SPACE SOCIETY IST PRESENTS

2022 EDITION, VOLUME 01

THE COSMIC HERALD

A VENTURE INTO SPACE



Vasilakakos, Kon. "The Milky way galaxy above the summits of Mount Olympus".

INSTITUTE OF SPACE TECHNOLOGY, ISLAMABAD



An initiative of Space Society at the Institute of Space Technology, Islamabad.

FOREWORD

“I wonder”. These two words have incalculable power and so it is right and proper that this magazine aims at evoking and inspiring wonder in its readers. From wonder’s bosom springs expansive thinking, the desire to explore new frontiers, and the strength to break old habits of thought. Without wonder, there can be no science or art – those markers that place us, humans, on the highest branch of the evolutionary tree.



Pervez Hoodboy, Pakistani Nuclear Physicist.

When unchained, the imagination can soar into the skies. That’s how space exploration started. That this new frontier is now too clichéd for me to repeat. The launch of the James Webb Space Telescope (JWST) last year is now resulting in spectacular pictures of galaxies, stars, and planets. New data is steadily filling in the gaps in our understanding of the Big Bang and its aftermath, particularly on the dynamics of early stellar evolution and the universe’s earlier stars.

But there is another side as well: the use of space for definite purposes. This is a mixed bag. On the one hand, communication satellites make possible so much of daily life such as driving instructions from Google and monitoring environmental changes. In the next century mining asteroids for precious materials could become a major industry. We are already seeing Japanese and European spacecraft dock up to asteroids barely 2-3 kilometers across.On the other hand, stands the specter of space weaponization that will potentially allow technologically stronger countries to vanquish less capable ones. The efforts to limit such capabilities have barely begun but, as with other international treaties, success will depend upon the willingness of those most capable.

In spite of a head start in the 1960s, Pakistan has slipped further and further behind in space-related matters.While material resources are frequently held to blame, there is a certain lack of national curiosity in scientific issues that underlies this. Even among the most educated, you will almost never hear conversations about JWST, the recent discovery of a 3 million-year-old ape-human, or advances in teleportation.

Why so little curiosity about the larger world? Why no urge to know what lies in or beyond it? Some 120+TV channels have political talk shows, religious, fashion, and cooking programs. But not one produces programs on discovery, science, or world history. Most science news does not get covered in the press and may not reach an audience interested in science. Science news competes with other kinds of news for a relatively tiny amount of space/time. Therefore most newspapers place a premium on brevity and simplicity.Coverage of issues in broadcast reports is even tighter. Because audiences for science stories often require considerable background information, science writers face a difficult challenge.

This reduced collective appetite for science news has two reasons. One is straightforwardly identifiable: the preponderance of closed, pre-modern thinking in society. The other, curiously enough, is a modern disease that is sure to get worse as technology improves. A post-industrial age product – the internet – is also creating a wonder deficit. It is, of course, true that instant access to the world of ideas and information helps titillate the imagination and that is directly responsible for the explosive growth of new knowledge.

But Google and smartphones are turning many smart kids into dullards and dimwits The problem is that search engines have made things too easy. Before you've even finished typing in a question, it's likely that the answer will be on your screen. Without your smartphone or iPad, you might have engaged in a stimulating discussion with your friend, racked your brains, and reflected upon possibilities.Through spirited debate, you could have tried to convince him he was wrong and you were right. Instead, one keystroke ends everything. Instant gratification stills your neurons even before they can fire.

The internet was supposed to feed wonder. Yes, it certainly can – but only if good, modern education installs the mental structures needed for sifting and critically examining information. As with many technologies, we have here a double-edged sword. To use the right edge is important.

Correct use must first recognize that facts are just ingredients, not knowledge itself. Knowledge enhances wonder, it doesn't kill it. In a well-disciplined mind with robust reasoning and mathematical skills, wonder inspires science, art, and poetry. These, in turn, feed the appetite that wonder excites in us and helps us escape the drab world of appearances, generating epicycles of boundless creativity and enduring inquiry.

I look forward to issue number two of The Cosmic Herald.

Dr. Pervez Hoodbhoy teaches physics in Islamabad.

ABOUT THE MAGAZINE



Here, at the Institute of Space Technology, Islamabad, we consider ourselves to be privileged to have access to great professors, extensive literature, and state-of-the-art laboratories. We sympathize with the fact that despite being interested in space, not many children could afford to be a part of such institutes for numerous reasons.

Space Society IST has been working in Pakistan to foster the interest of students in space science and technology. We organize several campaigns, competitions, events, games, lectures, and workshops to popularize space education. While working, we felt the overwhelming need to have a space-themed magazine in Pakistan, especially aimed at students to nurture their interests and to learn more about the universe.

To this end, we worked for more than 2 years to create this magazine and met many roadblocks along the way. But here we are, and if you are reading this, and if it inspires just one student to pursue a degree in STEM majors, we believe our mission has been successful. The Cosmic Herald is an endeavor of many undergraduate students at Space Society IST. While publishing this first edition, we understand that it may not be perfect, but just like the rest of the scientific community, we are learning. And we hope to improve it further in the future.

We hope that our endeavor is not a full stop in history, but rather a semi-colon.

Muhammad Rehmoz Salahuddin Ayub
Founder and Curator of The Cosmic Herald
Former President, Space Society IST

HONORABLE MENTIONS

It all began from a fateful online meeting in 2020 during the Covid pandemic when the executive body hit upon upon an idea; "How about instead of publishing articles on **our blog**, we create a magazine and make it accessible to everyone, especially to all the underprivileged students who are interested in astronomy"?

And with that, came forth the inception of The Cosmic Herald. The result was an endeavour of 2 years and dozens of students (and faculty alike) to realize the inception to reality. This could not have been possible without the supportive community we have at Space Society IST. We take pride in all of our members who played an integral role in furthering the mandate of society, and while it is not possible to list everyone's contribution on a page (it would warrant a magazine of its own), we would like to take a moment (and a page) to appreciate some key contributions.

We would like to thank these people for their unwavering support and help...

Former Faculty Patron: *Mr Wehaaj Sulehri (Ex Coordinator, Space Science Department)*
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A special thanks to Hamza Waseem, Duaa Jamshaid and Dilawaiz Saghir for reading the manuscript numerous times and pointing out numerous typos and formatting mistakes.

Space Society IST would not have been able to function the way it has, were it not for the hardworking executives, who work around the clock to ensure that the society stays on track. The last two years have been crucial in implementing this magazine, which is why we thank the office bearers for their constant guidance, support and hardwork.

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SATURN'S HEXAGON

by Moeez Aslam (BS EE-16)

Saturn's Hexagon

If someone were to ask you what your absolute favorite planet in the solar system is, what would you say? Would it be one of the inner planets, with their rocky appearances and murky colors? Surely not. What about the outer planets? Jupiter is nice, the biggest planet in our solar system, but it’s too dull. Uranus and Neptune are better, with their deep hues and their mysterious auras, but if you were someone with even a little knowledge of the planets, you will almost immediately think of Saturn.

And how could you not? The sixth planet sits comfortably in the outer region, away from the hustle and bustle of the inner planets. With its pearly appearance and its ridiculously breathtaking rings, it’s hard to think of another planet that even comes close to Saturn’s magnificence.

However, these two aren’t the only features that set Saturn apart from the rest. Like Earth, Saturn also has its own aurora that glimmers over its northern pole like a crown, giving Saturn a kingly status and bragging rights over all the other planets in terms of glamour and nobility.

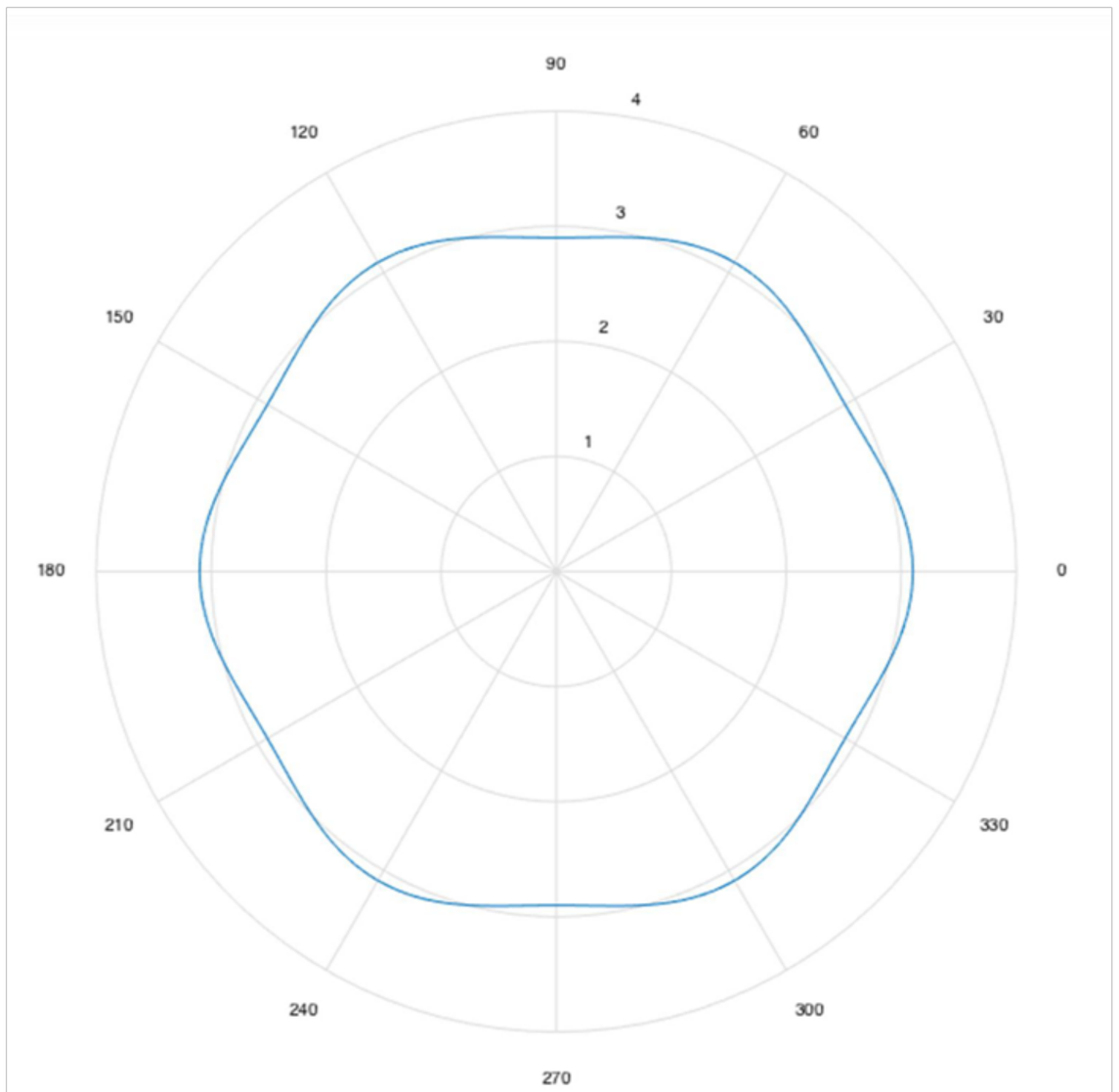
But today, we’re not here to talk about Saturn’s rings or even its crown. No, today we will discuss yet another one of its attributes that makes it stand out among the rest. It is something that sounds and looks so unbelievable that one starts to question how something so stunning could be made on its own, and not by some alien civilization. I am talking, of course, of Saturn’s hexagonal storm, that has been raging over its northern pole for decades, just beneath the aurora. The first time this phenomenon was detected was in the early 80s by the Voyager spacecraft. No further observation took place back then because the orbit period of Saturn is 29 years and so it took almost 30 years for the sunlight to pass over it again.

When the spacecraft Cassini went to study the photogenic plant in 2004, the northern pole was still in the shadows. But the spacecraft was able to capture thermal images and in those images, the hexagon was seen, extending hundreds of kilometers down in the atmosphere.

By late 2012, the northern pole finally came out of the shadows and Cassini was able to study it properly. The eye, which is the center of the storm, was observed to be fifty times larger than an average hurricane on earth, with wind speeds up to 500 kilometers per hour. The Cassini spacecraft, at the end of its 13-year-long mission, collected extreme close-up photographs of Saturn’s rings and clouds and using its mass spectrometer, also measured the composition of its atmosphere. All this data was then used by some researchers from Harvard to figure out how Saturn’s atmosphere could make this storm possible. Using the data, they built a 3D model of Saturn’s hexagonal storm.

Their computer simulation showed deep thermal convection, that made heat travel up to the planet's outer layers. Convection refers primarily to atmospheric motions in the vertical direction.As the planet heats up, convection may occur where the atmosphere heats up very rapidly. As the surface warms, it heats the overlying air, which gradually becomes less dense than the surrounding air and begins to rise.

The researchers found that these deep convection created three large cyclones near Saturn’s poles and an eastwards Jet stream. A Jet stream is a narrow band of very strong air currents that circle the planet. This combination of the cyclones and the jet stream led to the creation of a polygonal central vortex. It was also found that this storm extended several thousands of kilometers deep into the planet’s dense atmosphere.

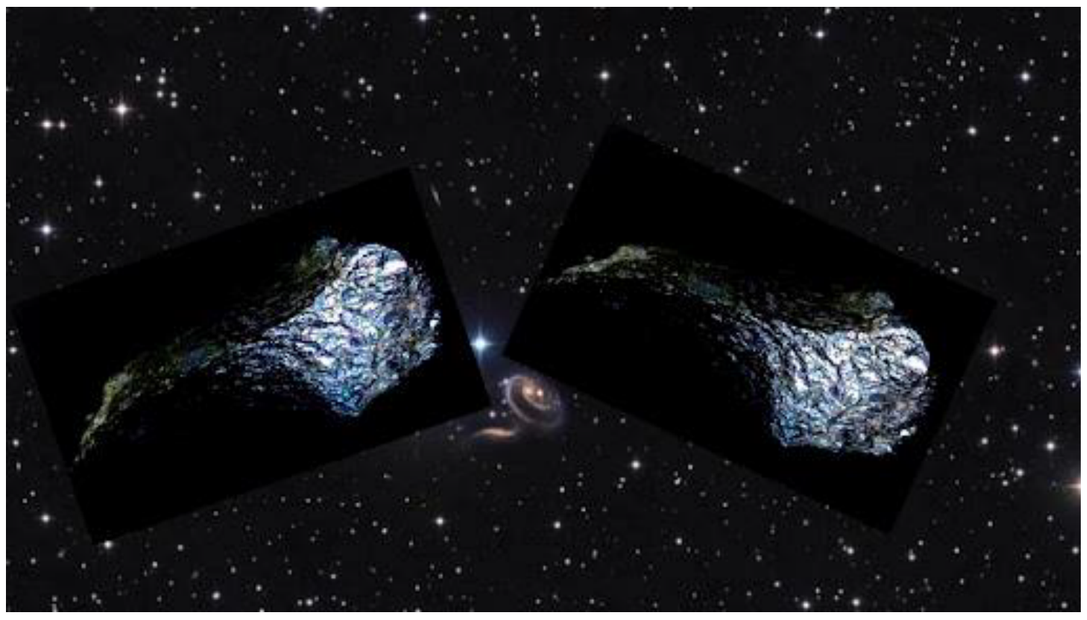


Source: *ELI5 - Reddit*

So, in simple terms, on earth, the polar vortex and the surrounding Jet stream have a wonky uneven shape. This is due to the presence of mountains, oceans, and other things that affect the path of the wind. Saturn, on the other hand, is a simple globe of gas, so there isn't really anything that disturbs the polar vortex and its Jet stream.

Now the hexagonal shape is due to the phenomenon of standing waves with the air that forms in the atmosphere. Standing Wave is a name given to the pattern of air currents that surround a planet. With nothing to disturb the flow of air, it curves around the planet in a perfect sinusoidal manner, giving it the appearance of a hexagon.

An important thing to note is that it doesn't have to be a hexagon. It is only because of specific conditions on Saturn as of right now. It could probably change into other polygonal shapes overtime. Whatever the shape, it is safe to say that Saturn has earned the title of the most photogenic and aesthetically pleasing planet in the solar system. A gem of the cosmos!



Source: https://theplanets.org/space-facts/

Cool Space Fact:

If two pieces of the same type of metal touch in space they will permanently bond.

This incredible fact is also known as "cold welding" and it happens because the atoms of two pieces of metal have no way of knowing they are separate. This doesn't happen on Earth because of the air and water found between the pieces.



APOCALYPSE? NO

by Minahil Bakhtawar

Apocalypse? No

On the eve of a peaceful winter night, a cold descended over the Scottish Highlands. At latitudes above 60 degrees, Compass needles flickered confusingly; North becoming South and East becoming West. Automatic gates and garages opened and closed on their own. Radio services malfunctioned, satellite communication was lost, power lines failed, and the sky began to change its colors. Sounds a lot like the onset of an apocalypse, no?

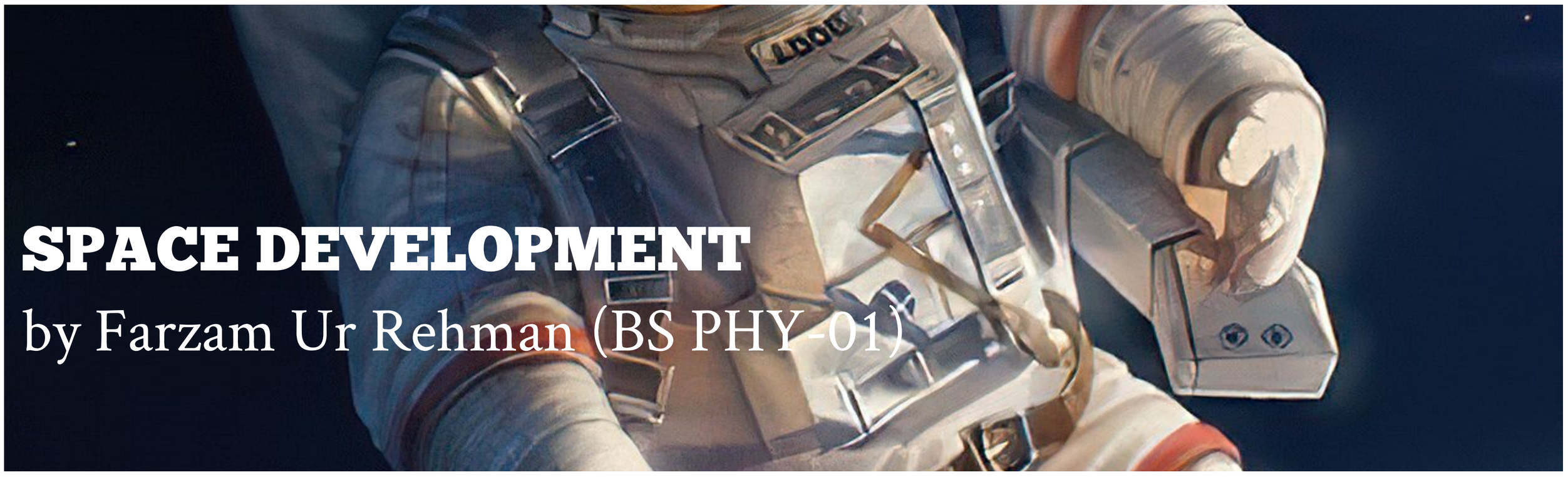
It is actually the appearance of Aurora. No, not the Disney Princess in pink clothes, but the scientific phenomenon called Aurora Borealis. Cascading lights of magnificent colors illuminate the sky as they seductively prance against the canvas of a black sky. Hues of greens and blues, tame yellows and red tinges ripple like a light sent down from heaven itself.

In the present day, it is an attraction for those who seek the wonders of nature but in the past, aurora borealis was riddled with superstitions. People assumed it signified doom and destruction. These fanatical beliefs were put to rest when science expounded its prowess and studied sun activity closely.

So the question arises, what did the scientists discover that removed the doom and gloom from mysterious lights in the night sky?

The giant ball of fire sitting in the center of the solar system gives off more than just heat and light. Owing to the constant nuclear fission going on at a really high temperature, the sun gives off massive amounts of energy along with positively charged particles and electrons. This is a sort of sprinkling effect. A phenomenon called *solar wind* carries these particles through interplanetary space and brings them to the Earth's atmosphere. For the most part, the earth's atmosphere protects humans from these particles but here's the catch, the sun doesn't always give off the same amount of energy. This means, that the sun sometimes gives off more energy than usual, and along with that, more charged particles. During a mass ejection, a solar storm happens. This ionized gas travels at a high velocity and reaches the earth. This is where the particles interact with the atmosphere but something interesting happens before then.

Of course, the Earth doesn't sit back and watch this gas do its thing, so an invisible shield works to diverge these particles. That is, the earth's magnetic field lines interact with the charged particles and deflect some of them towards the poles where these magnetic field lines concentrate. Coincidentally, this is also where the atmosphere is most open to space. These particles then burn with the oxygen and nitrogen in our atmosphere to give off an artistic display of lights. These are mostly witnessed when the sun is most turbulent. Solar activity peaks and sunspots increase. Since auroras are formed as a result of disturbed and unusual magnetic activity on the sun, they have some magnetic properties of their own. This explains the side effects that the northern lights bring for the common citizen. The side effects although indicate the onset of an apocalypse as communication systems fail and the power goes out, they are just an invite to the show. The lights want to be seen and they call to those who hear! A lot of these are passionate tourists who travel across the globe to witness the sky's ballet, some are scientists and others are those driven by positive superstition as they come to seek abundance in offspring and wealth.



SPACE DEVELOPMENT

by Farzam Ur Rehman (BS PHY-01)

One way ticket to space

The age of space tourism is just around the corner, 61 years after the Soviet cosmonaut Yuri Gagarin became the first person to visit space. 'Blue Origin' and 'Virgin Galactic' are one of the most eminent companies responsible for making sub-orbital flights accessible to common people.

Hundreds of people have already booked their tickets and have begun training for a once-in-a-lifetime voyage.

Glenn King, the director of space-flight training at the National Aerospace Training and Research Center, said that the oldest person in their training was 88 years old. Virgin Galactic have tagged one trip to cost approximately $250,000. They already have 600 tickets booked, with many on the waiting list.

The biggest barrier to space flight for most people remains the price tag, apart from which virtually anyone can go to space regardless of the health conditions. The three factors that would determine whether space tourism becomes commonplace are safety, profitability, and environmental concerns.

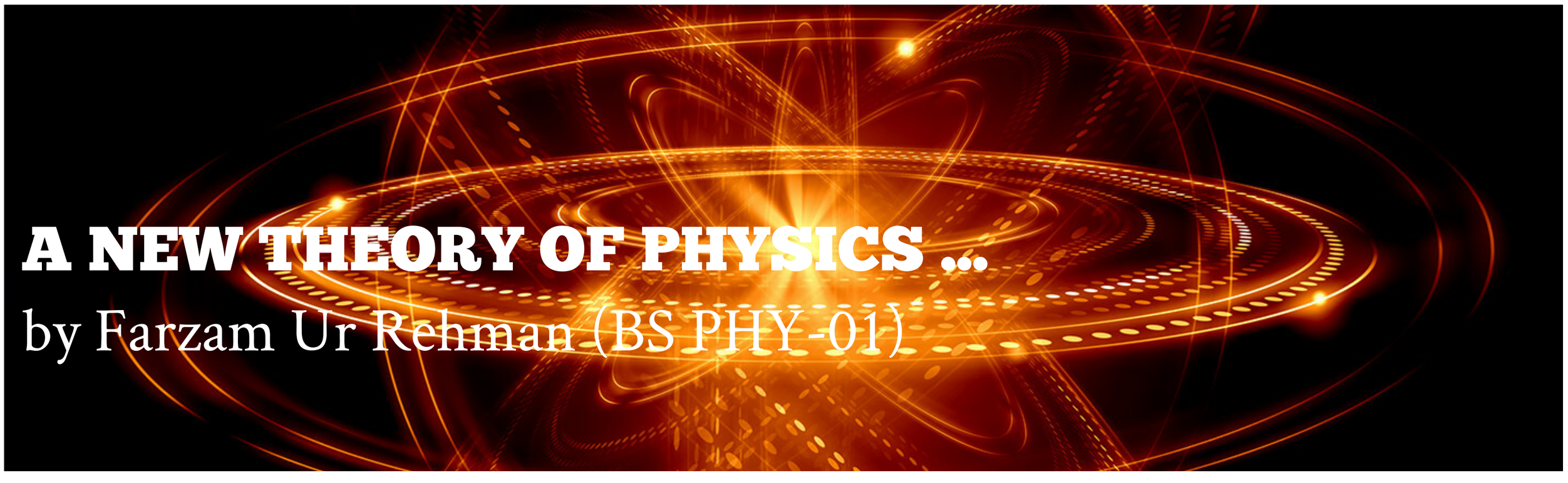
New lifeforms discovered on the ISS

With the help of advanced genetic testing, three new species of bacterium, never observed before in science, were discovered aboard the International Space Station (ISS), potentially offering researchers a new way to grow food in space.

Scientists examined 4 strains, 3 of which turned out to be previously unknown. Dr. Swati Bijlani, who lead the research, proposed naming a new species 'Methylobacterium Ajmali' in the honor of Ajmal Khan, a renowned Indian biodiversity scientist.

The discovery was published in the journal "Frontiers in Microbiology" in March 2021, and NASA believes that the species offer enormous potential for growing food on missions to Mars.

There are several agricultural processes in which bacterium can be used such as growth promotion, elimination of plant pathogens and nitrogen fixation. Scientists are optimistic that this breakthrough will provide as massive boost in the race to populate Mars, and thanks to the hard work of scientists from around the globe, we are inching ever closer to it.



A NEW THEORY OF PHYSICS ...

by Farzam Ur Rehman (BS PHY-01)

A new theory of physics could be just around the corner

Results from two experiments suggested that Physicists could be wrong in the way they think about our Universe. Two long running experiments, conducted in the United States and Europe, showed that muons (tiny sub-atomic particles) were not behaving as was expected of them. Confounding results, if proven right, reveal major flaws in the Standard Model (Our current best theory of the universe), and may call for a new theory altogether. "We think we might be swimming in a background sea of particles all the time that just haven't been directly discovered.", Fermilab experiment co-chief scientist Chris Polly said in a press conference in Illinois. "There might be monsters we haven't yet imagined that are emerging from the vacuum interacting with our muons and this gives us a window into seeing them". The Standard Model was developed also 50 years ago, and experiments affirmed repeatedly that its description of the particles and the forces that make up and rule the universe were satisfactory - until now. The muons' magnetic fields do not behave according to the Standard Model. This follows new results published in March from the European Center for Nuclear Research's Large Hadron Collider, which found a surprising proportion of particles in the aftermath of a high-speed collision. If confirmed, the United Stated may be credited for the biggest discovery in particle physics since the Higgs Boson. The details of the experiment are that muons are sent around a magnetized track that keeps them alive for long enough for the researchers to get a closer look. According to the observations, the magnetic spin of the muon is 0.1% off of what is predicted by the Standard Model. Further time would be needed to analyze the results and if found consistent, will count as a major discovery. Separately, at CERN, scientists have been smashing particles with each other to see what happens. One of the particle collider's many experiments measured what happens when particles called 'bottom quarks' collide. The Standard Model predicts that when these particles are smashed together, the result is an equal number of electrons and muons. Scientists' evaluation of over 15 years of data however, showed a 15% difference with significantly more electrons than muons. Neither result is being termed as an official discovery yet because there is always a chance that these might be statistical quirks. Physicists are excited that if these results are found true, they could lead us to further understanding the mysteries of the Universe such as dark matter and dark energy.



THE HUNT FOR THE GREAT CONJUNCTION

by Muhammad Shaheer Niazi (BS PHY-01)

The Hunt for the Great Conjunction

Sunset was near on the 21st of December, 2020, as I and a friend shot through the roads of Lahore on his bike. Our destination, the great conjunction. Our literal destination, the oval ground of the Allama Iqbal Medical College. A little foresight on the great conjunction, it is an astronomical event when Jupiter and Saturn align in the night sky, forming, for the naked eye, what looks like a single star. If one views it from the telescope, it is as if the both planets are hanging out next to each other; yet, in reality, they are millions of kilometers apart. It happens because in our line of sight, the planets align in their orbits, one behind the other. How rare is it? There are figures of 400 to 800 years given on the internet. The reality is that the conjunction happens every 20 years; we just cannot see it due to the sun being in between. The figures allude to the fact that this is the closest conjunction in 400 years, and is 800 years since it last happened. We finally arrived at our venue. The sun had just dipped below the horizon; the sky had begun to darken. In our understanding, Jupiter appears in the night sky as a bright star so we should've been able to spot it, but it was no where to be seen. There was a line of trees around the ground and I was sure that the planets were hiding behind those and that we had ruined our opportunity. My friend brought with her a telescope, a beautiful 90mm refractor. A refractor is a telescope that uses lenses to magnify an image. After setting up the telescope, we started moving it around to find the apparent star that was the great conjunction. We looked at the night sky in our phone to generalize the direction of our search in the night sky. The sky was just not dark enough. Trusting our location despite the trees, we stayed and waited, observing the moon meanwhile. Later on, other people also showed up to see what we were doing. At that moment, one of us spotted a star, significantly higher than we had expected it to be. I maneuvered my telescope to it, and to my surprise there it was! The great conjunction. There through the telescope, we could see Jupiter, with its bands of red gas and 4 bright moons, just a small distance away from Saturn with its majestic rings. The sight was mind blowing, clear and crisp. Everyone took turns to check it out. The only problem was the lack of automatic tracking mount on our telescope, which meant that we had to continuously adjust the telescope to account for the earth's rotation, as our great conjunction would slowly slip out of view. I spent the rest of the time taking *prime focus* photographs of the two planets. Prime focus requires that you move the lens of the camera with the eye piece of the telescope, in essence, converting the telescope into a primary lens for the camera. As time went on, the planets moved lower and lower into the horizon, till they entered the pollution band in our skies of Lahore. They started to dim out fast, despite being higher than the tree line. By that time, everyone had their taste of the conjunction. We had witnessed a rare astronomical event with our very own eyes, and that was the ultimate satisfaction we got from the rather unsatisfactory year of 2020.



ANGUISH

by Moeez Aslam (BS EE-16)

Anguish

She was alone. That statement wasn't entirely accurate. She wasn't alone. Of course she wasn't. She had her crew-members with her, even if they were in cryosleep. But where were they and why was she not with them? She always felt a bit groggy coming out of cryo. Why was she out of cryo anyway? It all came back to her of course, as her body slowly ejected the fluid keeping her in stasis. Her crew-members were in the crew room's cryo-chamber. She could see them through her one-way mirror, looking calm and peaceful beneath their glass caskets. She, on the other hand, was in the captain's quarters, in her separate cryo-pod. The reason for being out of cryo, she reminded herself, was because 14 more years had passed on their way to Eden-II, and it was time for the routine inspection, to see if everything was in working order. She tapped her temple to boot up her Vizla– her implant that enabled her to examine the entire ship right from her quarters. She tapped her temple again and this time her whole view was taken up by a holograph model of Athena, the ship she was captaining. Of course, this was all because of Vizla. If a crew-member were to enter her quarter, it would look as if she was staring at nothing. But no one would enter her quarter because everyone except her was asleep. She was alone. The holo of the ship was a beautiful sight. From her perspective, it looked like a submarine, swimming amongst the stars. The stars glittered and winked in elegant perfection, the pinpricks of light from faraway places. She sat up straight. Why was she seeing stars? The ship was supposed to be in hyperspace. There should be no stars visible. She checked the counter above her pod. "274 years to Eden-II", it blinked. They were out of hyperspace, why? She checked the ship's log. Nothing seemed out of the ordinary. The shields were working as they were supposed to – nothing had damaged the ship, no asteroid collisions, no debris fields in their path. The ship was in perfect condition. She was about to do a full system scan when she saw it. The fuel. The ship was running on reserve fuel. What had happened? Why were they on reserve? Where did all the fuel go? She brought up the hyper-drive stats. She could not believe what she was seeing. The fuel line was leaking. It had been leaking for the past 61 years. She was confused. Why hadn't she seen this before in her last 4 inspections? Then she realized the rate at which it was leaking was far too low for the system to detect. And when it did detect the shortage of fuel, she was 3 years into her 14-year hibernation. But this makes no sense, she thought. Why did none of the crew-member wake up from cryo? The system was supposed to wake them up in case of emergencies. She opened the crew-stats. At first she couldn't understand, or didn't want to understand, what she was seeing. Apparently, the fuel line was leaking right where the oxygen generator was. Over an oxygen supply line, in fact, that was going straight to the crew-members' cryo-pods. Her crew-members hadn't breathed in 7 years. They were in a glass casket after all. She was alone.



THE NEPHA MACHINE

by Syeda Farwa Rizvi (BS CS-01)

The Nepha Machine

“Run away, run, trip, stand, run. . . ” says the robotic Nepha Machine, on an infinite loop. I can’t believe I haven’t found a way to fix that pathetic machine yet but managed to rob 27 accounts in a span of three earth days, all while on the Moon might I add, but I guess that’d make things easier. Don’t get me wrong though, they deserved it without a doubt, and I’m not even keeping the money, it goes to those who could actually make a difference. I’m confident Aristotle would agree, don’t judge me yet. You see, since the Jacksons had become rich by robbing the poor, which the incapable spoiled brat they call a CEO, there may be distributive justice in merely giving the poor their money back. It may need bravery, like mine, of course, to make a stand against these political and corporate establishments in order to achieve justice in the event of this unfair society when powerful businesses like Jacksons and Fenaliat Corp. and their government allies abuse the poor. Claiming that ”theft” from the affluent and powerful may be a virtue from Aristotle’s perspective makes more sense in this situation. Anyway, now that I’m done justifying myself to, well myself, let me explain my situation exactly. For the past fifteen earth years, I, Jenna Namira, have been living on a, relatively small, pod ship on the moon. No, it is not because I am insane but it is because I was banished from the earth at the age of sixteen due to earthen laws misunderstanding what I am doing and calling it illegal. All I aim to do is restore justice where it is missing and sure that may include a disadvantage to some people but those people are far from innocent and are hidden by the dysfunctional laws. I stick by what I have done. But I need to find some upgraded pod ship, or possibly a planet to move to, because to my surprise a teenager’s pod ship can actually become really stuffy in a span of fifteen years and malfunction, like Nepha Machine. I should serve justice to Nepha soon though, maybe an upgraded version? Okay so maybe I keep a small fraction of the money, just enough so I could survive out here you see. But my small amount isn’t affecting the largely good I do. Trust me. Jenna? I mean me! I know, I am right. I don’t need Jenna to agree. I do agree. I- “R-run awa-y, trip, s-stand, stand, stand. . . ” Nepha continues.

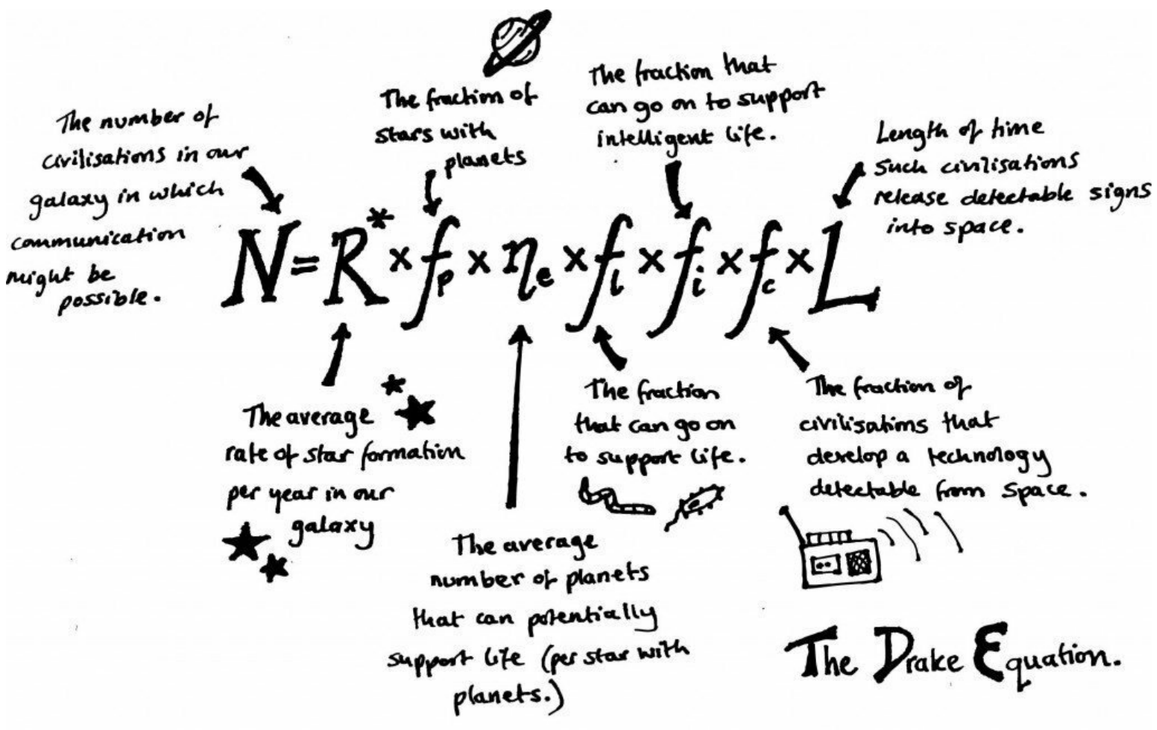


WHERE ARE ALL THE ALIENS?

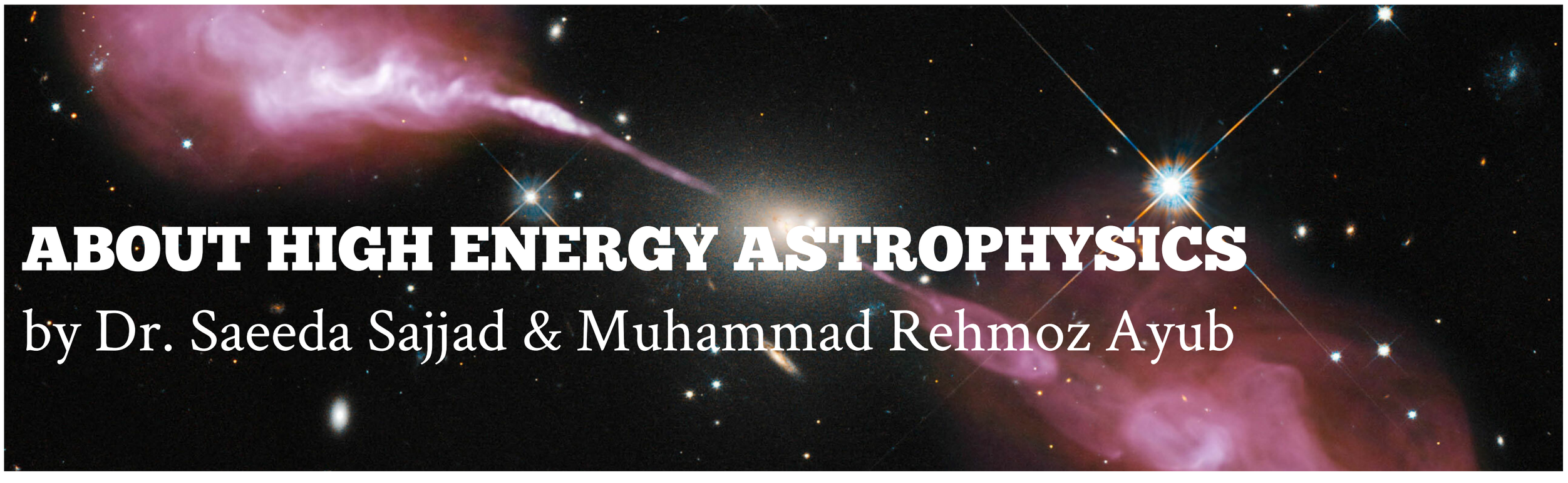
by Zain Ul Abideen (BS SS-09)

The Drake Equation and the Fermi Paradox

The Drake's Equation, proposed by an American Astronomer and Astrophysicist Dr. Frank Donald Drake, was developed to estimate the number of intelligent extraterrestrial civilizations in the Milky Way galaxy.



The solutions for the above equation can be found fairly easily; let's put in the values. The values for the estimate variables were taken according to the observational evidence available. The range of values for the estimate of N can range from 100 to 10000 depending upon whether the pessimistic or optimistic estimates are used. If the reasoning of drake's equation is to be believed, it is guaranteed that there is intelligent life beyond us in our galaxy somewhere; we just have to find a way of communicating with them. The Drake's Equation guarantees that intelligent life exists somewhere else in our galaxy as well. The universe has been expanding for 13.7 billion years, and we humans have been around for only 0.0015% of that. It is highly likely that many civilizations arose before us in the Universe and in the Milky Way, and considering how much advancements we have made in just a century, those civilizations must be at least type 3 as they had billions of years to bloom. If this reasoning is to be believed, then where are they? This question was first asked by the Italian physicist Enrico Fermi after which this paradox is named. A type 3 civilization would easily be able to detect us, or emit radio waves for us to be detected, but this doesn't seem to happen. So far, we have detected 0 evidence of extraterrestrial life. The explanations for this can be many. The obvious one is that the speed of light is slow when the vastness of space is considered. Maybe the signals are on their way to us, or maybe they've gone past us when we weren't able to detect them. Another explanation is that the aliens don't care about us; they're so much technologically advanced than us that we're like ants and spiders to them. Lastly, it is also possible that life is too rare, and we are all alone in the vastness of the Universe.



ABOUT HIGH ENERGY ASTROPHYSICS

by Dr. Saeeda Sajjad & Muhammad Rehmoz Ayub

High Energy Astrophysics

Importance of observation

In astronomy and astrophysics, like most sciences, the theoretical and computational models are verified through observations. Thus, astronomy is majorly an observational field.

Stellar Spectroscopy

We can have these observations from the whole electromagnetic spectrum, where each section of the spectrum tells us different properties of the source object. This holistic approach is known as multi-wavelength astronomy. Generally, energy tends to increase at lower wavelengths. Stellar properties can also be observed through stellar spectroscopy. Naturally, we would expect that observations in visible wavelengths would be the most observed. This wavelength of visible light tells us many interesting properties of source objects such as distance, velocity, radius, chemical composition, and temperature. An interesting property in the light emitting behavior is that the peaks are observed at different wavelengths, pertaining to the temperature of the body.If the temperature of the source is high, the observed peak wavelength is smaller. This observed inverse relation between the temperature and the peak wavelength is known as Wien's Law:

$$\lambda_{peak} = \frac{2.93 \times 10^{-3}}{T}$$

Where λ_{peak} is in meters and T is in kelvins. It is worth noting that while stars emit spectra in all wavelengths, only the peak wavelength has a dominating effect, which may not necessarily lie in the visible light region. However, due to atmospheric disturbance, these wavelengths may not be allowed to reach Earth (e.g., most UV rays get absorbed in the atmosphere). If we superimpose the peak wavelengths at different temperatures and the allowed wavelengths, we get the accessible peak wavelengths at ground level.

Stars - A paradoxical example of a black-body

While 'black' may not be the first word that comes to your mind when you look at stars, scientifically speaking, they exhibit almost ideal black body behavior (they absorb almost all in-falling light and emit light of their own). Hotter stars tend to be bluish while cooler stars are redder. According to their spectral classification, stars are majorly divided into 7 classes.

O -- B -- A -- F -- G -- K -- M

Advances in the multi-wavelength astronomy are due to the technological advancements of devices such as telescope, detectors, as well as large data collection and powerful computers.

Galactic Co-ordinate System

A helpful way of navigating the Milky Way galaxy is through the Galactic Coordinate System. You can imagine the Sun at the origin of a sphere enclosing the whole galaxy. The galactic latitude and longitude are projected on to the sphere from the Sun. Latitude would be 'above' and 'below' the galactic plane (ranging from +90 to -90) while the longitude will lie 'along' the galactic plane (from 0 at

the center to 180 at the anti-center). The galactic longitude will increase counterclockwise as you look at it from the North galactic pole. Obviously, the galactic center lies at 0 latitude and longitude. If an object is observed along the galactic longitude, it would most likely be a part of our galaxy. Whereas any object at high latitude would be outside the galaxy. This information helps in developing a sense of *what* lies *where* in the detection that we get.

Back to Multi-Wavelength Astronomy

As emphasized above, each region of the spectrum conveys different information about the source. Here, we compare the length of wavelength along with the observed information.

Wavelength	Pros	Cons
Visible	Can see starlight as it 'exists'	Cluttered by Dust
Radio	Pulsars, Quasars and Radio Sources	Radio waves observed on Earth are of low intensity
Infrared	Unaffected by dust	Highly temperature sensitive instruments
Ultra-Violet/X-Rays	X-Ray sources can be seen	Dust blocks radiation
Gamma	Most energetic, violent, and interesting phenomenon can be seen (Fermi Bubbles)	Can't use mirrors

High Energy Experiments

Experiments at CERN are in the TeV range, which is also the area of interest for High Energy astrophysicists, as well as particle physicists. Gamma ray astronomy is also done by employing two techniques: satellite-based telescopes (used for low-energy gamma ray) and ground-based telescopes (used for high energy gamma ray, which uses the atmosphere as a calorimeter).

Relationship between Flux, Energy, and the area of detection

Flux is defined as the number of photons (from a single or multiple sources) passing through 1 m^2 of an area in 1 second. It is easy to draw reasonable conclusions about a source when the flux of an object is high i.e., more photons are observed. But, when an object has a low flux, one can do one of the two things: either increase the surface area of the observing device or increase the exposure time. There are two factors that one should know about gamma ray flux.

Flux Variation with Energy – The flux decreases when energy is high. In other words, since more energy is required to accelerate a high energy photon, these photons will be observed in a lesser number. Therefore, high energy gamma rays will have a lower flux while low energy gamma rays will be observed relatively more abundantly.

Total Absorption of Gamma Rays at Lower Energies – Since high energy gamma rays are observed indirectly (their cascades in the atmosphere are studied), it is not possible to observe low energy gamma rays as they are not observed on the ground. This leads to an interesting conclusion: high energy gamma rays are observed on ground (low flux but high cascade) while low energy gamma rays are observed from satellites (low cascade but high flux).

Conclusion

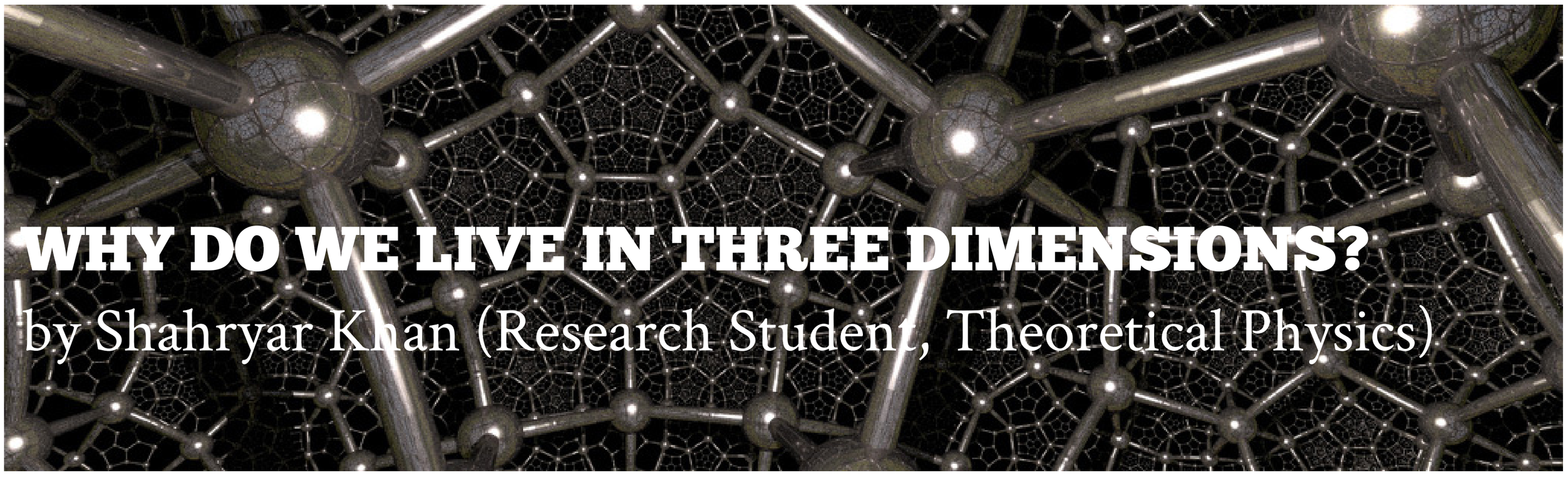
Now we are equipped to define the necessity of high energy astrophysics.

High Energy Astrophysics concerns with the physics of astronomical objects that pre-dominantly emit high energy electromagnetic radiation.

The sources of these radiations may be either galactic (pulsars, supernovae, neutron stars etc.) or extra-galactic (Active Galactic Nuclei (AGN) and Gamma Ray Bursts). A high energy astro-physicist is generally interested in observing the trajectory of high energy photons, as well as their behavior while traveling from the source to their detection under the influence of different fields. Since these particles travel at luminal speed, Special Relativity also comes into action.

References

Notes compiled by Rehmoz Ayub from graduate lectures delivered by Dr. Saeeda Sajjad (Assistant Professor at the Department of Space Science, Institute of Space Technology).



WHY DO WE LIVE IN THREE DIMENSIONS?

by Shahryar Khan (Research Student, Theoretical Physics)

Why do we live in three dimensions?

Introduction

The universe is full of mysteries. What is dark matter? What happens inside black holes? What is dark energy? How did the Big Bang happen? These are the mysteries that often keep scientists and curious minds like ourselves awake at night. But there is one mystery about the universe that no one ever talks about, perhaps because it is so obvious. Why is space 3-dimensional? This may not seem mysterious at first glance since our intuitions are finely tuned to live in a 3D world, but when we take a closer look, it begs asking why it should be 3D and not 4D or 5D or 10D or 77D? We will also take a look at why there is only 1 time dimension and not 2 or 3 or any other number.

Changing Spatial Dimensions

There are many possibilities here. Space can be in 4 or higher dimensions. Or it can be in 2 or lower dimensions. Let's explore what kind of a universe this will lead to.

More than 3 Space Dimensions

What would a universe with more than 3 spatial dimensions be like? We can't wrap our minds around it but we can say some useful things with the help of physics. In particular, it can be proven both in classical and quantum physics, that stable orbits are not possible if space is 4D or greater. This means that if two bodies are attracting each other by gravity, they can either pass by or crash into each other. There is no third way. Also, electron orbits around nuclei are impossible in such universes, which means complex atoms and molecules cannot form. This means that there will not be much else apart from elementary particles in such higher-dimensional universes. There is no possibility of complex life like us ever evolving. Also, in 4D or higher universes, inflation may not be possible according to some theories. We know that inflation happened in our own universe and it is required to flatten the universe and seed the universe with perturbations for the formation of large structures later on. Without inflation, these universes may be extremely curved which may lead to a chaotic evolution (extremely rapid expansion or contraction).

Less than 3 Space Dimensions

In a 2D or 1D universe, gravity does not exist according to general relativity. Life would find it really difficult to evolve without gravity since matter could not come together to form large conglomerates like stars or planets. Also, even if life could exist somehow in such universes, they would face some insurmountable anatomical challenges. 2D creatures cannot have a gut like ours since it would split their bodies in two. Nerves cannot cross each other, which makes the evolution of brains extremely difficult. In short, 2D and 1D universes are just too simple for any kind of complex life to form.

Changing Time Dimensions

This case is much more mysterious than the case of changing spatial dimensions, since we have no way of conceptualizing more than 1 time dimensions. But we will see below that if the number of time dimensions is not 1, the universe suddenly becomes unpredictable

More than 1 Time Dimension

It is very hard to visualize what a universe with more than one time dimensions will be like. But we can make some observations based on our knowledge of physics. It so happens that if there are more than 1 time dimensions, then energy no longer remains a scalar but becomes a vector. This has drastic consequences. Since energy is conserved, the energy vector's direction can never change in such a universe. Which implies that only those particles will come together that have exactly the same direction for their energy vector. If the energy vector is even slightly off, these particles can never come together and join. This makes the formation of structure very difficult. Another consequence of this fact is that particle decay becomes much easier. Many more types of decay are possible in such universes, which make matter much more unstable than it is in our universe. We can also look at this problem through the lens of partial differential equations (PDEs). We use PDEs to analyze physical systems and make predictions. In order to be solvable, a PDE needs to be ”well-posed”. This is a term coined by mathematicians to describe PDEs that have a unique solution for a given set of boundary conditions and that do not require infinite accuracy in the initial data. A non-well-posed problem would be one that gave multiple different solutions to a single set of boundary conditions (which would be unfavorable since it makes describing the universe and making predictions impossible). It would also mean we would need to measure data to infinite accuracy to have any hope of making predictions, which again is an impossible task. It turns out when we study physics in different dimensions, well-posed PDEs are not possible in any temporal dimension other than 1. In particular, for universes with 2 or more time dimensions, there are no well-posed PDEs and so we cannot solve equations to make predictions. Since brains are information-processing devices and can only evolve in a universe that allows the brain to make predictions about what will happen next, it is highly unlikely that brains (or complex life) could evolve in a universe with more than 1 time dimensions. There is very little chance of making definite predictions in such universes and so brains here would be utterly useless.

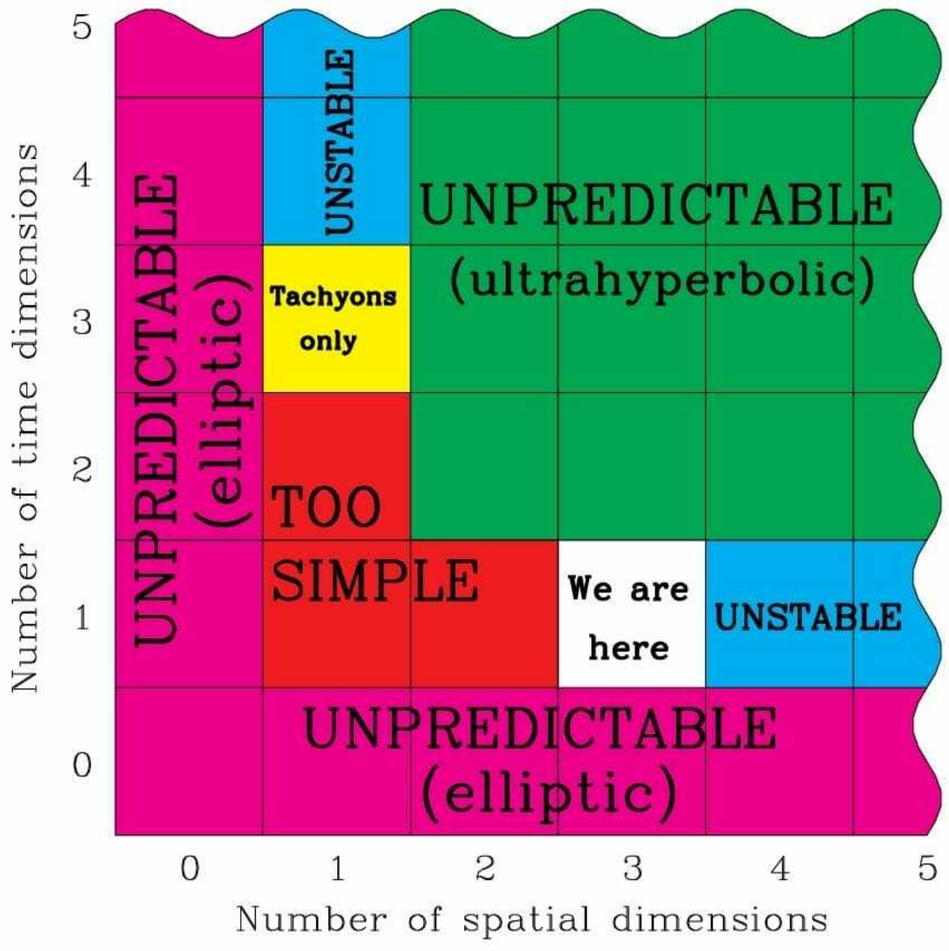


Figure 1. When the partial differential equations of nature are elliptic or ultrahyperbolic, physics has no predictive power for an observer. In the remaining (hyperbolic) cases, $n > 3$ may fail on the stability requirement (atoms are unstable) and $n < 3$ may fail on the complexity requirement (no gravitational attraction, topological problems).

Less than 1 Time Dimension

Only possibility here is that there is no time (i.e. 0 time dimensions). A universe without time is a static universe where nothing can happen. There is no real point discussing the possibility of ”life” in such a universe because life resumes growth and evolution, which are temporal processes. We can look at this from the PDE perspective as well. Well-posed PDEs are not possible when there are 0 time dimensions, so prediction and hence the evolution of brains is impossible in such universes.

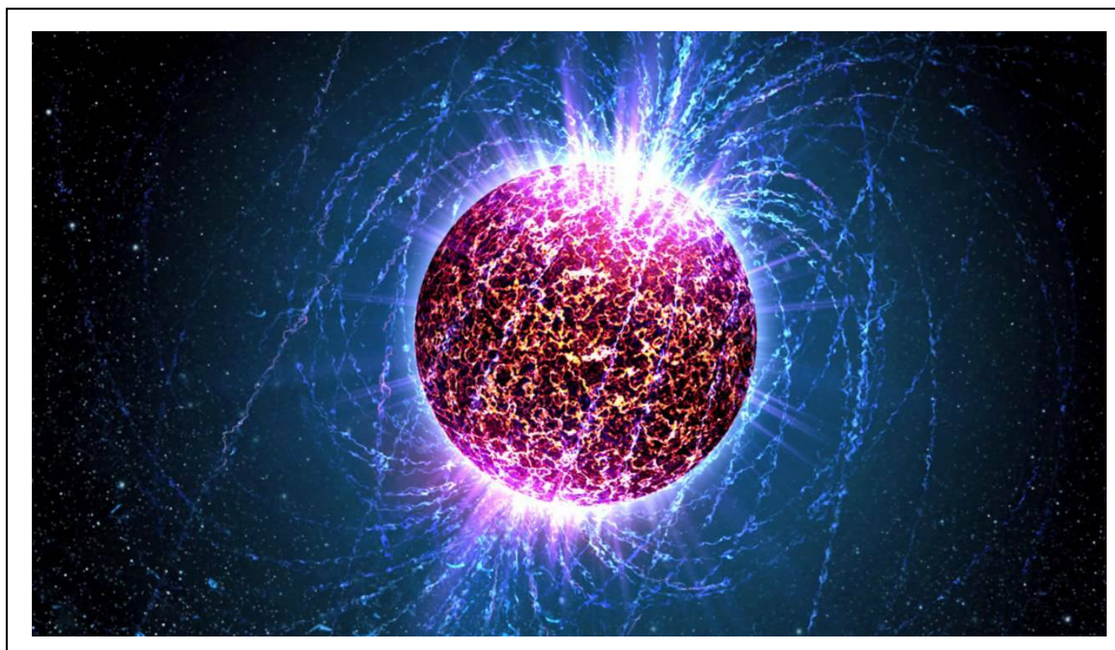
Conclusion

So we have seen in the course of this discussion how it would be extremely difficult for life to have a chance in any universe other than a (3+1) universe (3 space dimensions, 1 time). This is an ”anthropic” explanation, which means that we have only explained why ”we” find ourselves in a (3+1) universe, not that (3+1) universes are the only ones to exist. In fact, universes with different dimensions are very much possible according to our latest physical theories and it is plausible they exist in a kind of multiverse (collection or ensemble of different kinds of universes). The reason ”we” find ourselves in a (3+1) universe is because it was not possible for us to evolve in any other kind of universe. This explanation is akin to how we explain the fact that we find ourselves on Earth and not on

any other planet. The reason, as we all know, is that Earth is favorable to life, since it is abundant with water, oxygen, has an ozone layer, a protective magnetic field and is in the Goldilocks zone of the Solar System. The reason we didn't evolve on Mars is because we would not have been able to even if we tried! The barren landscape of Mars is equivalent to the barren landscape of a 4D, 5D, or 2 time dimension universe. So just as we love the Earth, we should also love our trusty (3+1) dimensions!

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On the dimensionality of spacetime. Max Tegmark. 1997.

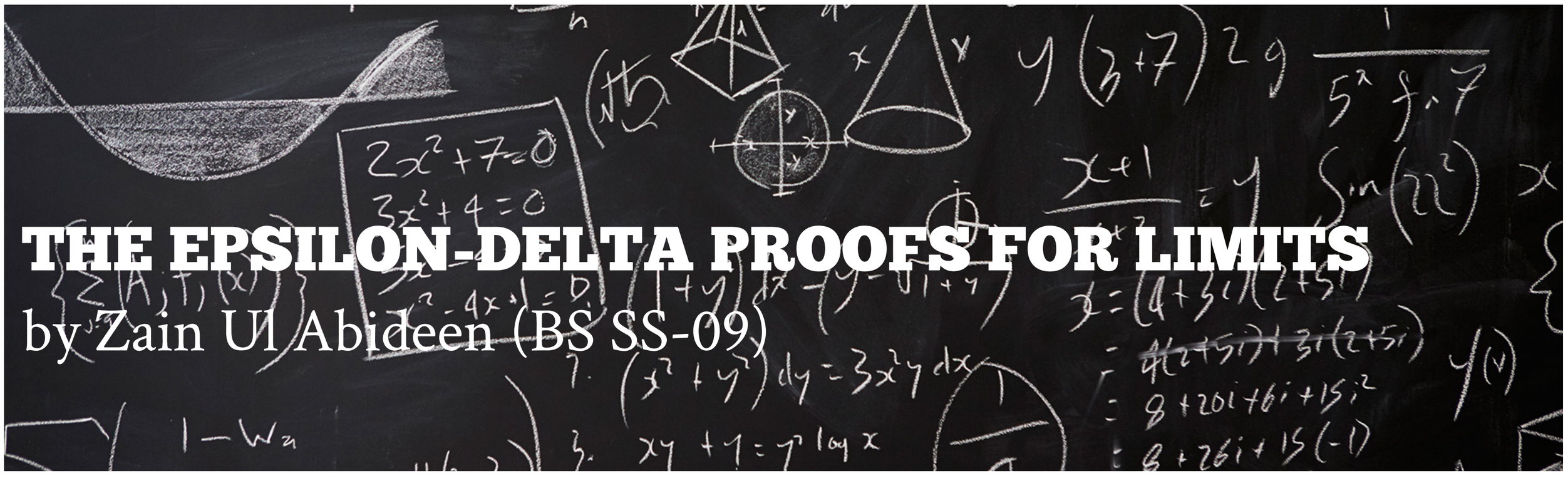


Source: https://theplanets.org/space-facts/

Cool Space Fact:

Neutron stars can spin 600 times a second!

Neutron stars are the densest and tiniest stars in the known universe and although they only have a radius of about 10 km (6 mi), they may have a mass of a few times that of the Sun. They can rotate up to 60 times per second after they are born from a core-collapse supernova star explosion and have been known to spin as fast as 600-712 times per second because of their physics.



THE EPSILON-DELTA PROOFS FOR LIMITS

by Zain Ul Abideen (BS SS-09)

A Simplified Method to Explain The Epsilon-Delta Proofs for Limits

Abstract

In this paper, I first give an intuitive introduction to logic used for mathematical proofs and then proceed to formulating the epsilon-delta definition for limits which turn the informal idea of 'approaching' a limit into rigorously defined mathematics. These epsilon-delta definitions can then be used to deductively prove the existence of a limit. This all only sounds difficult (and cool), no advanced mathematics is required to get a gist of it. The essence of pre-calculus, a strong understanding of algebra, and an open mind would be enough to not only understand it but also extend it.

Introduction to Logic in Mathematics

A proof, as the name suggests, refers to the idea of knowing something with a high degree of certainty. A conjecture is a statement that can either be true or false, and we can use different kinds of logic to prove or disprove a conjecture. In mathematics and physics almost all the time, the following two kinds of logical reasoning are used.

Deductive reasoning

In deductive reasoning, we construct a chain of facts that we already know to be true, in a proper way as to avoid any fallacies. Almost all of pure mathematics is based on deductive reasoning, and it is the most powerful line of reasoning in a sense that if a deductive proof is valid, it guarantees that the conjecture it was meant to prove is 100% correct, provided the facts used to construct the deductive argument are 100% correct. Deductive arguments can be said to take general facts and create specific solutions from them. Consider the following example:

Conjecture: Tobi has a tail.

Proof:

Fact number 1: All cats have tails.

Fact number 2: Tobi is a cat.

Hence using the facts 1 and 2, it can be deductively proved that the provided conjecture is true i.e. Tobi indeed has a tail. This is a basic example of a proof by deductive reasoning.

Inductive reasoning

For the inductive reasoning, we have to abandon the thrill of certainty and move to the realm of probabilities. Contrary to deductive reasoning, here we take a fact that we know to be true in a specific situation and generalize it. A fact that is certainly true in a specific situation is probably true in a general one. Consider the following example:

Conjecture: Tobi will probably eat tomorrow.

Proof:

Fact number 1: Tobi ate yesterday and all the days before till his birth.

Fact number 2: Tobi is a living thing and needs food to stay alive.

Hence using the above two facts we can inductively say that the provided conjecture is true i.e. Tobi will probably eat tomorrow.

Now, some of you might not be satisfied as to why it's probably true, why not certainly true?To give you some counter-examples, Tobi might die today. Although the chances of it happening are slim but non-zero nevertheless. There is also a non-zero chance that due to some undiscovered

phenomenon, Tobi might become immortal and never need food again. The possibilities are endless, and just a single counter-example with a non-zero probability is enough to convert ‘certainly’ to ‘probably’. All of the physics is based on inductive reasoning. We create and test the laws of the universe here on earth and then assume that the same laws will probably work anywhere else in the universe.

The Epsilon-Delta Definition

Functions

Before we proceed to defining the limits, we need to have a strong grip of what functions are. To put it in the most straight-forward way, a (single-variable) function is a mathematical object that takes in an input and gives out an output. Usually the input is denoted by x and the output by y or f (x). Consider the following example:

$$f(x) = x^2 + 2x + 1$$

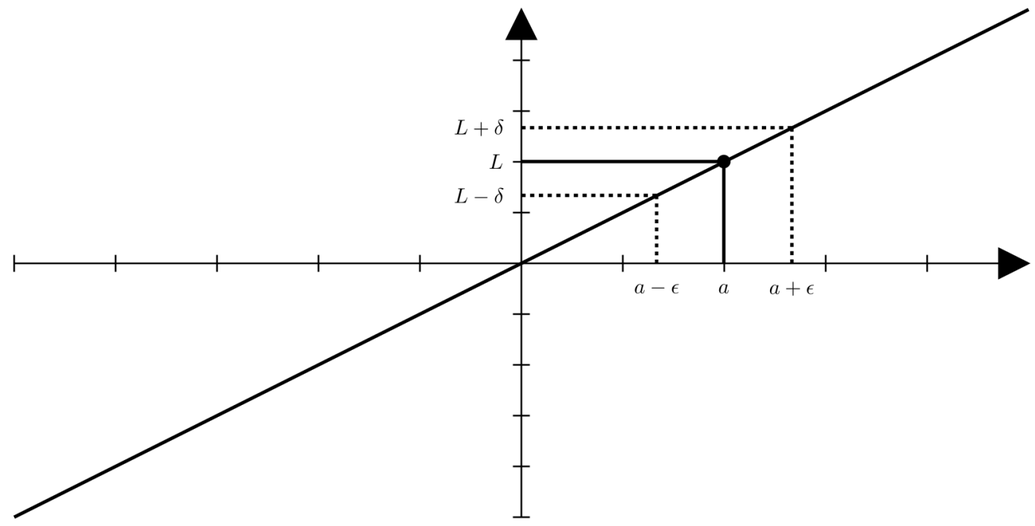
At x = 1, the value of y = f (1) = 1 + 2 + 1 = 4 and so on. Of course this is an oversimplified definition but should be good enough to provide the necessary intuition.

Limits

Consider a function f (x). At the point x = a, the value of the function y = f (a) equals L. Now assuming the function is continuous, as the input x gets closer and closer to a, the output y = f (x) gets closer and closer to L. This idea of getting closer and closer to a certain value is captured in a limit. It is notated as follows:

$$\lim_{x \to a} f(x) = L$$

Read as “the limit as **x** approaches **a** for f(x) equals L”. Note that x never actually reaches a, it just ever keeps getting closer and closer to a. Some of you might have noticed a problem with this, which is that this idea of a limit is loose. How do we express this idea of ever getting closer to a value using rigorous mathematics? We do just that through the epsilon-delta definition of a limit.



Let’s say we have a continuous function y = f (x) such that the value of the function equals L at the point x = a i.e. f (a) = L. Now let’s define ϵ to be an indivisibly small but finite number such that there is no number x that satisfies a < x < a + ϵ. Of course this condition is too idealistic, but taking a very small number for ϵ would work just fine. The values of the function at a + ϵ and a − ϵ equal L + δ and L - δ respectively as evident from the diagram. Mathematically, they can be written as follows.

$$f(a+\epsilon) = L+\delta$$
$$f(a-\epsilon) = L-\delta$$

By defining these constants this way, we are essentially saying that as long as a value of x lies in between a − ϵ and a + ϵ, the value of y is guaranteed to lie in the range L − δ to L + δ.

$$a-\epsilon < x < a+\epsilon \Longrightarrow L-\delta < y < L+\delta$$

The above inequalities, by using some basic algebra, can be written in the following modular forms:

$$|x-a| < \epsilon \Longrightarrow |y-L| < \delta$$

Which means that as long as the distance between x and a is less than ϵ, the distance between y and L will be less than δ. This rigorous definition is much more convenient to work with compared to the loose idea of ’approaching’.

Now instead, we can just say that a limit exists if the above condition is satisfied.

The Epsilon-Delta Proof for Limits

In the above definition of a limit, some of you might have noticed a relation. For any smooth function, the limit must converge to a single point. For the limit to converge, as ϵ gets smaller, δ must get smaller as well.

$$\epsilon \propto \delta$$

$$\epsilon = K\delta$$

If, for a specific limit, we can show that the modular inequalities are true from the above equation, the limit can be said to exist. Let's now apply all this abstraction to a few concrete examples.

Example

Conjecture:

$$\lim_{x \to 2} x^2 + 2x + 2 = 10$$

Proof:

Comparing this with the above general equations, we get that a = 2, f (x) = x^2 + 2x + 2, L = 10. If we can mathematically show that |x – 2|< ϵ and |x^2 + 2x + 2 – 10|=|x^2 + 2x - 8|< δ from ϵ = Kδ, the limit would be said to exist. Let's do some algebra now:

$$|x^2 + 2x - 8| < \delta$$

$$|x^2 + 2x + 1^2 - 1^2 - 8| < \delta$$

$$|(x+1)^2 - 1 - 8| < \delta$$

$$|(x+1)^2 - (3)^2| < \delta$$

$$|(x+1-3)(x+1+3)| < \delta$$

$$|x-2||x+4| < \delta$$

$$|x-2| < \frac{\delta}{|x+4|}$$

The term |x – 2| also appears in the ϵ inequality so we made it the subject from above. This gives us a hint about what the equation connecting ϵ and δ could be.

Let's make the following assumption and see if it holds or not.

$$\text{let } \epsilon = \frac{\delta}{|x+4|} \text{ as } x \to 2, \frac{1}{|x+4|} \to \frac{1}{6} = K$$

Now let's substitute this equation and see if it satisfies the inequalities that guarantee the existence of a limit.

$$|x-2| < \epsilon$$

$$|x-2| < \frac{\delta}{|x+4|}$$

$$|x-2||x+4| < \delta$$

$$|x^2 + 2x - 8| < \delta$$

This is indeed the second inequality! This relation of ϵ and δ satisfies the inequalities hence it can be deductively said that the provided limit exists. If the limit did not exist, no equation connecting ϵ and δ would satisfy the inequalities. The value of ϵ in-terms of δ we assumed converted the first inequality to the second inequality i.e. satisfied both inequalities.

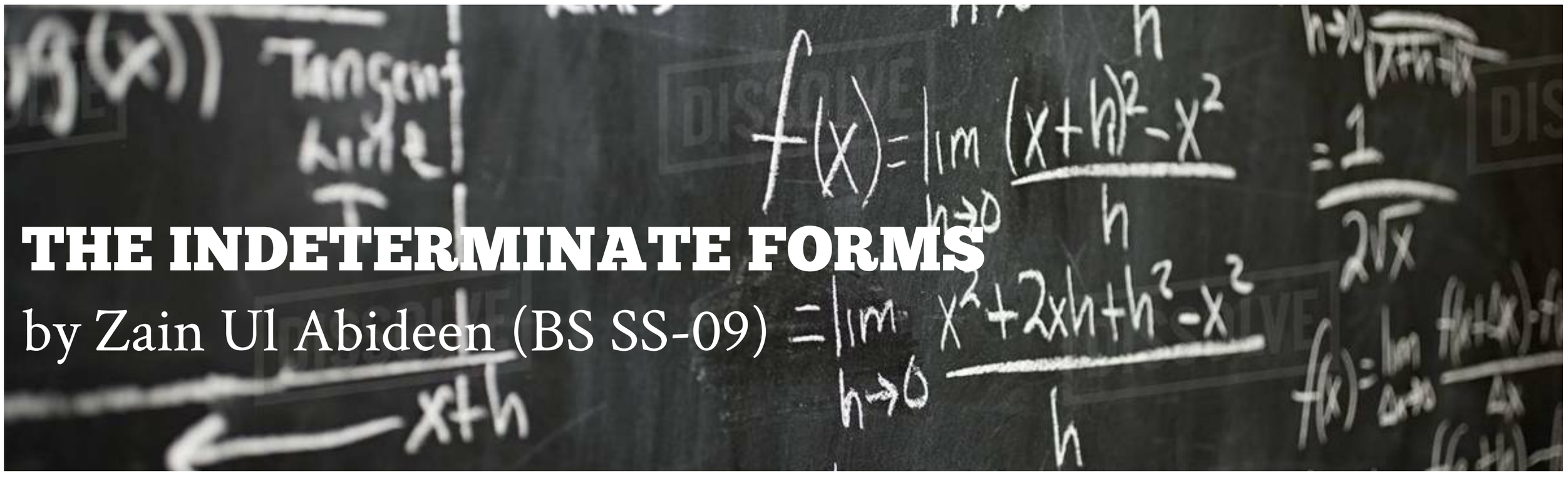
Conclusion

Some of you might wonder why we can't just use the reasoning that as we put closer and closer values of x into the calculator, the values of y get closer and closer to L. The only thing we can conclude from this is that the limit is probably true. We cannot test every single value of x as it approaches a certain value. Using the epsilon-delta proof we did above, we can say with a 100% certainty whether a certain limit exists or not. Now, how would we extend this idea of epsilon-delta proof to trigonometric, exponential, and essentially every non-polynomial functions? Well, we can derive a polynomial approximation for those functions using Taylor series and use the inductive reasoning that since the limit exists for the approximation, it would probably also exist for the function.

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Thomas, George Brinton, et al. *Thomas' calculus.* Addison-Wesley, 2005.

Kelley, David. *The art of reasoning: An introduction to logic and critical thinking.* WW Norton & Company, 2013.



THE INDETERMINATE FORMS

by Zain Ul Abideen (BS SS-09)

An intuitive approach to Indeterminate forms

Abstract

This algorithm was developed by using the fact that functions approach their linear approximations when sufficiently zoomed in at that point. After that, simple translations can be used to remove any indeterminate forms.

Formulation

Let's take the following general form:

$$L = \lim_{x\to a} \frac{f(a)}{g(a)}, \text{ where } L \to \frac{0}{0}$$

Alpha:

The first step would be to replace both f(x) and g(x) with their linear approximations at a. We can safely do this because sufficiently zooming into the functions near a point will make them linear. All functions are linear at infinitesimal scales. We can calculate these linear approximations by first calculating the derivatives of the functions at point a i.e. f'(a) and g'(a), and then substituting these as gradients into the equation of a straight line y=mx+c. The resulting form would be as follows.

$$L = \lim_{x\to a} \frac{m_1 x + c}{m_2 x + d}, \text{ where } c, d \in \{constants\}$$

Beta:

The second step would be to translate both f(x) and g(x) such that their point of intersection, which is also the same point the limit approaches to, moves to zero. This can easily be done by tweaking the input x to the functions by a certain amount. After the translation, the constants should disappear and the form should look something like shown below.

$$L = \lim_{x'\to 0} \frac{m_1 x'}{m_2 x'}$$

Gamma:

After the cancellation, we would be left with the ratio of gradients, which is also equal to the ratio of derivatives of the two functions.

$$L = \frac{m_1}{m_2} = \frac{f'(a)}{g'(a)}$$

This above form is know as the ***l'hopital's rule***. The intuitive reasoning helped us derive it.

Example

Evaluate the following limit:

$$\lim_{x\to -5} \frac{x^2 - 25}{x + 5}$$

$\frac{d}{dx}(x^2 - 25) = 2x \Longrightarrow 2(-5) = -10$ at point $x = -5$

$x^2 - 25 \approx -10x - 50$ near point $x = -5$

$$L = \lim_{x\to -5} -\frac{10x + 50}{x + 5}$$

By using the coordinate transformation $x = x' - 5$, we can shift the point to origin.

$$L = \lim_{x'\to 0} -\frac{10x'}{x'} = -10 \text{ Answer}$$

Works used:

Thomas, George Brinton, et al. *Thomas' calculus.* Addison-Wesley, 2005.



THE BENJAMIN FRANKLIN EFFECT

by Muhammad Rehmoz Ayub (BS AERO-17)

How to win favors in social interactions?

Imagine you're waiting in a long queue at a bank, waiting for your turn to pay a bill. An elderly woman, in her late fifties, seems a bit troubled and walks up to you. She asks you about which counter she has to pay her bill at. You look at her bill. It's the same utility bill that is paid on the counter of the queue you're standing at. You gaze over at the 'amount before due date' section. It's a meager amount. You look behind yourself. It's a long line and it will take the woman another 2 hours to be able to pay her bills. Out of compassion you offer to pay her bill by yourself. She offers you the money and you reluctantly take it. After you've paid the bill, you hand over the stamped paper and the change to her. She squints her old eyes at the bill. Her expressions change from scrutiny to grateful, and give you an approving nod. You walk out of the bank, and for some reason you wonder why you helped the old woman. Maybe it seemed the right thing to do. But then, you could've helped the elderly man standing 10 feet behind you too. You realize you've grown to like the old woman. It was her troubled expressions that made you help her. But the real reason remains elusive. And we'll figure out the actual reason, together. But I digress. And by the end, I hope it shall become clear to you as to why you helped that woman.

Have you ever thought about the relation between your actions and thoughts? Let's think together: Our actions are an obtrusion of our thoughts. We do what we think is right and leave what seems incorrect, immoral or unethical. The logic that went up in the previous sentences is completely coherent by the axioms of common sense; thought before action. Turns out, that's totally not how our thought process works!

We are not beings of thought but rather creatures of action. Any action that we do leaves a footstep in our mind. These footsteps are imprinted in our neural network. Any action against our self-held principles will brew disquietude. The brain cannot handle dichotomies between our ideologies and our actions. Therefore, the brain literally changes our perception to be at ease with the dis-junction. This is known as **"Cognitive Dissonance"**.

Benjamin Franklin, an American polymath and one of the Founding Fathers of the United States, was the first person, at least historically, to point out this counter-intuitive behavior of the human brain. He stated in his auto-biography, mentioning an old rival whose friendship would prove valuable to him in the future:

"He that has once done you a kindness will be more ready to do you another, than he whom you yourself have obliged".

The Benjamin-Franklin effect is a shining example of cognitive dissonance in play; the greater the gap between the act of performing the favor and the way a person feels toward the person they're helping, the more likely that person is to experience the Benjamin Franklin effect [1].

I read about this concept not long ago. But pondering over my actions led me to the recollection of how it affected me and people I knew, sub-consciously. Whether it was me asking the chef at a local Burger Shop for extra sauce, or it

was me being asked to help an elderly woman cross the road. The person who helped, in both cases, started to like the helped person more; the chef became my friend, and I developed sympathy for the old woman. Therefore, it has led me to reasonably believe that the Ben-Franklin effect does work, even when both involved parties fail to notice it.

So, how do you win favors in a social setting? The counter-intuitive genius of Ben-Franklin effect can be applied in almost every social interaction. The sales industry can teach their employees how to use the effect to turn the tide of closing in their favor. For example, an employee can ask a potential client for a personal favor. This can be anything; ranging from doing a short survey to asking for a client's perspective of the market and where it is headed. The client can feel empowered and develop a connection with the employee, thus, improving the chances of a successful closing. In your immediate surroundings, if there's a particular person who doesn't like you very much, ask them for a small favor, such as asking them to lend you their book for a short time or to hold your bag while you tie your shoes. This will rewire their brain into thinking that since they did a favor for you, they must like you. There are two caveats worth mentioning; the favor should be personal as impersonal favors tend to decrease the liking [2] and asking someone for a big favor might end up with them refusing to do it. As a result, they might end up forming a negative opinion about you [1].

The Reverse Benjamin Franklin effect

The reverse case also exists for Ben-Franklin Effect. Just as someone starts liking a person for whom they did a favor to, they can also start hating the people they hurt. We see this case in murderers, dehumanizing their victims as it puts them in psychological ease with the guilt. The same goes for soldiers in wartime atrocities; they start loathing the enemy to lessen the cognitive dissonance of killing. Unfortunately, we, as humans, start resenting the very people we cause pain.

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EPISTEMOLOGY

by Syeda Farwa Rizvi (BS CS-01)

Epistemology

There are several reasons why epistemology should exist. According to Aristotle (384 – 322 BCE), philosophy starts with a sense of astonishment or perplexity. Almost everyone aspires to better understand the world around them, and many of them do so by formulating numerous ideas. However, since many worldly things are difficult to explain, most individuals are inclined to give up and settle with whatever level of knowledge they have attained.

According to Parmenides, knowledge cannot be subject to change. As Plato noted in the Theaetetus, one implication of this approach is that the things we see via our senses cannot serve as a reliable source of knowledge. To the degree that humans possess knowledge, it is derived via reason in discovering immutable things. According to Plato, knowledge may be gained by reason by first exploring the nature of immutable things and then exploring how that knowledge might be gained. The allegory of the cave, found in Book VII of the Republic, is the best-known of Plato's literary methods for illustrating his theories.

The allegory portrays humans dwelling in a cave, which is a metaphor for the realm of senses. The only things people perceive in the cave are shadows or pictures that aren't real. These people begin their ascension out of their mental cave into reality through a difficult intellectual process that includes rejecting and conquering the familiar rational world. As a result of this procedure, one may grasp the concept of immutable things and so gain knowledge. Few can make it to the summit, where they may be rewarded with a direct view of the Sun, the ultimate repository of all knowledge.

Plato's exploration of unchanging things starts with the insight that each faculty of the mind recognizes a distinct set of objects: hearing, sight, and smell. According to Plato, knowledge is likewise a mental capacity, and hence there must be a distinct set of things that it recognizes. Some of these objects may be referred to as predicates, such as "good," "white," and "triangle". "This is a triangle," for example, means that a particular spatial object, such as a figure made in the sand, has the quality that it is, in this case, a triangle. The common quality of being triangular is what Plato distinguishes in this instance: individual angles are drawn or painted. There is no such thing as a "specific" in the realm of appearances, where the first kind of objects are always situated in space and time. When it comes to shaping or thought, the two of them have one thing in common. Forms, unlike specifics, may not exist in time or space; they also do not change. Because of this, they are the things that one sees when one has a certain amount of knowledge. Plato's approach of dialectic, which he learned from his teacher Socrates, is based on the application of reason to find eternal forms. To get a "true definition," the technique uses a series of questions and answers.

Plasticity, in Plato's sense, is defined as having all the elements required for a certain thought to be true, but not more. Becoming a sibling necessitates and suffices both being female/male and having a brother/sister for one to qualify as a member of the "being a sibling" category. It is clear to everyone who knows these requirements what being a sibling

is all about. Plato uses the dialectical approach to analyze the notion of justice in The Republic. In answer to Cephalus, Socrates stated that under certain circumstances, it is simply not telling the truth or repaying obligations. Let's say you borrow a weapon from someone who goes insane after that. If that individual wants his weapon back so that he may murder someone innocent, telling him that he no longer owns the weapon would be a lie, as you borrowed it, not bought it. As a result, "justice" cannot be equated with "honesty in word and action." Socrates tries to come up with a definition that can't be contradicted by making a series of definitions and testing each one against various plausible counterexamples. So, he grasps the essence of justice, the commonality that all right things have in their form. Definitions and forms are at the heart of Plato's quest for knowledge. However, how should we define knowledge in general? According to Plato in Theaetetus, to know anything, you must believe it to be true. Falsehood has no way of being detected. People may claim they are aware of something incorrect. They may believe they know something, but in reality, they have no way of knowing for sure. Information is more than just a firm opinion. For example, suppose that someone gets a dream in January that there may be an explosion in September and, based on this dream, develops the idea that there may be an explosion in September. If an explosion does take place in September, we'd want to know about it. True belief in the explosion but lack of understanding of the phenomenon. To sustain their genuine viewpoint, the individual lacks a strong rationale for doing so. In other words, the individual lacks rationale. Plato makes the case that real belief is justified knowledge by using similar arguments.



Source: https://theplanets.org/space-facts/

Cool Space Fact:

The footprint on the moon will be there for 100 million years.

The Moon has no atmosphere, which means there is no wind to erode the surface and no water to wash the footprints away. This means the footprints of the Apollo astronauts, along with spacecraft prints, rover prints, and discarded material, will be there for millions of years.



MONSTER OF THE COSMOS

by Kiran Sardar (BS CS-01)

Amidst Milky Way
Lies a place
Floating beyond the fabric of time and space
Hidden beneath the layers of a black Cape
It's called, monster of the cosmos
Beautiful yet deadly.
It swallows the star, as a whole.
Extracting every bit of light and hope
Once shiny,
Now dies.
Without any fumes or smoke
Into a deep slumber
And endless void
It's a stern ring of bright yellow and red
Making the heart of a star, dread.
It's called, monster of the cosmos
Beautiful yet deadly.

~Kiran Sardar

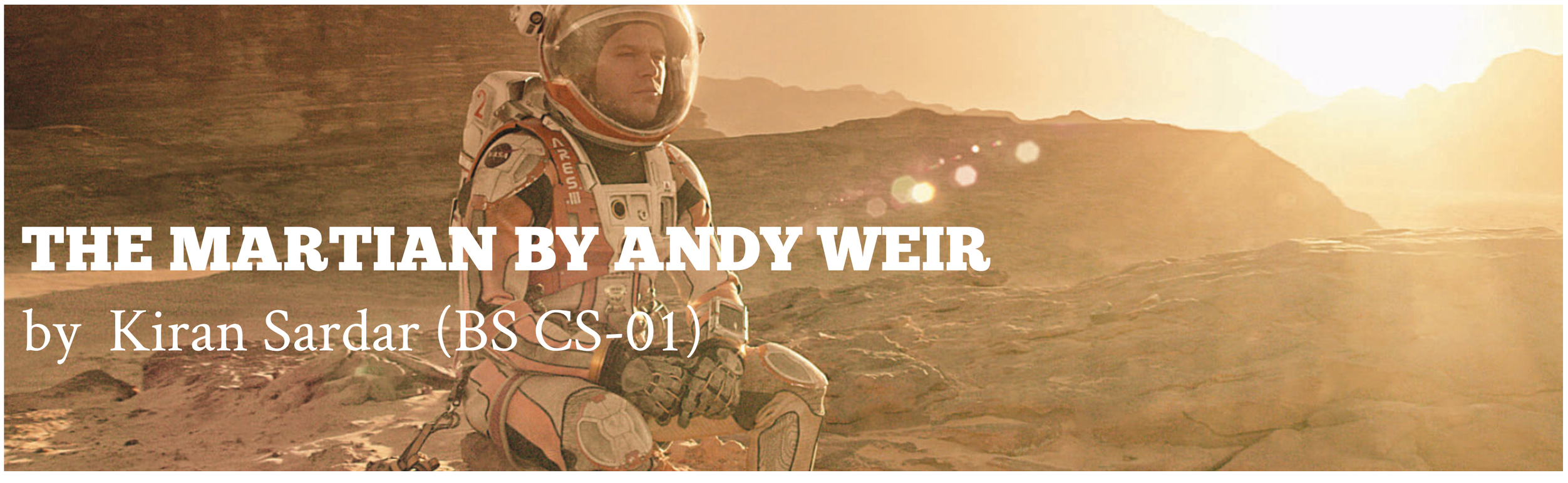


ANDREA GHEZ, THE 2020 NOBLE LAUREATE

by Nawal Haider (BS MAT-13)

Andrea Ghez, the 2020 Noble Laureate

Andrea Mia Ghez was born in New York City on June 16, 1965. When she was a youngster, her family relocated from New York to Chicago, where she attended the University of Chicago Lab School. She started out with arithmetic as her major in university however later modified to physics. She acquired a BS in physics from the Massachusetts Institute of Technology in 1987 and the completed a doctorate in 1992 from the California Institute of Technology. She is an astronomer as well as a professor in the University of California. Her studies make a specialty of the middle of the Milky Way galaxy. In 2020, she has become the fourth lady to be presented the Nobel Prize in Physics. Ghez was a pioneer in an effective image generation technique known as adaptive optics, which corrects the distorting effects of the Earth's surroundings in real time and turns the center of our galaxy into a laboratory for studying black holes and their crucial role in the history of the universe. She and her colleagues have uncovered numerous surprises in the environs around supermassive black holes using adaptive optics at the Keck Observatory, such as younger stars when none were expected and a loss of antique stars where many were expected. Ghez and her team announced in the year 2000 that astronomers had been able for the first time to see that the bright stars rise up over the supermassive black hole. In 2003, she and her crew stated that the case for the Milky Way's black hole had been bolstered appreciably and the proposed suggestions would be excluded. Ghez and her colleagues used the Keck Observatory in 2005 to take the first clear image of the Milky Way's center, which included the area surrounding the black hole. The Search for the black hole began in early 90's while Ghez and her colleagues endeavored to reveal the pictures of our galactic center. They were able to look through thick soil that filters visible radiations by imaging the Galactic Center at infrared frequencies. With the help of the world's biggest telescope facility at Keck Observatory which boasts a 10m-aperture, the team used adaptive optics to get high resolution images of the center of our galaxy. The orbit of the star on the galactic middle is the maximum proper proof for the presence of a supermassive black hole on the middle. One of stars, S2, has made a whole elliptical orbit considering specified observations start in 1995. It takes around sixteen years to finish its orbit. In order to make this evidence stronger it would take decades to absolutely report the orbits of a number of those stars. In October 2012, another star namely S0-102, was recognized by her team at UCLA, orbiting the Galactic Center. In 2020, Andrea Ghez shared with a Nobel Prize for her 23 years long journey along with Reinhardt Genzel and Roger Penrose. Genzel and Ghez shared the award for their findings of a supermassive black hole with greatest probability that governs the orbits of stars in the Milky Way's center. Ghez, as a result of extra-ordinary research, was elected to the National Academy of Sciences and the American Academy of Arts and Sciences. She was also the first woman to receive the crafoord Prize from the Royal Swedish Academy of Sciences, and was also appointed a MacArthur Fellow back in 2008.



THE MARTIAN BY ANDY WEIR

by Kiran Sardar (BS CS-01)

Genre: Novel, Science fiction, Humor

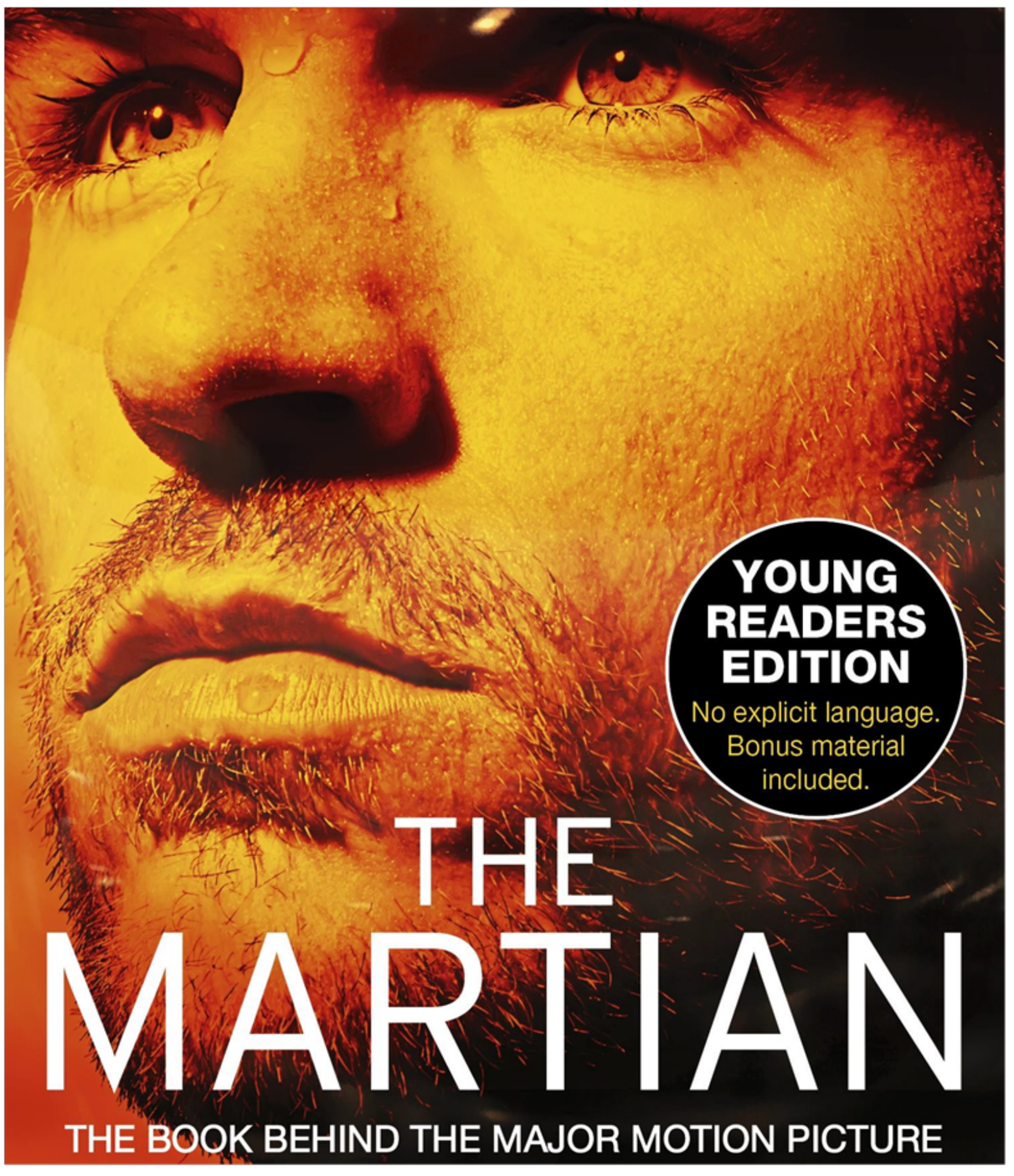
RATE: 8/10

The Martian is one of those books that waste no moment and dive right into the action. Written by Andy Weir, the core theme of the book revolves around Human isolation and survival on our neighboring planet, Mars. The main character of the book is, Mark Watney who is an astronaut, a mechanical engineer, and a botanist. An odd combination in general but a killer one for survival on Mars. Watney is one of six astronauts on a Mars mission and unfortunately, the only one left on the red planet when things go wrong. From there, his journey for survival on mars begins. While he waits for a rescue mission to save him. Mark encounters a ton of difficulties such as food shortage, sand sorts, and solitude.

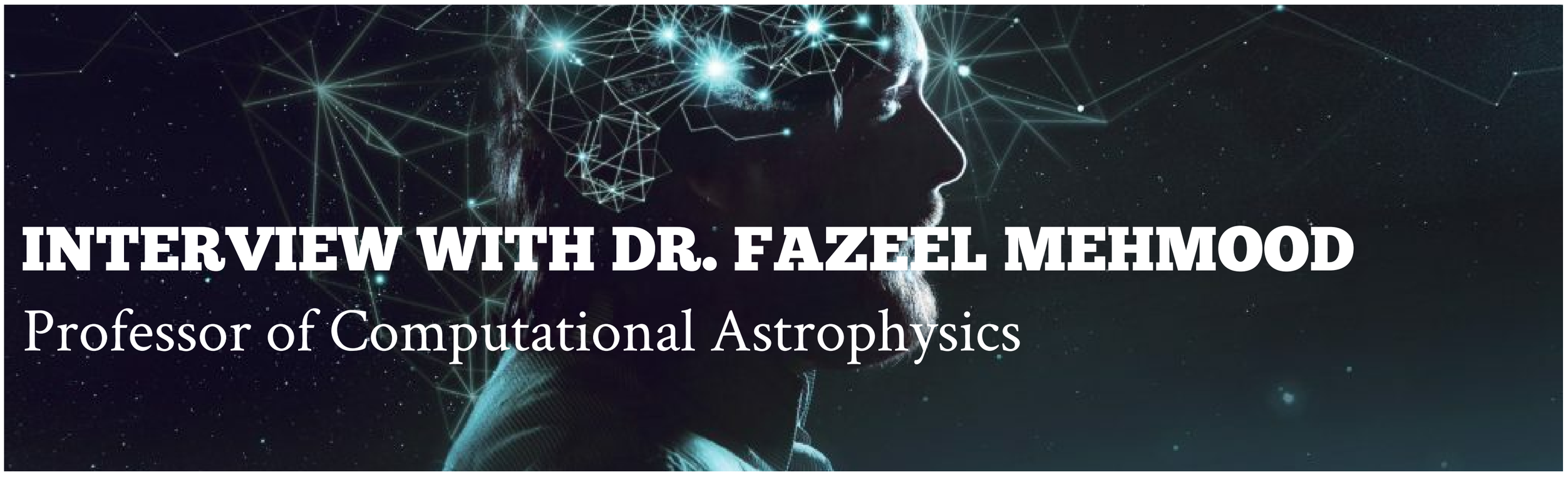
PROS: The combination of humor and space fiction is enlightening, and it keeps the book going. Also, the fact that Watney comes up with creative ideas to encounter the problems on Mars is mind-boggling. The writing style, most of the book is written in the form of folksy log entries by the astronaut.

CONS: Other than that, the writing, in general, sometimes feels bland, as out of nowhere more compassionate and serious side to Mark's personality is shown which does not go with the character arch. Also, the author shifts the focus from the main to the side characters, way too much sometimes which can be confusing for the readers.

The book being a little predictable is not about whether Mark will survive or not. The question is how will he do so? Nonetheless, if you want to read an entertaining book, space fiction fused with humor, then this book is definitely for you!



Source: *The Penguin Australia*



INTERVIEW WITH DR. FAZEEL MEHMOOD

Professor of Computational Astrophysics

Interview with Dr. Fazeel Mehmood Khan



Dr. Fazeel is a professor and a researcher at Institute of Space Technology, Islamabad. He got his PhD from the Max Plank Institute in Heidelberg Germany. His areas of expertise are in Supermassive Black holes, Gravitational waves, Galaxy mergers and Computational Astrophysics.

Q: What makes supermassive black holes stand out from regular stellar mass black holes?

Supermassive black holes are billions of times more massive than their stellar mass counterparts. Their event horizons are measured in orders of astronomical units rather than kilometers. The event horizons of stellar mass black holes violently rip matter apart whereas if we were to cross the event horizon of a Supermassive black hole, we wouldn't even know it because of their low mass to volume ratio.

Q: How the supermassive black holes are formed?

This is an active area of research in modern astrophysics. There are three most likely explanations for this problem. First of the theories suggest that in the early universe, it had less time to expand so matter was less far apart than it is today. At that time, it was possible for many stellar mass black holes to merge together to form a Supermassive black hole. The second most prevalent theory is that in the early universe, a cloud of gas with a diameter in orders of astronomical units could have formed and a direct collapse could've resulted in the formation of a supermassive black hole. A third explanation is that at galaxy mergers, due to some complex phenomenon, matter tends to concentrate towards the center which could in theory lead to the formation of a Supermassive black hole.

Q: What is so special about the gravitational waves emitted by a black hole when all astronomical objects emit them?

Black holes are the most massive breed of astronomical objects in our universe. To generate strong gravitational waves, very large mass and acceleration is required, and black holes have them both. The detection is limited by our current technological capabilities. At this time, we are only able to detect the strong ones, and not the ones produced by, let's say, our planet when it revolves around the sun.

Q: What is Computational Astrophysics and how is it different from theoretical Astrophysics?

Broadly speaking, Astrophysics can be divided into three main branches. The first and the oldest one is observational astronomy which was pioneered by the likes of Newton and Galileo. The second branch is theoretical Astrophysics, which uses mathematical techniques to create models that aim to capture the essence of our universe. The third and the most recent one is Computational Astrophysics. Due to the large scales of our universe, direct experimentation is next to impossible. This forces us to take the computational route which involves making simulations on supercomputers and adjusting the scales as per our needs to get the results. Many times, even the best of

supercomputer are unable to deal with the vast scales so physicists have to manually reduce the scales to get the results and then extrapolate them and hope they work in the real universe as they did in the simulation.

Q: How can the methods of astrophysics be useful to engineers?

The laws of physics remain the same throughout the universe. The same equations of fluid dynamics that astrophysicists use to calculate the hydro-static pressure in the cores of stars, engineers use to calculate lift in air-crafts. Science and Engineering has an inseparable link, and the techniques of one discipline are widely applicable in the other.

Q: What was the thing that made Dr. Fazeel interested in Astrophysics and Space Science in general?

Dr. Fazeel had an interest in physics from the very start. He performed really well in electronics, nuclear physics and computational physics. In that time, there were only a few books available on Astrophysics and virtually no courses were offered in this domain. He completed his Bachelors and Masters locally and got an opportunity for an Astrophysics doctorate in Germany. He had problems starting out due to his lack of knowledge in Astrophysics but he soon made up for it by taking supplementary courses. Now, he is one of the well-reputed Astrophysics researchers in Pakistan.

Q: What advice would Dr. Fazeel like to give to students who want to pursue a career in Astronomy and Astrophysics?

Astronomy, like many other sciences, is not how it looks. Students get fascinated by the images taken by telescopes but in reality, astronomy and astrophysics is just a fancy name for mathematics that's applied to space. It is quite easy for physics majors to shift to Astrophysics but hard for engineering majors unless they work on instrumentation or make up for the deficiency in math and physics courses. It is also very hard to secure funding for bachelors or even masters but becomes easier for doctorate. What Dr. Fazeel recommends is that students complete their bachelors and masters locally at good universities and then apply abroad for funded PhDs.

Q: What is the importance of practice problems at the end of each chapter and can students safely neglect them?

Practice problems are used to sharpen the tools acquired in the whole chapter. For those who want to develop a sound understanding of the topic and potentially conduct research, they must solve the end-of-chapter problems. Even scientists who stop using their tools start to forget things and end up worse than before. So, it is must for anyone who wants to, one day, become exceptional to do a lot of practice problems.

This interview was conducted by the members of the publications team of the Space Society IST.

A GLIMPSE OF OUR SOCIETY

At the Institute of Space Technology, Islamabad, Space Society IST has an illustrious presence. While being an academic society, several of our events are designed in a way that they do not lose the element of entertainment (such as Halloween Night, Space Games or trip to Chinji National Park). Some of the events we conducted in the last year are presented below.













A LITTLE MESSAGE

This magazine is to be distributed **free of cost**. Our primary mission is to educate and foster the interests of youth. Please feel free to share this with anyone interested in space, astronomy or science.

While this magazine is an effort on our side to popularize space technology in Pakistan, Space Society IST also conducts several lectures, workshops, competitions, observatory sessions and much more throughout the year.

If you like our initiatives, please consider following us on our social medias. You can also email us for any queries, concerns, feedback or collaboration invitations.

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A video about Space Society IST.

We hope you enjoyed reading this magazine as much as we enjoyed creating it!