributors, for without them this magazine would never have metamorphosed into an actual physical object.

This journey has been, for lack of better words, truly epic.

Editorial Board,
Vidyut.

Her love for vintage goes beyond just books and movies. She lives vintage and Don Corleone. A die-hard feminist,for her individuality is a testimony to all things accountable. She is eclectic and needs everything 'The Minimalist' way. A science freak,a nature lover,a traveller,a free thinker,a humanist,and a pulp fiction addict,these are her many 'n-dimensional' idiosyncrasies.'If being is all that it takes,then being confident is in my moment' - Upasana

Pooja Malik - A physics geek by nature, she considers quantum mechanics her one true love. (Apart from Jensen Ackels, that is.) She has a passion for debate,activism, travel and photography and strongly believes in a wide variety of things. In her opinion, feminism is presently the most important concept to understand and apply, physics is the holy grail of science and of course, salt lines are a totally acceptable way to combat your fear of demons.

Sharmistha Chatterjee - She's a physics crazed, control freak with an inborn ability to manage situations. Her love for reading is surpassed only by the witticism of Sherlock or the lack of it in Ross ! She loves talking and interacting with people, exploring hangout joints and most of all lazing in lawns when it's sunny :)

Sania Heba - She considers herself a writer until someone asks her to write her own bio. Then she has an identity crisis. With a passion for writing, debate and anything that includes Doctor Who, she spends her free time looking up crazy physics theories or cooking up her own. She believes in the power of words, the need to break stereotypes and that no question is a stupid question. (Unless you question the creepiness of Weeping Angels.)

The Act of Seeing

In Sir Arthur Conan Doyle's A Study in Scarlet , Sherlock Holmes chastises his long-suffering companion and biographer, John Watson, for observing but not seeing. Here our sympathies must lie with Dr. Watson, since in reality seeing is easy, while observing is difficult – which was perhaps Holmes's point. Indeed, we do not even need to think about seeing; our eyes and brain do it all for us without conscious effort. What we think we see, that is, observe, is something altogether different.

What is it that happens when we see? This question has a basic answer in that what we see is a representation of the physical world around us. Seeing transmits information: there is a tree over there and a sea lion balancing a ball on its nose next to it. But how has the information from the strange scene just described been obtained? Was the process of seeing, that is, the gathering of the data, a passive or an active one? The ancient Greek philosophers, as one might well expect, were the first to consider this question in detail, and in general two basic ideas prevailed.

The ancient Greek were among the first to encourage active exploration. In this situation it was envisioned that a form of light (an inner fire) was generated within the eyes, and upon exiting the pupils filled the surrounding space with an active 'seeing' agent that would interact with and reflect off of solid surfaces, and then, the reflected light that returned to the eyes would reveal the vista before us – the tree, the ball, the surroundings.

Although the classical Greek notion of what light is turned out to be quite wrong, the concept was not damaging to the search for the correct interpretation and development of ideas concerning the workings of light and its interactions with matter. Indeed, the foundations of geometric optics, still valid to this day, were first (at least in part) laid down by the great mathematician Euclid of Alexandria.

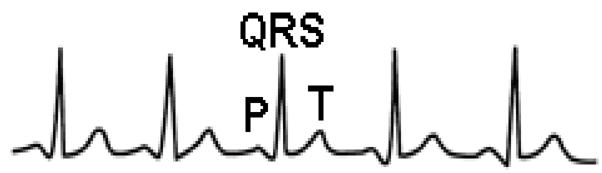
Writing circa 300 B.C. Euclid set out to explain the geometry of vision. Although much of what he wrote need not concern us here, the key, indeed, fundamental, concept that Euclid introduced was the abstract idea of a light ray. Such beams were envisioned to be thin threads of light that traveled in a specific direction (emanating from the eye as far as Euclid was concerned) in a perfectly straight line – this latter attribute being referred to as the rectilinear propagation of light. With this concept in place Euclid then argued that vision – that is, what we see – is composed of those objects situated within a vast cone of light rays, the apex of which is located at the center of the observer's eye.

The abstract concept of a light ray, and the recognition of the rectilinear propagation of light was a brilliant first step, and although it took another 400 years to work out the details, it was eventually realized that these concepts, if combined with the idea that light rays always travel along the shortest possible path, could explain the laws of reflection and refraction. Hero of Alexandria circa A.D. 100 is often given the nod as the first philosopher to explicitly state the idea of light rays traveling along the shortest path length, and he used this property to prove mathematically the law of reflection.

-Upasana Mohapatra
(Second Year)

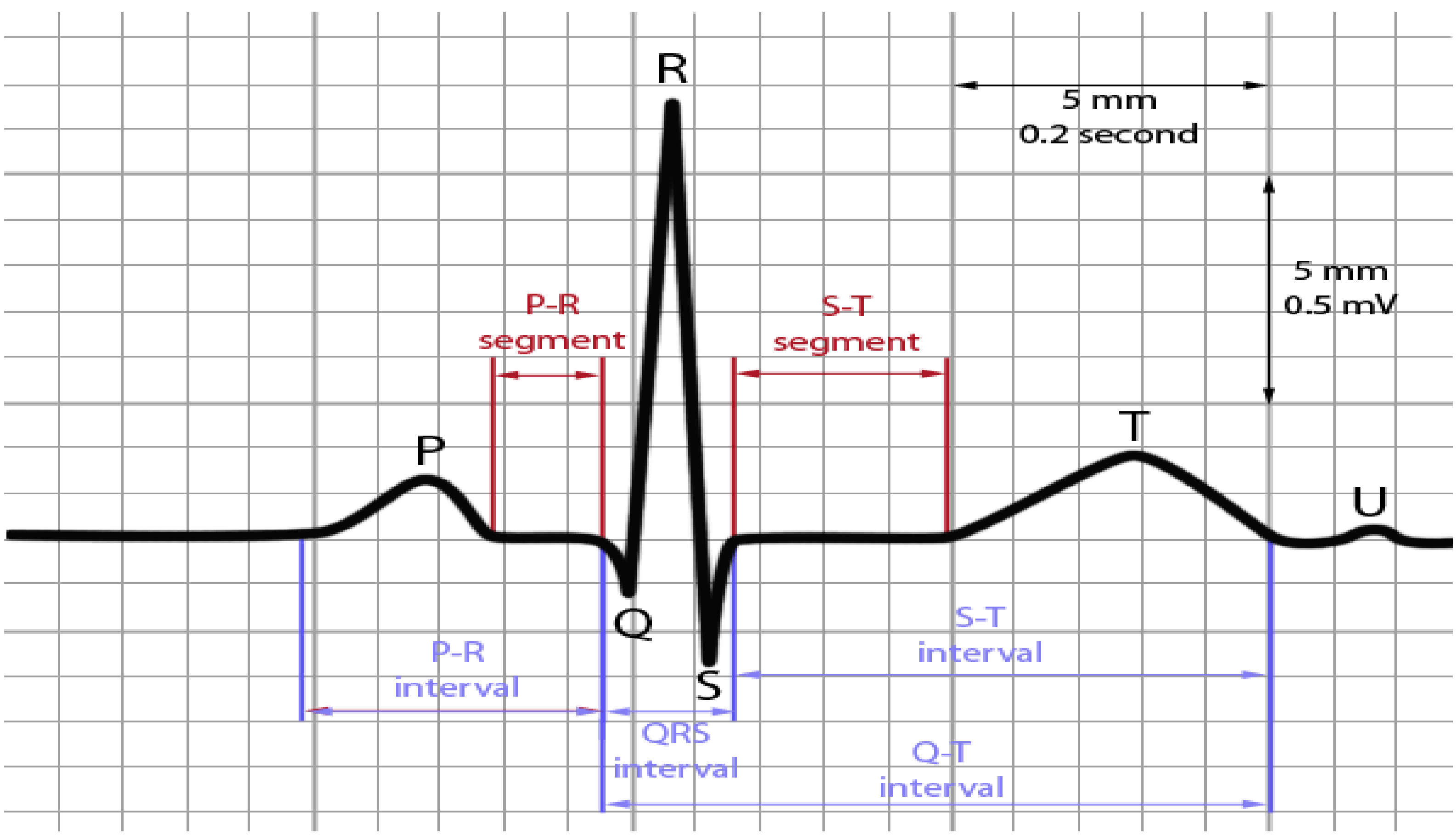
PHYSICS BEHIND ELECTROCARDIOGRAM(ECG)

The figure to the right shows a typical ECG. Three characteristic features of the waveform are easily identified: the P wave, the QRS complex, and the T wave. The P wave is associated with the activation of the atria, the QRS complex with the activation of the ventricles, and the T wave with repolarisation of the ventricles.



Electrocardiogram Intervals:

- The P-R interval is the time from the beginning of the P wave to the start of the QRS complex.
- The QRS interval or duration or width is the time from the beginning to the end of the QRS complex.
- The QT interval is the time from the beginning of the QRS complex to the end of the T wave.
- The RR interval is the time from the peak of one R wave to that of the following R wave.

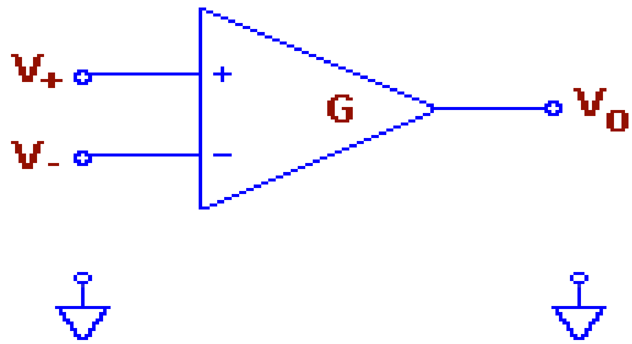


Electrocardiograph: Technical Principles

The electrocardiograph is essentially an electronic device that amplifies the very small potentials present at the surface of the body, so that they can be displayed on a video screen or recorded permanently on paper. The signal is picked up by electrodes placed at certain well-defined anatomical positions on the body surface.
ECG is an electronic amplifier with two input terminals, a non-inverting input terminal (+) and an inverting input terminal (-). The output voltage V_o is simply proportional to the difference between the voltages V^+ and V^- appearing at the two input terminals:

$V_o = G(V^+ - V^-)$,

Where, G is the gain of the amplifier.
The amplifier is thus termed a differential amplifier, since it measures the difference between two voltages.



Electrical voltage or potential, unlike length or mass, is not an absolute quantity, but rather a relative quantity, in that potential itself cannot be measured, only differences in potential. Thus V+ and V- are each measured with respect to some third reference point that is arbitrarily taken to be at zero potential. In electrocardiography, this point is the right leg.
The differential amplifier has the advantage that any component of the signal appearing simultaneously at both inputs is cancelled out and so does not appear at the output. This "common-mode rejection" is important, since electrical 115-volt power wiring in a building can induce signals at 60 Hz (the power line frequency) on the body surface that are many times larger than the ECG signal itself. Use of a differential amplifier prevents this large spurious signal from swamping out the ECG signal.

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Raagya Arora
(Second Year)

THE MORE YOU KNOW: HALO PHENOMENON

The word '**HALO'** means a nimbus, ice-bow or gloriole.
Halo phenomenon is an optical phenomenon produced by light interacting with ice crystals and clouds in the atmosphere, resulting in a wide variety of colored or white rings, arc and spots in the sky. Many Halos are formed near and around the sun or moon. The colors of these rings are red on the inside and violet on the outside.
This phenomenon is basically due to the optical phenomena of **reflection** and **refraction** of light that passes through the ice crystals present around the sun or moon in the sky. Due to this refraction of light through these ice crystals, seven colors are seen in a halo (red, orange, yellow, green, blue, indigo and violet). Atmospheric phenomena such as halos were used as part of weather forecasting before meteorology was developed. They often mean that the rain is going to fall within the next 24 hours.

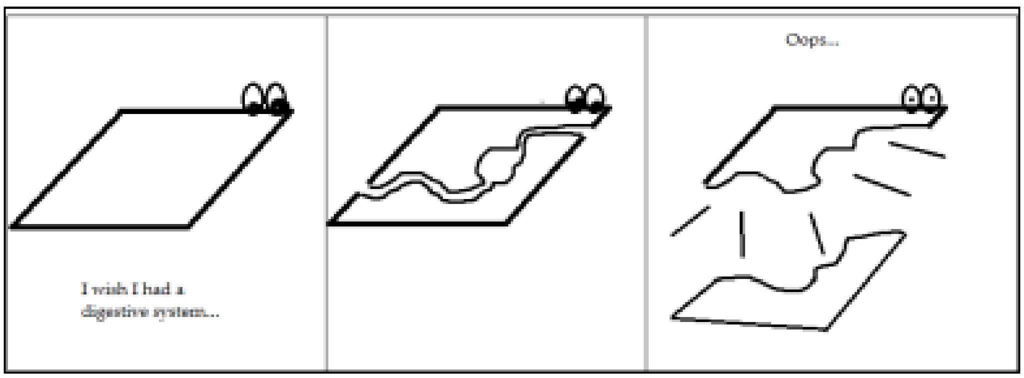
Due to the complex combination of different types, orientation, movement patterns of the ice crystals and the angle of the sun, there can be many types of halos. The most common among them is **22° inner halo** (also known as the small halo), which means that the visual radius (the angle of vision lines between the sun or moon and the solar or lunar halo) is 22°.

-Tanya Verma
(Second Year)

Extra Dimensions, String theory and the TARDIS!

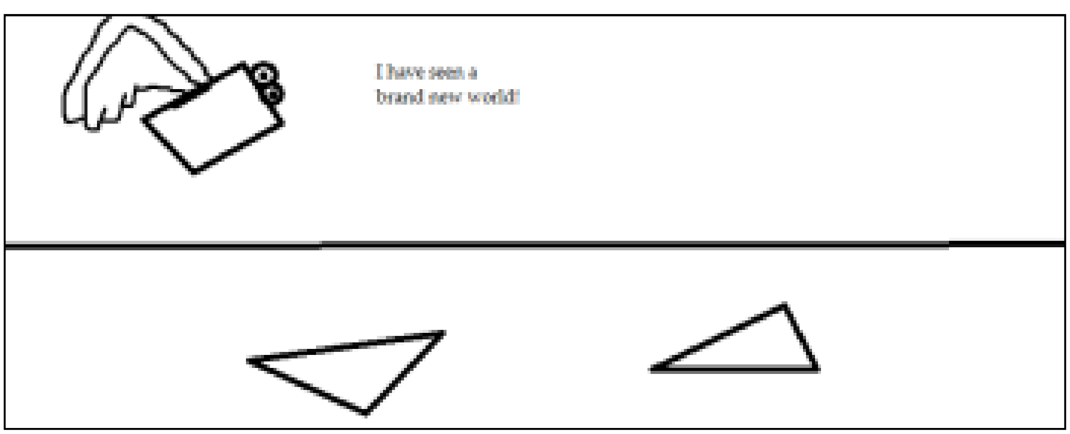
Imagine if I told you that your notion of reality is flawed. Imagine if I told you that instead of being three dimensional beings, you are just an imprint of a four dimensional snake like object in a three dimensional world. Sounds crazy doesn't it? Well it might not be very far from the truth. It's hard to visualise four dimensions, but string theory tells us there might as well be 10 dimensions. Outrageous! You say. Why can't we be happy with the three we have? Apart from the fact that the string theory is our best shot (as of now) at uniting the classical and quantum mechanical models of physics, it also has something to do with gravity. Or rather, the weakness of gravity. Now, gravity is very much weaker than electromagnetic force and scientists were trying to figure out why. So they came up with a theory that states that gravity drops down much faster that electromagnetic force because of the extra dimensions it traverses.

Coming back to the dimensions. The first proposed example to explain these dimensions (which I will ~~steal~~ er…quote) is the flatlanders. Flatlanders are two dimensional beings (something like *conscious paper*). A flatlander can't have any kind of digestive tract with two openings because that will rip them apart. A bit like this:

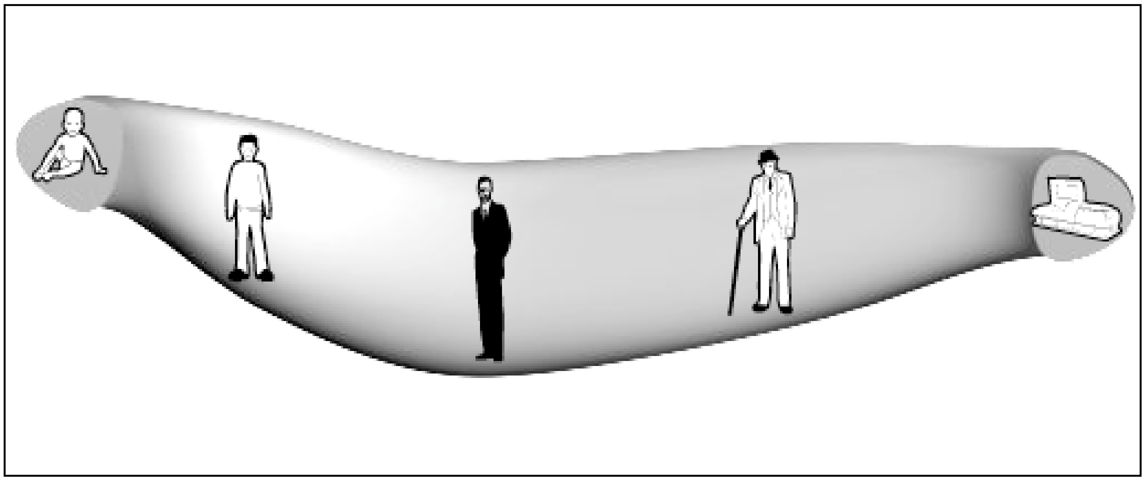


So our conscious paper or flatlander perceives everything two-dimensional-ly. In its world, there is just left and right but no concept of *above*. So for example, if a flatlander (let's say, a very orthodox and stubborn square) comes in contact with another flatlander (say, a triangle), the only way it can figure out the shape of the triangle is by observing how the lengths change as it moves around the triangle.

Now to convince this stubborn square that there does exist a three dimensional world, we'd have to pull it up in space (our 3-dimensional world). By observing his 2-dimensional world from our 3-dimensional world, our flat friend would see the error of his ways.



If we apply this same analogy to us, we become the ignorant, arrogant square trapped in our 3-dimensional world. The only way we can effectively visualize the fourth dimension is if a four dimensional being pulls us into his world. Scientifically, this fourth dimension is time. And so we come to our snake-y incarnations. If we were to perceive ourselves in the fourth dimension we would look something like this:



We can continue theorizing more and more dimensions until we reach the tenth dimension.
Now, this is not all theoretical, mind you. We can actually test for the existence of more dimensions at the LHC, CERN.

And this is where my imaginative musings begin. So we might have extra dimensions. And if you have seen the first video referenced, you might know that it is possible to *jump* from one place to another in a single dimension by*using the dimension above it.* So for example a flatlander can traverse the entire length of a flat piece of paper *instantly,* if we were to somehow roll the paper in the third dimension. This, my friends, is *teleportation.* Similarly, if we were to somehow, fold the dimension of time we could, theoretically jump from one point in our timeline to another point instantly. Or in another words time travel. So here is my theory, (completely imaginative), the Doctor is a humanoid alien. And his TARDIS makes these *trans-dimensional* jumps possible. But we know that the TARDIS itself is a living being. So that would make TARDIS a higher dimensional being. If travel between parallel universes was also possible, I would say the tenth dimension. So it can not only travel in time but also in space…

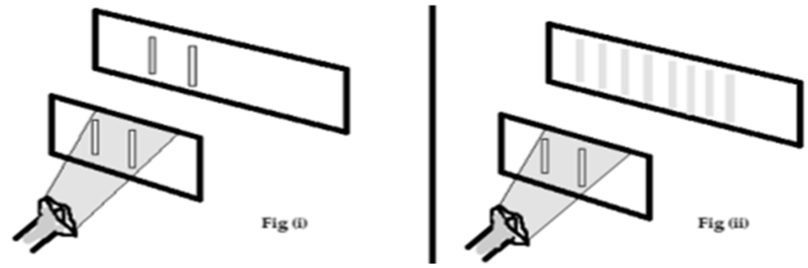
Intrigued much?

-Sania Heba
(Second year)

Confundo! Two slits and...*a thing*

For the duration of this article, I would request you to take a metaphorical spade, dig a six feet deep hole in the far recesses of your logical brain, and bury your common sense there. Because if we are to dive into the complexities of this particular theory, logic is the last thing of any help. The theory I am talking about is of course, quantum theory: the most confusing, most wibbly-wobbly, and therefore, in my opinion, the most *astounding* theory to grace the history of physics.

It all started with an experiment with light. You take a light beam, pass it through two slits and voila! Instead of the pattern your logical brain would suggest (fig i), you actually get something of the form of fig (ii).



Well, that's because light behaves as a wave! You say. *It's a standard interference pattern!* That's all high school physics, I know. The experiment displayed the wave nature of light. But there was also a lot of evidence supporting that light is made up of particles called photons. The question now was if light is made of photons and photons are indeed particles, if you send single photons through the slits, would you get the same result? The logical brain again says no. If you throw balls through two holes in a wall you would just get two piles of balls not a pattern. To which quantum theory just gives a smug smile. *Ah logic. Ridiculously boring*.

And then a team of scientists finally performed the experiment with photons, in Paris in the 1980s. Any guesses on the result? Ten points to Ravenclaw if you guessed that the pattern observed after sending millions of photons *one by one* through the slits was the same as the pattern in fig (ii). Now sit back and take a moment to comprehend these results. You send a photon through the silts. It hits a point on the screen or photographic plate or whatever leaving a mark. The second photon does the same but arrives at a *different* location. Then the third, then the fourth and so on until millions of photons later the pattern begins to emerge. It's as if the photon has gone through both the slits at once, interfered with itself and arrived at a point. But even if the photon somehow performs this feat, how does it know exactly where to place itself? Why don't all the photons follow the same trajectory and arrive at the same spot? And so the problem was laid out and physicists all over lost their nights' sleep to come to a solution. And they did come to a conclusion which was somewhere along the lines of this:

Of course there were some people who just said maybe it's a weird property of light. Maybe that is all there is to it. And quantum theory gave a condescending smile again. Because soon the experiment was being repeated with other particles, electrons and then finally atoms and the results were the same *every single time.* After the predictability of Newton's laws, the uncertainty that quantum theory brought to the table changed forever the way we look at physics.

-Sania Heba
(Second year)

FRACTALS

A fractal is a natural phenomenon or a mathematical set that exhibits a repeating pattern that displays at every scale. If the replication is exactly the same at every scale, it is called a self-similar pattern. An example of this is the Menger Sponge. Fractals can also be nearly the same at different levels

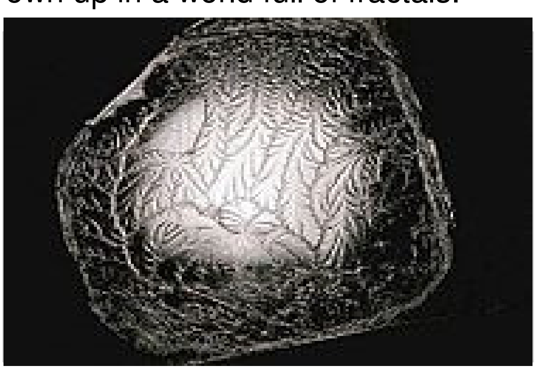
The mathematical roots of the idea of fractals have been traced through the years as a formal path of published works, starting in the 17th century with notions of recursion, then moving through increasingly rigorous mathematical treatment of the concept to the study of continuous but not differentiable functions in the 19th century, and on to the coining of the word *fractal* in the 20th century with a subsequent burgeoning of interest in fractals and computer-based modelling in the 21st century. The term "fractal" was first used by mathematician Benoît Mandelbrot in 1975. Mandelbrot based it on the Latin word *frāctus* meaning "broken" or "fractured", and used it to extend the concept of theoretical fractional dimensions to geometric patterns in nature.

As mathematical equations, fractals are usually nowhere differentiable. An infinite fractal curve can be conceived of, as winding through space differently from an ordinary line: still being a 1-dimensional line yet having a fractal dimension indicating it also resembles a surface.

According to Falconer, rather than being strictly defined, fractals should, in addition to being nowhere differentiable and able to have a fractal dimension, be generally characterized by a gestalt of the following features;

- Self-similarity, which may be manifested as:
    1. Exact self-similarity: identical at all scales; e.g. Koch snowflake
    2. Quasi self-similarity: approximates the same pattern at different scales; may contain small copies of the entire fractal in distorted and degenerate forms; e.g., the Mandelbrot set's satellites are approximations of the entire set, but not exact copies.
    3. Statistical self-similarity: repeats a pattern stochastically so numerical or statistical measures are preserved across scales; e.g., randomly generated fractals; the well-known example of the coastline of Britain, for which one would not expect to find a segment scaled and repeated as neatly as the repeated unit that defines, for example, the Koch snowflake
    4. Qualitative self-similarity: as in a time series
- Multifractal scaling: characterized by more than one fractal dimension or scaling rule.
- Fine or detailed structure at arbitrarily small scales. A consequence of this structure is fractals may have emergent properties.
- Irregularity, locally and globally, that is not easily described in traditional Euclidean geometric language. For images of fractal patterns, this has been expressed by phrases such as "smoothly piling up surfaces" and "swirls upon swirls".
- Simple and "perhaps recursive" definitions see Common techniques for generating fractals.

Perhaps the most remarkable thing about the study of fractals is that there are fractal patterns all around us! Even if you don't think you know anything at all about fractals yet, you actually already do, because you've grown up in a world full of fractals.



A fractal is formed when pulling apart two glue covered acrylic sheets

High voltage breakdown within a 4"block of acrylic creates a fractal Lichtenberg figure

-Pragya Arora
(Second Year)

A universe as beautiful as you...

I have never seen a flower blush, when I took its hue
and held it there a prisoner captive to my view.
I have always heard the song that is in the autumn breeze,
playing taps in harmony with the forest leaves.
I love the smell of rain that brings the spring-time into bud,
and swells my love of nature into a teeming flood.
I celebrate the cycle of the daytime into night
and find equal blessing in the shadow and the light.
I've always felt affinity for all created things,
and surrender to the pleasure that their beauty brings.
And though I could spend a lifetime sailing on drops of dew,
I have never seen a universe as beautiful as you.

I've often sat myself by gentle mountain streams,
and overflowed the dams that were holding back my dreams.
I've breathed the scented forest on the mountainside,
and washed away my sorrows in an evening ocean tide.
I've laid down in a meadow and debated with the moon
and spent some quite moments on the surface of Neptune.
I got married to a zodiac with one of Saturn's rings,
then spied a supernova and went on a cosmic fling.
I've run away to nebulae in galaxy brochures,
and bathed in scenes of wonders on distant planet shores.
Every cosmos in creation could parade before my view,
But I've never seen a universe as beautiful as you.

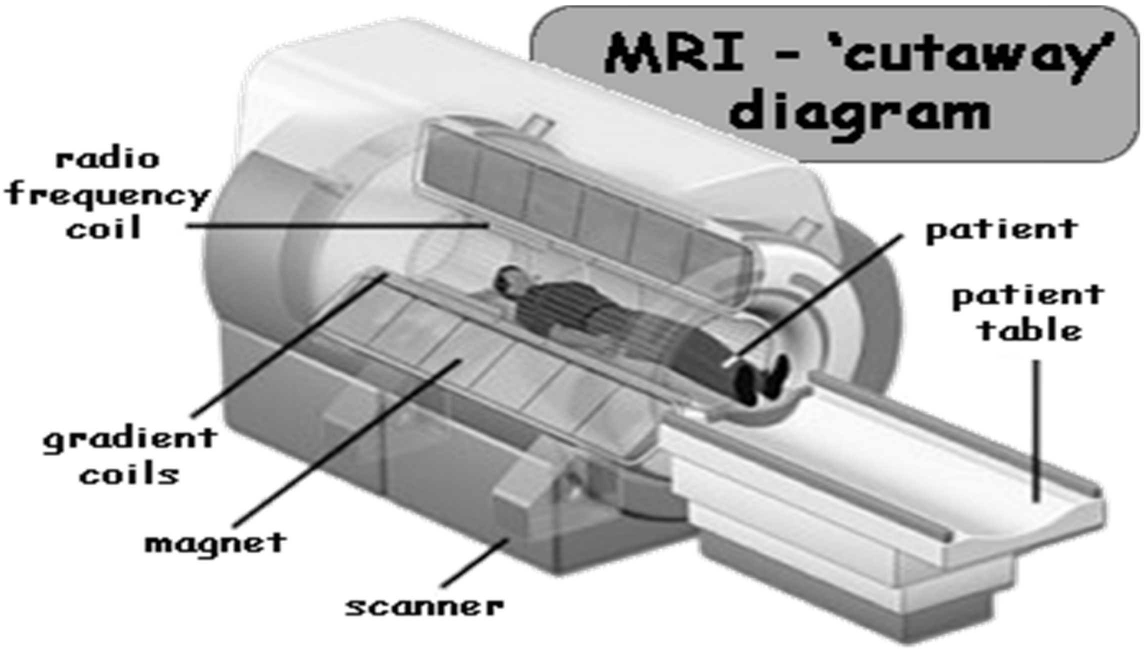
I've never seen a tree once withdraw its shade,
and deny a creature, the comfort of its aid.
I've never seen any anger in the Sun at noon,
when it burns relentlessly on the desert dune.
At sunrise I take an oath to live with all my might,
and reinforce my gratitude each and every night.
I could spend some hours riding on a crystal flake,
drifting wildly in a gale mindless of my fate.
Many times I've been through trials of wind and rain and snow,
then sentenced the splendours that the seeds show.
And though I have searched throughout creation, I must say this is true,
I've never seen a universe as beautiful as you.

-Priyanka
2nd year

PHYSICS INVOLVED IN MRI

Magnetic Resonance Imaging (MRI) works by measuring the way the hydrogen atoms absorb and then relax and re-emit electromagnetic energy. Most of the human body is made up of water molecules, (which consist of only hydrogen and oxygen atoms) and fat, (which also contains hydrogen atoms). You are made up of about 60% hydrogen atoms!

The nucleus of a hydrogen atom is a proton, and protons are very sensitive to magnetic fields. When the proton spins it generates a magnetic field. Therefore the nucleus of a hydrogen atom is like a tiny magnet. When your body is in a strong magnetic field all of your hydrogen nuclei align - just like a row of compass needles lining up with a magnetic field.



MRI scanners use powerful magnets. When the powerful magnets that are used in magnetic resonance imaging (MRI) are switched on, all the protons in your body are pulled so that they spin in the same direction, in the same way that a magnet can pull the needle of a compass. The scanner contains several electric coils. This produces variations in the strength of the magnetic field at different points in your body. This variation means that each hydrogen nucleus experiences a slightly different magnetic field strength. This is important for detecting the position of a particular hydrogen nucleus. The frequency of these waves depends on the strength of the magnetic field where each nucleus is and this means that the scanner can work out the location of each nucleus.

The MRI scanner sends a pulse of radio signals to certain areas of the body which 'snaps' the protons out of position. The pulse gives enough energy to the hydrogen nuclei in that area to change direction. When the pulse of energy ends the nuclei snap back to their original orientation and each nucleus gives off energy in the form of a radio wave. When this happens, each proton transmits a radio signal that provides information about its exact location in the body. On its own, a single proton will not provide much useful information, in the same way that a single pixel on a computer screen is essentially just a coloured dot. However, just as millions of pixels can create images, so the radio signals of millions of protons can be collected together and combined to create a detailed image of the inside of the body and also allow the scanner to work out what type of body tissue the hydrogen nuclei are part of.

-Raagya Arora
(Second Year)

BIOSIGNATURES AND SEARCH FOR EXTRA TERRESSTRIAL LIFE

DEFINITION

A biosignature is any substance – such as an element, isotope, molecule, or phenomenon – that provides scientific evidence of past or present life. Measurable attributes of life include its complex physical and chemical structures and also its utilization of free energy and the production of biomass and wastes. Due to its unique characteristics, a biosignature can be interpreted as having been produced by living organisms; however, it is important that they not be considered definitive because there is no way of knowing in advance which ones are universal to life and which ones are unique to the peculiar circumstances of life on Earth.

In astrobiology

Astrobiological exploration is founded upon the premise that biosignatures encountered in space will be recognizable as extraterrestrial life. The usefulness of a biosignature is determined, not only by the probability of life creating it, but also by the improbability of nonbiological (abiotic) processes producing it. An example of such a biosignature might be complex organic molecules and/or structures whose formation is virtually unachievable in the absence of life. For example, some categories of biosignatures can include the following: cellular and extracellular morphologies, biogenic substance in rocks, bio-organic molecular structures, chirality, biogenic minerals, biogenic stable isotope patterns in minerals and organic compounds, atmospheric gases, and remotely detectable features on planetary surfaces, such as photosynthetic pigments, etc

Biosignatures need not be chemical, however, and can also be suggested by a distinctive magnetic biosignature. Another possible biosignature might be morphology since the shape and size of certain objects may potentially indicate the presence of past or present life. For example, microscopic magnetite crystals in the Martian meteorite ALH84001 were the longest-debated of several potential biosignatures in that specimen because it was believed until recently that only bacteria could create crystals of their specific shape. However, anomalous features discovered that are "possible biosignatures" for life forms would be investigated as well. Such features constitute a working hypothesis, not a confirmation of detection of life. Concluding that evidence of an extraterrestrial life form (past or present) has been discovered, requires proving that a possible biosignature was produced by the activities or remains of life. For example, the possible biomineral studied in the Martian ALH84001 meteorite includes putative microbial fossils, tiny rock-like structures whose shape was a potential biosignature because it resembled known bacteria. Most scientists ultimately concluded that these were far too small to be fossilized cells. A consensus that has emerged from these discussions, and is now seen as a critical requirement, is the demand for further lines of evidence in addition to any morphological data that supports such extraordinary claims.

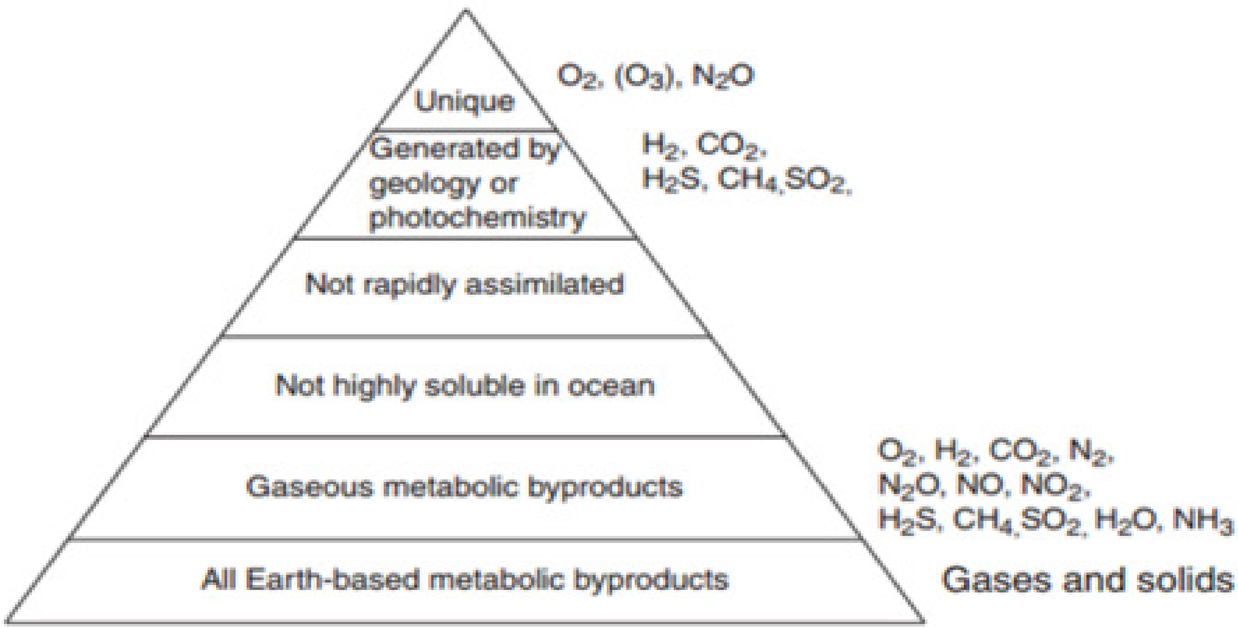
More on Earth's Biosignatures

The table below also gives some of the pros and cons of different biosignature candidates on Earth.

Biosignature	*Example*	*Pros*	*Cons*
Inorganic gases	Oxygen, ozone, methane	Detectable in planetary spectra	Most are also produced abiotically
Organic gases (not including methane)	DMS, isoprene (and other foliar emissions)	Many different compounds	Usually existing in very small concentrations
Solids	Banded iron formations Sulfur	Stability, greater range of compounds	Requires localized sources difficult to detect
Photopigments	Chlorophyll	Fairly unique	Relatively complex in an evolutionary sense
Dissolved molecules	Ocean chemistry	Can sustain a great range of compounds; life lives in water	Dilute, relatively little partitioned into vapor phase

More on Earth's Biosignatures

On Earth, there are a large number of chemical biproducts produced by the many forms of life. But, only a small subset of these are classified as biosignatures. This is because biosignatures must first of all be gaseous, otherwise they could not be detected in transmission spectra. Of those gaseous byproducts, those that are known to be produced naturally through geology or photochemistry must also be eliminated. Of the remaining chemicals, those that are soluble in water or easily broken down are less likely to be found. The final set of all remaining biosignature candidates are oxygen (O_2), ozone (O_3), and nitrous oxide (N_2O). Scientists also look for water (H_2O) and methane, however they can also be produced naturally and so are not considered strong biosignatures. This hierarchy of biosignature classification is illustrated in the image.



SEARCH FOR EXTRA TERRESTRIAL LIFE

Extraterrestrial life of or belonging to Earth"]) is defined as life that does not originate from Earth. It is often also referred to as alien life, or simply aliens (or space aliens, to differentiate from other definitions of alien or aliens). These hypothetical forms of life range from simple bacteria-like organisms to beings far more complex than humans. The possibility that viruses might also exist extraterrestrially has been proposed. Many scientists consider extraterrestrial life to be plausible, but there is no direct evidence of its existence. Since the mid-20th century, there has been an ongoing search for signs of extraterrestrial life, from radios used to detect possible extraterrestrial signals, to telescopes used to search for potentially habitable extrasolar planets. It has also played a major role in works of science fiction.

-Pragya Arora
(Second Year)

Till The End of Time

Like a pendulum, she swayed with life.
On a crest today, reaching equilibrium tomorrow.
Few seconds of stability when chaos is least
Everything in place, just like it should be.
But one blink of an eye and she's sliding down a slope
Leading to a trough of disappointments and regret
Waiting for her like she's a prey.
She succumbs to the pull of negativity, falls in the pit.
Crouching in the corner, trying to get up.
As the clock of life ticks on, she gathers her courage
Learns her lessons, decides to fix her life.
She applies the vital external force and conquers inertia
Finally standing back on her own feet, she hears her calling loud and clear.
She starts climbing back, closer to her dreams
The pitch of her calling were getting higher
She looks back and smiles at Doppler.
Pushing forward, she reaches where she belongs to
Physics was in her blood, but she wasn't the only one.
She finds entities that share her spark
Some were an up, others a down quark.
A strange force pulls them together and glues them up
She reaches a closeness she had never felt before,
They stuck strong, the three of them building a proton.
But that wasn't the end, but just a beginning
Of new friendships and stronger bonds
They went ahead and interacted with more exotic entities
Bumping into them time and again
Forging new links they went on
Till they called themselves nucleons.
Now their amity grows older than time
And they stand at crossroads, as the Universe inflates
A choice has to be made, whether to stay or to go
To choose balance or add to entropy, instead.
But deep down their hearts, they all know
Whether they dwell or advance
Their centers shall always attract
The force holding them together will remain intact
Till the end of time,
Till the end of time.

-Shruti Chakravarty
(Third Year)

PHILAE LANDS!

While India was celebrating its scientific advancements after the Mars Orbital Mission, another phenomenal mission by the European Space Agency (ESA) was taking the World by a storm. Yes! I am talking about the much less reported ROSETTA SPACE MISSION. This mission which has for the first time landed a robotic probe-*Philae* on the surface of a comet and also, put a spacecraft in orbit around it has been voted the most important scientific breakthrough of 2014 by the editors of the journal "*Science*". By landing the Philae probe on a distant comet, 67P/Churyumov-Gerasimenko just inside Jupiter's orbit, the Rosetta team has begun a new chapter in our understanding of how the solar system formed and evolved and ultimately, how life came to be on Earth.
Rosetta mission, launched on March 2, 2004, made four slingshot flybys to boost its speed — one around Mars and three around the Earth. On its journey to the comet, it photographed asteroids, studied other comets and provided information about the atmospheres of Venus and Mars. Scientists at the ESA put Rosetta in hibernation mode in June 2011 while it travelled a distance of 373-million-mile (600 million kilometers). It was awakened again in January 2014, when it still had four more months to travel. Philae, made contact on 12th November, 2014.
Rosetta's payload includes instruments that will provide information about how the comet develops its coma and tails, how its chemicals interact with one another and with radiation and the solar wind and, will analyze the comet's composition and atmosphere.

Preliminary analysis of data sent back from Philae's Cosac instrument suggests that there are carbon-based organic molecules on the comet. This could prove to be very important information for scientists studying conditions on the very young Earth, which is believed to have been regularly bombarded by comets. The lander's *Mupus* instrument was also able to hammer at the comet's surface, which we now know is covered by a layer of dust about 10–20 cm thick on top of an unexpectedly hard material thought to be water ice. An instrument on Rosetta has detected water, methane and hydrogen as well as rarer molecules such as formaldehyde and hydrogen cyanide, findings that could indicate whether comets delivered the vital ingredients of life to the early Earth. Scientists using the ROSINA mass spectrometer discovered that the ratio of deuterium to hydrogen in the comet is much greater than that found on Earth.

This adds strength to the growing body of evidence that the water on Earth was delivered by asteroids and not by comets contrary to what was thought earlier.

The mission, however, was not without its problems. Despite landing in an awkward position where its solar panels do not currently receive enough sunlight to power its instruments, Philae managed to complete all of its planned measurements on battery power alone. The lander was also not able to secure itself to the comet surface as planned, however it did manage to drill into the surface and acquire a sample for analysis.

-Sharmistha Chatterjee
(Second Year)

Source: Facts about the mission taken from http://rosetta.esa.int/

GREEN FLASH!

A green flash is an optical phenomenon that occurs right after sunset or right before sunrise. The word "flash" refers to the sudden appearance of a green color which stays for a brief duration, usually lasting about a second or two at moderate latitudes. Usually, the effect is very subtle, but occasionally the result is intense. The green flash is not that common and is visible only if the sun is rising or setting on a clear, unobstructed and low horizon.

Green flashes occur because the Earth's atmosphere acts like a weak prism to refract (bend and spread out) sunlight into a spectrum of individual colors — red, orange, yellow, green, blue and violet. Red has the longest wavelength and Violet has the shortest. Therefore, Blue and violet light are refracted the most and red light is refracted the least. This scattered blue light is the reason the sky appears blue. During the course of the day, the Sun's disk is fully visible above the horizon and so, the different colors of light rays overlap to the extent where each individual color cannot be seen by the naked eye. During sunrise or sunset, the sun is at the horizon and light travels a longer distance than it does during the day, hence only the red component of light reaches our eyes, causing the sun to appear red at these times.

As the sun starts to slip below the horizon, the colors of the spectrum disappear one at a time, red rays sliding below the horizon first. In general, therefore, the red image of the Sun disappears first, followed by yellow, green, blue and violet. So, at sunset (or sunrise), the refractive delay of the sunset is usually a second or two longer for blue and violet than for red. At an instant when the other wavelengths have just slipped below the horizon, we observe a *green flash*. The violet and the blue colors do not reach the eye of the observer as they are refracted by air molecules in all directions and green is the last color seen at sunset. Hence, the momentary green flash! It is possible to observe this phenomenon only when the sky is clear and stable. On very rare occasions, with particularly clear air, enough of the blue or violet light rays make it through the atmosphere, causing even a blue flash to be visible.

At sunset, the color usually goes from red or orange to green or blue. At sunrise, the process is reversed, and a green flash may occur as the top of the sun peeks above the horizon.

-*Sharmistha Chatterjee*
(Second Year)

INSIGHT

"*Rigorous reasoning is crucial in mathematics, and insight plays an important secondary role these days. In the natural sciences, I would say that the order of these two virtues is reversed. Rigor is, of course, very important. But the most important value is insight--insight into the workings of the world. It may be because there is another guarantor of correctness in the sciences, namely, the empirical evidence from observation and experiments."*

Thinking in the language that a person is aware of requires no effort. One could say the same when referred to "Insight". To a physicist who has a proper insight of the physical world, he could effortlessly think about a physical phenomenon backed only by his insight. Insight is very subtle and yet, very powerful within itself. People who haven't had the opportunity to go to school, or haven't studied science base their little knowledge of science from evidences and experiences.
There is a natural pattern on how and why things happen and these people follow the pattern, which is entirely instinctive and insightful. Personally, I have started my own endeavor in science from one such beautiful insight.

Of course rigorous reasoning is important because it gives a definite answer. However, it is not the only way to finding an accurate answer, at least not in Natural Sciences. As Professor Jagannathan mentions, there are empirical evidences from observations and experiments that guarantees the correctness in the sciences.

When I was in high school, I remember our Tibetan teacher explaining that the three sources of knowledge in Buddhism are experience, reason and testimony. He went on to describe that experience plays the most important role, followed by reason and testimony in that order. That is, as important as rigorous reasoning may be, the validity of reasoning is derived only when there are considerable empirical evidences backing it up. And insight generates everything from rigorous reasoning, discoveries to empirical evidences and more.

I have learned that insight gives me a chance to be original above all else. When someone gives herself to the power of insight, she creates the path to discoveries and inventions or more powerful insights, which is the most original creation.

-Tenzin Kunsang
(Second Year)

Hearing Colors!

Ever thought of hearing a color? What if you could hear your red dress say ‘red’? When we can see with our eyes and hear with our ears in the first place, this thought sounds really weird, right? Not anymore. For people born with achromatopsia (absence of color vision) seeing colors is nearly impossible, but thanks to advancements in science they can now hear colors.

In 2003, Adam Montandon along with artist Neil Harbisson created an eyeborg which is a body modification app that fits on the wearer’s head and helps him/her perceive colors through sound waves. The head mounted antenna senses color, converts it into a real time sound wave. This sound wave reaches the ear by the bones of the skull through the process of bone conduction. In this process the bones of the skull conduct the sound wave and send it to the ear.

This device – the eyeborg - is fitted with a color sensor which detects the frequency of the color and sends it back to frequency chip installed in it. Since every color has a characteristic frequency the chip installed in the device reads that frequency and then produces a sound. That sound is different for all the colors. For example, red sounds like a long beep and green like a short beep, etc. With regular use of the device, the person with color blindness can detect the color present in front of him/her because he/she can remember the sound corresponding to each color. It’s similar to how we recognize color by how they look whereas a color blind will recognize it by how it sounds. It is obviously a difficult job remembering a color by sound but it’s similar to the process of learning all children undergo when they’re taught the names of colours and must remember that an apple is usually of the color red and that grass is green.

Eyeborg is not only beneficial to people who are blind to colors, but it can also be used to enlarge the scope of one’s vision. The device lets one recognize infrared and ultraviolet rays, which are undetectable to human ears, by making them audible.

Another very interesting thing that is possible through this device is the inverse of the process. The device, as already mentioned, creates a sound for each color. Therefore, we can now create the color pattern of a sound. For example, if your name has 10 short beeps and 10 long beeps then the sound of your name creates a pattern that comprises of the colors red and green. This way we have a color pattern corresponding to what we speak. Our words get colored! Neil Harbisson created a color pattern of Adolf Hitler‘s speech . [To check that out, listen to his Ted talk ‘I listen to colors’; link given at the end of the article.]

It is outstanding to have come up with an application of frequency that could help people with color blindness perceive colors. This application also illustrates how our body adapts to new senses. It is a wonderful coordination of our brain, ears and eyes, made possible through innovations in the field of science.

P.S: Link to Neil Harbisson’s Ted talk:
http://www.ted.com/talks/neil_harbisson_i_listen_to_color?language=en#t-475618

-Pooja Malik
(Second Year)

MATTER, ANTI-MATTER, DARK MATTER….. Are they family members??

To understand the relationship between matter, anti-matter & dark matter, let's begin with our junior classes' definition of matter.
Since our childhood we have learnt that matter is anything that has mass and volume (occupies space). For example, a car would be said to be made of matter, as it occupies space, and has mass.
Matter is usually classified into three classical states i.e. solid, liquid and gas, with plasma sometimes added as a fourth state.

All the objects from everyday life that we can bump into, touch or squeeze are composed of atoms. This atomic matter is in turn made up of interacting subatomic particles—usually a nucleus of protons and neutrons, and a cloud of orbiting electrons.

Matter might dominate the Universe today, but this hasn't always been the case. When particles of matter were forged in the intense heat of the Big Bang, they were accompanied by equal quantities of 'anti-particles', identical in mass but with an opposite electric charge.
Every elementary particle in the Universe appears to have a partner particle called its antiparticle that shares many of the same characteristics, but many other characteristics are the opposite of those for the particle. For example, the electron has as its antiparticle the antielectron.

The British physicist Paul Dirac first predicted the existence of antimatter in 1928. For each of his theoretical equations, there appeared to exist another associated solution, with all the properties reversed, which did not seem to physically exist in the known universe. This antimatter, then, is the "mirror image" of matter, and the antiparticles of which it is composed are the mirror images of normal particles, being the same size but having opposite electrical charge.
Because the properties of matter and antimatter parallel each other, we believe that the physics and chemistry of a galaxy made entirely from antimatter would closely parallel that of our matter galaxy. Thus, is conceivable that life built on antimatter could have evolved at other places in the Universe, just as life based on matter has evolved here.

Now the question arises: then what is dark matter??
Dark matter is the general term for matter that we cannot see to this point with our telescopes, but that we know must be there because we see its gravitational influence on the rest of the Universe. Many different experiments indicate that there is probably 10 times more matter in the Universe (because we see its gravitational influence) than the matter that we see. Thus, dark matter is basically what the Universe is made out of, but we don't yet know what it is!

There are various candidates for the dark matter, ranging from ordinary matter that we just can't see because it isn't bright enough (for example, ordinary matter bound up in black holes, or very faint stars, or large planet-like objects like Jupiter) to more exotic particles that have yet to be discovered
The nature of the dark matter is perhaps the most fundamental unsolved problem in modern astronomy.
Could the Dark Matter be Antimatter?

-Sarojini Mahajan
(Second Year)

THE FAMOUS ARCTIC!

Imagine the night is dark and you can see the stars stretch out like a vast canopy above you when suddenly you notice a shimmering green light that rises above, forming patterns. .. Soon then is a curtain of green waving across the sky.

People in this continent say that they can hear the snow and sometimes, the sun wears a crown; the boats fly, and people lose the track of land and sky.

You are in Arctic my friend. It is a polar region located in the northernmost part of earth. Still wondering why boats fly here and how the sun wears a crown? Read on ahead to find out!

Due to the special atmospheric conditions in the Arctic, it is possible to see and hear unbelievable things here. Let's talk about a few such phenomena and try to understand the scientific reason behind them.

Aurora: Also called the 'northern lights', these appear in the clear, dark nights of the Arctic during the periods of active solar storms. A solar storm/wind occurs when plasma particles that escape from the burning surface of sun enter into the space. These solar winds travel at extraordinary speed and when they reach the earth, a few such space matters are deflected, while a few others bombard earth's magnetic field and deform it. These space particles come in contact with atmospheric gases, which produce the aurora.

Sun's crown: A corona is a luminous ring that surrounds the sun or moon. It is caused by the diffraction of light coming from the sun or the moon when they shine through a diffuse mist or thin cloud. The light is diffracted around the cloud droplets. It looks similar to halos, and the difference between the two is the process of formation: halos are formed when light is refracted as it passes through ice crystals present in a cirrostratus cloud.

The Flying Boat: The flying boat is an optical illusion which occurs in the Arctic due to a particular weather condition called the temperature inversion, wherein cold air lies close to the ground with warmer air above it. Since cold air is denser than warm air, it bends light towards the eyes of someone standing on the ground, thus changing the appearance of a distant. Distant objects can appear to float high above their actual position, such as a boat that looks like it is floating in the sky, or an object below the horizon can become visible.

Whiteouts: Whiteouts occur when the sky and snow assume a uniform whiteness, making the horizon indistinguishable and eliminating the contrast between visible objects both near and far. To a human eye, this appears as though the sky and the land have become one.

Hearing Snow: People have sometimes reported hearing noises from very far away, while in the Arctic. This phenomenon occurs because cold atmospheric conditions bend sound waves differently than the air at lower latitudes. At latitudes as high as at the Arctic, the air near the surface tends to be colder and denser than air above it. This causes sound waves to tend to bend down toward the surface rather than up and away from the earth, as they do in more temperate latitudes where air temperature, on average, decreases with height. The range at which sound can be heard depends on the temperature of the air, the speed and direction of the wind, and the rate at which sound energy is absorbed by the earth's surface. For instance, soft snow absorbs sound energy very efficiently, effectively muting the transmission of sound. In contrast, a hard-crusted snow surface absorbs little energy and a smooth ice surface is an almost ideal reflector of sound. Therefore, given the right conditions, conversations in the Arctic can sometimes be heard up to three kilometers away.

-Pooja Malik
(Second Year)

SIR C HANDRASEKHARA V. RAMA N

(The molecular scattering of light)
Nobel Lecture, December 11, 1930

The colour of the sea

In the history of science, we often find that the study of some natural phenomenon has been the starting point in the development of a new branch of knowledge. We have an instance of this in the colour of skylight, which has inspired numerous optical investigations, and the explanation of which, proposed by the late Lord Rayleigh, and subsequently verified by observation,forms the beginning of our knowledge of the subject of this lecture. Even more striking, though not so familiar to all, is the colour exhibited by oceanic waters. A voyage to Europe in the summer of 1921 gave me the first opportunity of observing the wonderful blue opalescence of the Mediterranean Sea. It seemed not unlikely that the phenomenon owed its origin to the scattering of sunlight by the molecules of the water. To test this explanation, it appeared desirable to ascertain the laws governing the diffusion of light in liquids, and experiments with this object were started immediately on my return to Calcutta in September, 1921. It soon became evident, however, that the subject possessed a significance extending far beyond the special purpose for which the work was undertaken, and that it offered unlimited scope for research. It seemed indeed that the study of light-scattering might carry one into the deepest problems of physics and chemistry, and it was this belief which led to the subject becoming the main theme of our activities at Calcutta from that time onwards.

The theory of fluctuations:

From the work of the first few months, it became clear that the molecular scattering of light was a very general phenomenon which could be studied not only in gases and vapours but also in liquids and in crystalline and amorphous solids, and that it was primarily an effect arising from molecular disarray in the medium and consequent local fluctuations in its optical density. Except in amorphous solids, such molecular disarray could presumably be ascribed to thermal agitation, and the experimental results appeared to support this view. The fact that molecules are optically anisotropic and can orientate freely in liquids was found to give rise to an additional type of scattering. This could be distinguished from the scattering due to fluctuations in density by reason of its being practically unpolarized, whereas the latter was completely polarized in the transverse direction. The various problems requiring solution indicated in this essay were investigated with the aid of a succession of able collaborators. It is possible to mention briefly only a few of the numerous investigations which were carried out at Calcutta during the six years 1922 to 1927. The scattering of light
in fluids was studied by Ramanathan over a wide range of pressures and temperatures with results which appeared to support the "fluctuation" theory of its origin. His work also disclosed the remarkable changes in the state of polarization which accompany the variations of intensity with temperature in vapours and in liquids. He also traced the transition from surface-opalescence to volume-opalescence
which occurs at the critical temperature.

The anisotropy of molecules:

As stated above, the state of polarization of the light scattered in fluids is connected with the optical anisotropy of the molecules.

The optical analogue of the Compton effect

Interpretation of the effect:

It appears desirable to emphasize that though the conservation principle of Compton is useful in interpreting the effects disclosed by experiment, it is by itself insufficient to explain the observed phenomena. As is well known from studies on molecular spectra, a gaseous molecule has four different species of energy of increasing orders of magnitude, namely those corresponding to translatory motion, rotation, vibration, and electronic excitation. Each of these, except the first, is quantized and may be represented by an integer in an extended sequence of quantum numbers. The aggregate energy of a molecule may, therefore, assume any one out of a very large number of possible values. If we assume that an exchange of energy occurs in the collision between the molecule and the quantum, and limit ourself to the cases in which the final energy of the molecule is less than that of the incident quantum, we arrive at the result that the spectrum of the scattered light should contain an immense number of new lines and should in fact rival in its complexity the band spectrum of the molecule observed in the emission or absorption of light. Nothing more different from what is actually observed can be imagined than the foregoing picture. The most conspicuous feature revealed by experiment is the beautiful simplicity of the spectra of even complicated polyatomic molecules obtained in light-scattering, a simplicity that is in striking contrast to the extreme complexity of their emission or absorption spectra. It is this simplicity that gives to the study of light-scattering its special significance and value. It is clear that the effect actually observed was not and could not have been foreseen from an application of the conservation principles.

The general principle of correspondence between the quantum and classical theories enunciated by Niels Bohr enables us, on the other hand, to obtain a real insight into the actual phenomena. The classical theory of light scattering tells us that if a molecule scatters light while it is moving, rotating or vibrating, the scattered radiations may include certain frequencies, different from those of the incident waves. This classical picture, in many respects, is surprisingly like what we actually observe in the experiments. It explains why the frequency shifts observed fall into three classes, translational, rotational and vibrational, of different orders of magnitude. It explains the observed selection rules, as for instance, why the frequencies of vibration deduced from scattered light include only the fundamentals and not the overtones and combinations which are so conspicuous in emission and absorption spectra. The classical theory can even go further and give us a rough indication of the intensity and polarization of the radiations of altered frequency. Nevertheless, the classical picture has to be modified in essential respects to give even a qualitative description of the phenomena, and we have, therefore, to invoke the aid of quantum principles. The work of Kramers and Heisenberg, and the newer developments in quantum mechanics which have their root in Bohr's correspondence principle seem to offer a promising way of approach towards an understanding of the experimental results. But until we know much more than we do at present regarding the structure of molecules, and have sufficient quantitative experimental knowledge of the effect, it would be rash to suggest that they afford a complete explanation of it.

The significance of the effect:

The universality of the phenomenon, the convenience of the experimental technique and the simplicity of the spectra obtained enable the effect to be used as an experimental aid to the solution of a wide range of problems in physics and chemistry. Indeed, it may be said that it is this fact which constitutes the principal significance of the effect. The frequency differences determined from the spectra, the width and character of the lines appearing in them, and the intensity and state of polarization of the scattered radiations enable us to obtain an insight into the ultimate structure of the scattering substance. As experimental research has shown, these features in the spectra are very definitely influenced by physical conditions, such as temperature and state of aggregation, by physico-chemical conditions, such as mixture, solution, molecular association and polymerization, and most essentially by chemical constitution. It follows that the new field of spectroscopy has practically unrestricted scope in the study of problems relating to the structure of matter. We may also hope that it will lead us to a fuller understanding of the nature of light, and of the interactions between matter and light.

Rendezvous

-Nikita & Supriya
(First Year)

Our department came up with this cool idea of publishing the first ever department magazine. We were supposed to give in articles, reports etc for the same. I hadn't come up with anything till the last moment. My friend Supriya and I, were assigned the interview section, so we decided to write a mail to one of these amazing professors at Department of Physics and Astrophysics, Delhi University, **Professor Patrick Das Gupta**, for an interview. We were delighted when he accepted the request and enthralled by the knowledge he shared. Talking to a physicist who is trained in classical music, performs magic tricks and writes stories! We couldn't have imagined anything more interesting. The conversation lasted for over an hour. Here is a glimpse of it:

Nikita: What persuaded you to join the field of Astrophysics?

Dr Gupta: What always is the case with people who get into physics are that they are interested in physics right from their school days. So, after I did my schooling, I got a National Science Talent Scholarship to do Science and I joined BITS, Pilani. There I got into reading popular physics books. The first thing that ignited my imagination was the 'Hubble's Law' which essentially claims that farther a galaxy, more the relative distance between earth and that galaxy, and hence that galaxy is known to be moving at a faster rate than the ones closer to earth. In other words, '*The rate at which the distance between two galaxies is increasing is proportional to the separation between the two galaxies.*' That really surprised me. Imagine someone being able to discover the law for the entire system of galaxies at very large scale! I was intrigued by that law. That was the starting point of my interest in Astrophysics.

Supriya: So... this particular incident is the only reason that you pursued Astrophysics?

Dr Gupta: No, not really. That was the first excitement I got after reading a popular physics book. Naturally, I read more books. I came across other interesting topics like black holes, quantum mechanics and more. They were enigmatic topics, very mysterious and surprising... For awhile there, I was immensely interested in Quantum Mechanics. Later on, Particle Physics got onto me. I remember this one professor at BITS Pilani, Professor Shastri to whom we insisted that he teach us Particle Physics. You see, back in those days, we didn't have any paper on the same topic. So just like that, my interests kept on shifting from one to another. But eventually, one should settle down with the subject that not only intrigues him/her, but additionally, one has an aptitude towards it. That is to say, two things are important when it comes to choosing a particular field. The subject should interest you, and you should be good at it.

Nikita: What were your experiences from your journey as a graduate to a professor in Delhi University?

Dr Gupta: Like every field, the journey had its own share of ups and downs. Everything got much more interesting after BITS Pilani, when I joined IISc, Bangalore to do research. There, for the first time, I encountered professors who were excellent teachers. There was Professor N. Mukunda and Prof N. Kumar. And another one named Professor R. Raja Raman who is now associated with JNU. But back in the days, he was in a centre for theoretical studies at IISc Bangalore. When I first joined IISc Bangalore, these three gentlemen gave courses. Prof N. Mukundu gave a course on classical dynamics. Prof Raja Raman gave a course on quantum mechanics. Prof N. Kumar gave a course on Mathematical Physics. It was then that I realized that teaching is a profession that could make a subject immensely fascinating. That is one of many reasons why I got into teaching myself. Because these three professors were great.

teachers and that highly motivated me. Then, after a year, due to some reason, I decided to leave IISc, Bangalore. I freshly applied at TIFR, Mumbai. There, in the theoretical astrophysics group, there was Prof Narlikar. I decided to work with him. He would give me interesting problems. I remember the first problem he gave, which was to try to formulate electrodynamics without having electromagnetic fields. Just two charges interacting. He had already worked on this. So, I decided to try something new-namely interaction of two magnetic monopoles. I tried developing a Lagrangian to describe two monopoles interacting. I looked at research papers and realized that we cannot have Lagrangian for two interacting monopoles. Then I went to Prof Narlikar and told him that there doesn't seem to be any mathematically viable Lagrangian to describe two interacting magnetic monopoles. He said, "I see your point. Now work on a different problem." It was exciting. After that I went for a post doctoral fellowship at IUCAA, Pune. I worked with Prof Naresh Dadhich. He once said, "You know, very soon, gravitational wave is going to be a thing. So why don't you work on it with Dr Sanjeev Dhurandhar?" Dr Sanjeev Dhurandhar had collaboration with Cardiff, U.K. So there we learned some interesting things about gravitational waves. You see, in theoretical physics, it's better if you do various kinds of works rather than focusing on one, so that you would be learning different physical aspects. These are the highs. Nature always has surprises in-store for us. At one time, you might think, 'Now I have understood this and it is starting to get boring.' However, around the same time, someone might have discovered something fascinating. So the best thing about doing research is that every time nature is revealing a bit of itself, there is another new thing freshly blooming waiting to be discovered and understood.

Supriya: Can you brief us about the research work that you are currently into?

Dr Gupta: Right now, I am doing three aspects of research work. The first is that I have a new idea regarding dark energy. Hubble showed that Universe is expanding. But not only is the universe expanding, the rate of expansion is increasing! Now when there is gravity and there is some acceleration, this means there is some kind of anti-gravity. And general relativity allows that. So I've given a new model, which comes from differential geometry that there is some completely anti-symmetric field. And my claim is that this anti-symmetric field must be added as a fundamental component of gravity and that can explain the acceleration. The second thing that I am doing is whether or not I can have torsion from this totally anti-symmetric field that I've proposed. The third thing that I am working on is whether you can use Bose-Einstein condensation to test gravity. The next thing is, whether the white dwarfs can be generators of gravitational waves.

Nikita: Despite being one of the most intriguing fields, what would you consider the reason for the depressing state of science as a career option in India?

Dr Gupta: There are many reasons for this. Here are several personal opinions. First of all, the origin of science is in the Western countries. They got a big lead because of the Renaissance that took place between 13th and 16th Century in the Europe. It started from Italy, but gradually spread around. Renaissance essentially was, as many historians have pointed out, when the church started teaching people how to read. Now once you start reading, people would read all kinds of things. So they started reading the ancient knowledge: Socrates, Plato, Aristotle. Their knowledge was not about religion; their knowledge was about observing and trying to find order in what they were observing. Then with arrival of printing press, the whole thing mushroomed. If people had something to say, they were writing it down and it was communicated and distributed all over. So there was a sudden burst of knowledge. So they got a big boost. Galileo, who truly speaking, is father of modern Science, started observing, made controlled experiments, made mathematical formulations. He realized that if you want to study nature, you need the language of mathematics. So Galileo was doing this in the 16th Century. Therefore west got a 300-400 years lead as far as Asia is concerned. But we didn't do badly either. As soon as modern education came to India, people like Jagdish Bose developed devices to detect radio waves.

Soon after in the beginning of 20th Century, C.V. Raman came. He got the Raman Effect for which he got the Noble Prize. Although there was a 300 years lag, we were picking up. But as a result of the lag, if you move one step, the other people have moved three steps ahead.
Second major reason would be that there are more jobs available for engineers. Glamorous jobs abroad. So part of the reason is the glamour associated with the western world, which attracts bright people with genuine talent.
There is a third reason. The sudden boom in the cable network, social media. So many young people are very much attracted to it. I call them -the electronic entertainment- as the monsters that eat time. So even if one has talent, if one does not put in work, the talent doesn't flower. So there are very talented people but they are immature to realize that if they don't work hard, they cannot hone their talent.

Supriya: As an undergraduate, what opportunities do you think we should be aware of?

Dr Gupta: Enormous opportunities are there in India. Right now, anyone who has interest in astrophysics, this is the right time. Why? Because of the great opportunities that have come up! First thing, India has recently signed the funding of TMT which will come up in Hawaii. It means Indian people can directly go there, take the data and do the research. Remember, TMT is not going to come up in two years. It will start only in 2020. So anyone who wants to pursue his/her career in Astronomy, in another 3-4 years, is in great situation! So once the TMT data comes out, a lot of young people are required. So job prospects are very high. The second thing is, next year ISRO is going to launch an astronomy satellite called ASTROSAT. It is going to study individual astronomical sources at various wavelengths. It’s going to be a fantastic facility with lots of data pouring out. And someone has to analyse this data. So a lot of young people will get the opportunity. Then there is World Radio Telescope coming up called the square-kilometre array. It is over 1 sq-km area and radio telescopes will be set to detect very faint radio frequencies, quasars, pulsars. And India will also be collaborative partner. Then you have LIGO India project, named as INDIGO. Although it has been tabbed by the parliament...
For those interested in cutting edge experiment, LIGO India, which is dealing with Interferometers, requires experiences in diverse fields. Students interested in LASER optics, it is going to use squeezed light, which is not normal LASER but a part of quantum optics. There are also a lot of mechanically challenging experiments. Those who are interested in computers, it requires running programs which would be running very fast. So LIGO is a diverse set up which will require not only scientists but also engineers. Then there are other research establishments like INO. It has already been passed. INO will be looking at neutrinos which are very mysterious particles. Earlier it was thought that neutrinos are mass-less, but soon it was found that neutrinos have mass. One of the prime objectives of INO is to look at the masses of neutrinos. So anyone who is interested in imagining new theoretical particle physics model which will explain this will be highly benefited by this. Then we have GMRT, Giant Meter Radio Telescope which is a TIFR project and it has been going on for a number of years. So that also requires a number of young people to work towards it. There are various cosmic Ray Laboratories which are a part of TIFR o they too require a lot of young people. So India is poised with a lot of new experiments and they become fruitful only if young people join. These are very exciting opportunities for young people...

Nikita: Exciting times, indeed! It was a pleasure talking to you sir.
Supriya: Thank you for your time!

Those who made history...

The Nobel 2014...

Starting in the 1970s, the three researchers tackled a range of challenges in device physics and materials science to create light-emitting diodes that could shine blue light. Red and green LEDs were already available by the late 1960s. The advent of the first luminous blue LED, which took place in 1993, completed the visual spectrum. A wide range of potential applications, from domestic lighting to optical storage, opened up.

Compared with incandescent light bulbs, LEDs are 10 times more energy efficient, last 100 times longer, and are much more resistant to vibration and shock. Given that 20–30% of the world's electricity is consumed by lighting, the widespread adoption of LEDs will significantly reduce the world's energy consumption and, with it, its emission of carbon dioxide into the atmosphere.

Echoing the words of Alfred Nobel's will, the Nobel selection committee remarked that the invention of the blue LED is "of great benefit to mankind."

Toward blue LEDs

Blue LEDs work in the same way as their red antecedents. Two layers of semiconductor, one p-doped, the other n-doped, abut each other. Applying voltage across the layers, from p to n, drives the extra electrons from the conduction band of the n-doped layer to fill holes in the valence band of the p-doped layer.

If the electrons can cross the bandgap without having to gain or shed momentum—that is, if the conduction band's minimum and

the valence band's maximum face each other across momentum space—each electron–hole recombination yields a photon whose energy matches the bandgap. Materials that have such "direct" bandgaps make efficient LEDs, but they are the exception rather than the rule among semiconductors. The world's preeminent semiconductor, silicon, has an indirect bandgap. Most LEDs—from the original red LEDs to the prize-winning blue LEDs—are made of direct-bandgap compounds drawn from elements from groups III and V of the periodic table.

Red and green LEDs are made from gallium arsenide and gallium phosphide. In principle, extending the family to achieve shorter wavelengths entails pairing Ga with a lighter element from group V, nitrogen, whose smaller size yields tighter binding and, with it, a wider bandgap.

The quest to harness GaN's bandgap for light emission began in the 1950s even before the red LED made its debut in 1962. By the early 1970s, progress had foundered. Making pure GaN device-sized crystals, let alone doped crystals, proved too difficult . Prospects brightened in the mid 1970s when a new technique came online for building crystals layer by layer: metalorganic vapor phase epitaxy (MOVPE). Amano and Akasaki set themselves the goal of using MOVPE to make crystals of p- and n-doped GaN. In 1986, after a decade of effort, they had found a successful recipe: Deposit GaN with its dopants on top of a layer of aluminum nitride that is itself deposited on a sapphire substrate. The sapphire–AlN foundation guides the formation of a crystalline GaN layer. Working independently, Nakamura hit on a similar recipe in 1991.

Doping GaN with magnesium or zinc yielded p-doped crystals, but not ones that could accept electrons efficiently. Fortuitously, Amano and Akasaki found in the late 1980s that samples they had examined with an electron microscope became better acceptors. The cause, Nakamura discovered, arose during crystal growth: Dopants formed efficiency-sapping complexes with hydrogen atoms, whose presence as a contaminant arises from the use of organic precursors in MOVPE. Irradiating the crystals with electrons breaks up the complexes. Annealing has the same beneficial effect.

The final step toward making efficient blue LEDs was to exploit the concept of heterostructures. In GaN LEDs, as in GaAs LEDs before them, different semiconductors from the same groups of the periodic table are combined in layers. Family membership ensures that the layers, which have different bandgaps and refractive indices, are structurally compatible with each other. With a judicious choice of layers, the electrons and holes that combine to emit photons can be squeezed into a narrower volume, thereby boosting efficiency. Further gains in efficiency come from exploiting the layers' optical properties.

For their first blue LEDs, Amano and Akasaki layered GaN with aluminum gallium nitride; Nakamura paired GaN with indium gallium nitride and InGaN with AlGaN. By 1993, Nakamura had made a tiny blue LED that shone as brightly as a candle. Light emission in the device took place in a layer of zinc-doped InGaN sandwiched between n- and p-doped AlGaN, which, in turn, was sandwiched between n- and p-doped GaN. To date, the paper describing the landmark device has been cited more than 3000 times. Besides the potential for slashing the world's electricity bill, GaN-based LEDs have other important and widespread applications. The devices deliver light to the screens of cell phones, computers, and TVs. In poor countries, solar-powered LED lights are supplanting lamps fueled by kerosene.

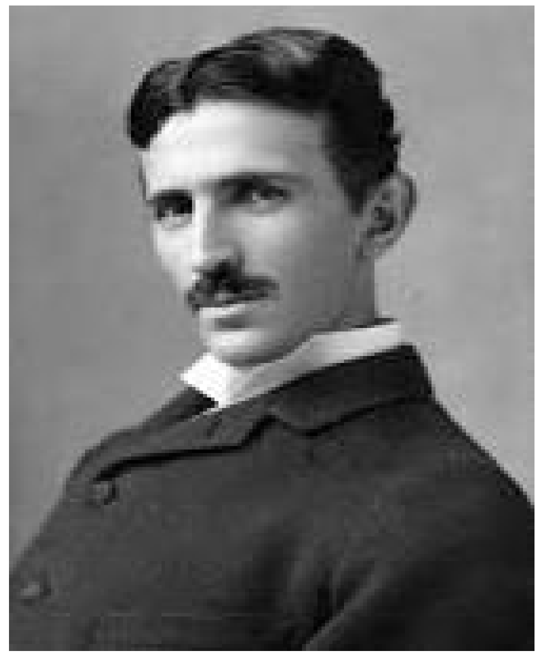
-*Sourced from: Physics Today*

Nikola Tesla: The genius with a death ray

Talk about geniuses and you would get the standard answers: Albert Einstein, Stephen Hawking, Leonardo Da Vinci, etc etc. Hardly ever do we get to hear the name Nikola Tesla. Whereas the truth is, all our modern devices ranging from AC motors, RADARs, hydroelectric power plants, even the radio, are a direct or indirect result of this man's unrivalled genius.

But wasn't the radio invented by Marconi, and the RADAR by Robert A. Watson-Watt? You say. Well…no. All of Marconi's work on the radio was based upon Tesla's. He was using 17, yes, *seventeen,* of Tesla's patents. RADAR. Same story. Tesla pitched his idea of the RADAR to the U.S. Navy in 1917, *eighteen* years before Robert's discovery. But Thomas Edison convinced the U.S. Navy that the radar had no use in war. Come to think of it, Thomas Edison had much to do with Tesla not being recognised. The feud between Edison and Tesla of course, is legendary. But as W. Bernard Carlson said, "They're different inventors and you can't really say one is greater than the other. The American society needs some Edisons and it needs some Teslas." Personally though, I would always prefer Tesla over Edison.

Tesla was an eccentric man; the quintessential mad scientist. And one of his craziest – or what would have been the craziest, if it had worked out – invention was the death ray. It was a hypothetical device that would bring about, quite literally, death.



A concentrated beam of sub-atomic particles flying at the speed of light, annihilating anything and everything in their path: that was Tesla's death ray, the one he claimed to have invented. His scientific papers vanished mysteriously after his death, and the truth behind the death ray, continues to be elusive.

Nikola Tesla was indeed a man ahead of his times. Yet he lived a poor life and died alone. His legacy, however, continues to inspire. He was truly the genius with a death ray.

-Saniya Heba

A life in science: Marie Curie

“A scientist in his laboratory is not mere technician: he is also a child confronting natural phenomena that impress him as though they were fairy tales.”

-Marie Curie

(1867-1934)

Marie Curie, a woman who gave her entire life for science and a woman whose dedication towards her work was so intense that she did not even care about her life. She was the first woman Nobel Laureate and also the first person in the world to win two Nobel Prizes. Maria Sklodowska, better known as Marie Curie, was born in Warsaw in modern-day Poland on November 7, 1867. Her parents were both teachers, and she was the youngest of five children. Marie was a quick learner and graduated out of high school with a gold medal.

This, however, was not enough as women in Poland were not allowed to gain higher education and she could not attend the men-only University of Warsaw. She instead continued her education in Warsaw's "floating university," a set of underground, informal classes held in secret at different locations to avoid detection by the Russian Czar’s police. Both Marie and her sister, Bronya, dreamed of going abroad to earn an official degree, but they lacked the financial resources to pay for more schooling. Undeterred, she worked out a deal with her sister where she would work to support Bronya while in school and later Bronya would return the favor after completion of studies.

Marie worked as a tutor and a governess to the children of the owner of a beet-sugar factory. She used some of her spare time to teach the children of the Polish peasant workers how to read, risking punishment if the Russian authorities found out. Marie read widely in many subjects and in the year 1891 and joined the Sorbonne University in Paris. She completed her master's degree in physics in 1893 and earned another degree in mathematics the following year. Marie received a commission to investigate the magnetic properties of different types of steel. To carry out the work, she needed a lab to work in, when she met the French physicist Pierre Curie. A romance developed between the brilliant pair, and they became the “scientific dynamic duo”.

She was fascinated with the work of Henri Becquerel, a French physicist who discovered that uranium casts off rays, weaker rays than the X-rays found by Wilhelm Roentgen. Curie took Becquerel's work a few steps further, conducting her own experiments on uranium rays, in a lab set up in the Paris Municipal School. Her studies led to the conclusion that the amount of rays given out depended only on the amount of uranium and not on anything else like weather, temperature, moisture, etc. Neither did it matter whether the sample was solid or powdered or pure or combined with other elements. The rays, she theorized, came from the element's atomic structure. Intrigued by these findings, Pierre joined her and they worked together like detectives looking for their suspects. Their efforts finally paid off when they discovered two new elements; Radium and Polonium and they coined the word '*radioactivity'* to describe the phenomena.

In 1903, Marie Curie made history by becoming the first woman to win the Nobel Prize. She won the prestigious award along with her husband and Henri Becquerel, for their work on Radioactivity. Three years later, after the death of Pierre Curie, she was appointed as professor in the Sorbonne University, becoming the institution's first female professor. She received another great honor in 1911, winning her second Nobel Prize, this time in chemistry. She was awarded for discovering the elements Radium and Polonium by isolating radium and also, studying the nature and compounds of this remarkable element. She became the first scientist to win the Nobel Prize twice. While she received the prize alone, she shared the honor jointly with her late husband in her acceptance lecture.

When World War I broke out in 1914, Curie devoted her time and resources to helping the cause. She championed the use of portable X-ray machines in the field, and these medical vehicles earned the nickname "*Petite Curies*." As her first radiological assistant she chose her daughter Irene, a scientifically well-versed 17 year old. Mother and daughter, accompanied by a military doctor, went to the battlefield and saved the lives of many wounded men

All of her years of working with radioactive materials took a toll on Curie's health. She was known to carry test tubes of radium around in the pocket of her lab coat. In 1934, Curie went to the Sancellemoz Sanatorium in Passy, France, to try to rest and regain her strength. She died there on July 4, 1934, of aplastic anemia, which can be caused by prolonged exposure to radiation.

She also passed down her love of science to the next generation. Her daughter Irène Joliot-Curie followed in her mother's footsteps, winning the Nobel Prize in Chemistry in 1935, along with her husband, for their work on the synthesis of new radioactive elements.

Marie Curie made many breakthroughs in her lifetime and is one of the most famous female scientists of all time. She once said, “Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.” The work of her entire life was also the cause of her death, call it tragedy or honor, her entire life story has inspired many young minds and continues to do so till date.

-*Sharmistha Chatterjee*

BEEN THERE DONE THAT!

(First hand accounts)

Summer School experience at DU

I got an opportunity to attend the Summer School in Physics organized by the Department of Physics and Astrophysics, University of Delhi during June 2014. It was a very well executed programme, considering it was a first for the Department. The programme was planned keeping in mind, the students who wished to pursue a future career in research. It was an extensive school, with talks on topics ranging from Quantum Physics, Astrophysics, Solid State Physics, Nuclear and Plasma Physics and many more by accomplished professors. The main focus was on giving the attendees a flavor of the subjects and research in those fields. There were many lab visits where the students were very patiently and thoroughly explained the techniques used in various ongoing projects. The University has extremely well-equipped laboratories which left most of us awestruck. We also had lab sessions where computer languages like C and Octave were taught which form an integral part of Computational Physics in Higher Education. During the last few days, we were asked to go through research papers and prepare a presentation on the one that fascinates us the most. We also submitted reports on what we learned, which sessions had appealed to us the most and how the school helped us.

All in all, it was a great opportunity to actually learn and appreciate the beauty of Physics, without any deadlines or confines of syllabus. All our speakers were very friendly and interactive and discussed various subjects with the students in between sessions as well. It was a great learning experience for all those who have a passion for the subject. ☺

-Shruti Chakravarty
(Third Year)

Mitacs Globalink Internship Experience

My fascination with everything astronomical always made me want to do one of those internships where you get to spend the entire day in the lab analyzing data and images of stars and galaxies taken from a telescope. Never did I expect though that that lab would be situated in Canada and that on returning home at 9 p.m. after finishing the day's work, I would be greeted by the Sun and by a group of lively Mexican, Brazilian and Indian roommates!

All this was possible because I was being hosted in the summer of 2014 by the University of Lethbridge through the Mitacs Globalink Program. Under the supervision of Dr. Locke Spencer, a professor in the Department of Physics & Astronomy at the university, I worked on a project to help verify the spectral calibration of the High Frequency Instrument of European Space Agency's Planck telescope. Over the summer, I learnt a new programming language, handled hundreds of gigabytes of data and developed processing algorithms to verify the calibration, thus increasing the net confidence in Planck data. I also got to experience an amazing work environment as I worked closely with my extremely helpful and knowledgeable supervisor, a post-doctoral researcher and 5 other undergraduate students working on various related projects in astrophysics. The freedom that my supervising professor gave me to pursue my own ideas inculcated in me the ability to look at a problem from several vantage points and then think of an innovative solution to the problem which, I believe, will really help me in a career in research.

Living alone in a new country also gave me the chance to step out of my comfort zone and explore my independence. Apart from working in the lab, I also took some time out to interact with people from the diverse international community at the university and explore the new country I was in. Canada's natural beauty and the kindness and warmth of people that I met there are things I am never going to forget.

I know many of you may wish to opt for an international internship, but shy away from applying for one. Probably because you think it would be a burden financially or probably because your parents are a little worried about letting you live alone in a city located on the other side of the globe. Well, Mitacs Globalink is a fully funded program that covers your airfare, visa application costs, accommodation and even gives you a stipend to cover your living expenses. Also, Mitacs takes utmost care in ensuring that you are extremely comfortable and in the safest possible environment on campus. There are several other international internship programs, but none makes the entire process as easy for you as Mitacs does. Applications open in early August and they offer several projects with a considerable number of physics projects to choose from. Keep in mind though, that the application process is fairly competitive, so you definitely need to pay a lot of attention to all parts of your application especially the resume and statement of purpose.

When I came to know about the Mitacs Globalink Program, initially I was a little apprehensive to apply as well, but as it turns out it was one of the best decisions I ever made. So if you wish to do an international internship this summer, do consider applying for Mitacs Globalink.

All the best for the applications, people! :)

-Pragya Chawla
B.Sc. (Hons.) Physics, 3rd Year

P.S. I will be happy to help you with the application process, so don't hesitate to contact me if you have any queries. Mail me at: chawlapragya@gmail.com

NIUS EXPERIENCE

The **National Initiative on Undergraduate Science (NIUS)**, a major initiative of **HBCSE (TIFR)** concerning tertiary science education in India was launched in the summer of 2004. The program includes initiating and guiding students over an extended period for proto-research, preparing and editing lecture notes, and promoting undergraduate research. Introducing innovative experiments and rejuvenating the Undergraduate Laboratory is an important component of NIUS.

We recently attended the nius camp 11.1 at HBCSE .It was an amazing experience. the camp started from 10^{th} june and ended on 20^{th} june .all the lectures were given by leading scientists of the country. The camp itself was a two week extensive enrichment program. We had scientists from various institutes like HBCSE,, BARC, IISER Kolkata, TIFR,NCRA IUCAA Pune etc. to give short lectures and presentations on topics like nanotechnology ,quantum mechanics ,quantum computation, cosmology ,particle physics ,relativity and stellar evolution .The way the lectures were delivered and the understanding of concepts given by teachers was different ,new and interesting. In particular, I was fascinated by the environment of research and the dedication of both students and teachers to gain and provide as much knowledge as possible in a time of 10 days .we were allowed to interact with teachers anytime even after the lectures were finished and during the breaks as well ,we were provided access to the library which had a excellent collection of books ,even provided with notes, study material and presentations .

The lectures on Dark Matter and Cosmology had everyone gazed and were portrayed amazingly and was made really easy by the lecturer. The lectures on Stellar Structures and Seismology were really interesting . Applied optics lectures too, were a wonderful insight to applied physics in astronomy, and how an engineering student may contribute part to physics technology .the way interferometry and solar radio astronomy was introduced it left an impact on all of us and everyone wanted more on the topic. Cosmology lectures were enjoyed by everyone the most with the best of videos and pictures showed in class the topic seemed more and more interesting .Apart from these we were also given lectures on relativity, solitons and waves and introduction to nanostructures all the lectures were equally good and made all of us appreciate the beauty of physics and its application to a wide range of phenomenon in nature.

Apart from Physics, there was another thing we gained through this ten day camp. And that was the platform we got to interact and learn with and from students from various institutes across the country. People from various institutes got a platform to exchange their views ,knowledge and experiences. We got to see people with extreme humility despite their great achievments in some of the most respected exams in the country. And yes, made a whole lot of new, wonderful friends!! , I must say, the camp was really an experience of enrichment for life which I will never forget.

-Pragya Arora
And
Raagya Arora
(Second Year)

Jenesys

The mention of Japan and Japanese people had always elicited a positive response in me. When I first heard that the Japan International Cooperation Center (JICE) had invited 24 students and 1 professor from University of Delhi to visit Japan, I was really excited. After filling in a comprehensive application form and being interviewed by a committee, I was one of the 9 students selected from Miranda House to be a part of the science and technology batch of students invited to visit Japan under the JENESYS 2.0 program. As expected, the first thing about Japan that enthralled me was their cutting-edge technology and its ubiquitous and innovative use. We enjoyed a demonstration of ASIMO, the world's most advanced Humanoid Robot and a 3D Planetarium Show at National Museum of Emerging Science and Innovation. We also saw life-size exhibits of space missions at Japan Aerospace Exploration Agency's Campus at Sagamihara and visited a precision instruments manufacturing small-scale industry as well. A day that we spent at Kanagawa Institute of Technology enlightened us about their hands-on teaching practices and a visit to their Safety Learning Center informed us about the innovative ways and simulations through which the Japanese teach their citizens disaster management techniques. Throughout the week, we visited famous tourist attractions like the Asakusa Temple, Tokyo Tower, Tokyo Sky Wheel, Enoshima Island and Aquarium. But the most amazing part of the trip was the homestay. I was one of the three Miranda House students who were being hosted by an old Japanese couple. During the stay, they taught us Japanese, fed us some amazing Japanese food, narrated stories of their several overseas trips, taught us a lot about Japanese culture and ensured we were as comfortable as possible at their house. What fascinated me most about the country were its people. Everyone that I met during my week-long stay there was hospitable, kind, polite and always happy to go the extra mile to help anyone they saw. The patience and eagerness with which the monks taught us Zazen meditation at the Sojiji Temple, the love and care our host family showed us when we stayed at their home for two days and the punctuality and helpfulness of the JICE coordinators were all things I will never forget. The only regret that I have is not having sat in the extremely popular bullet train, Shinkansen, but I do hope to visit the country again one day and do that. Until then, I plan to maintain my ties with the people I met there and spread as much information as I can about how amazing a country it is.

-Pragya Chawla
(Third Year)

FRESHER'S