The Ultimate Space Safari around Black Holes

A graphic novel on Black holes and gravitational waves produced by them

Project II Report

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An education project in association with the **Astronomical Society of India.**

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Contents

1. Introduction

Curiosity is a consequence of our intelligence. We, the human beings, are naturally curious and the Cosmos is the biggest mystery. History tells that we could simply not resist our temptations of exploring space. And exploration of any sort, is a very fundamental trait present in all of us, whether it is physical exploration or mental. Our thinking brain will always ponder about its existence and relevance. And we must never stop wondering ... because a sense of wonder brings excitement to our existence!

Rachel Carson, who sparked the modern environmental movement with her 1962 book 'Silent Spring', wrote a little known essay a few years earlier called "The Sense of Wonder." And there she wrote:-

'A child's world is fresh and new and beautiful, full of wonder and excitement. It is our misfortune that for most of us that clear-eyed vision, that true instinct for what is beautiful and awe-inspiring, is dimmed and even lost before we reach adulthood.'

Therefore, this opportunity of instilling a sense of wonder in high school students must seized at all costs.

Apart from that, it is important to note that the universe functions on two very different theories of physics - General Relativity and Quantum Theory.

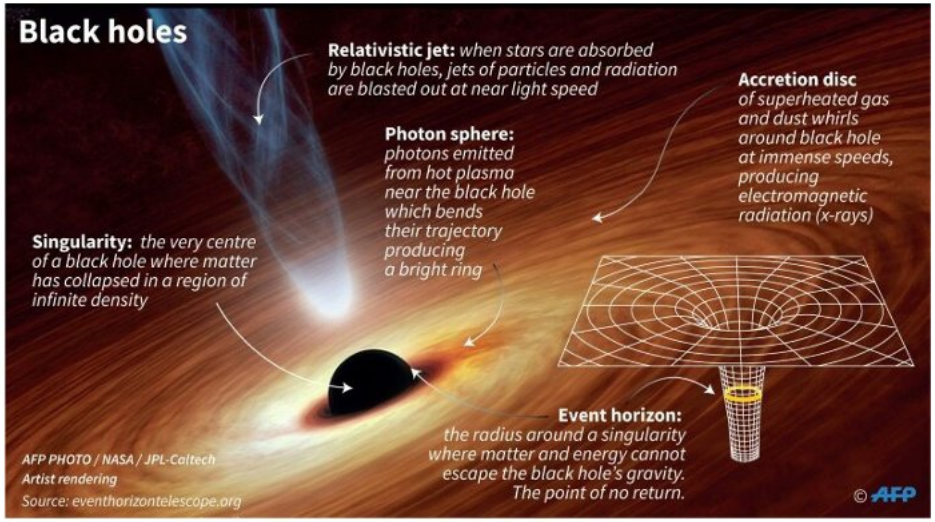
- General relativity accounts for gravity and all of the things it dominates: orbiting planets, colliding galaxies, the dynamics of the expanding universe as a whole. That's big.

- Then there is quantum mechanics, which handles the other three forces – electromagnetism and the two nuclear forces. Quantum theory is extremely adept at describing what happens when a uranium atom decays, or when individual particles of light hit a solar cell. That's small.

Basic introductions to both these theories are covered in secondary and senior secondary school education.
However, in detail some concepts can still be expanded for not only strengthening the basics but also providing more interesting information before the student's college-stage.

So what is a black hole?

"A black hole is a celestial object that compresses a huge mass into an extremely small space."
Black holes are generally created when big stars die and collapse onto themselves, confining all the gravity inside into a small area which creates a gravity sink in the fabric of space-time. And this is a black hole. Yes it is complicated but let's look at the comparitive analogy below.
The gravity is so strong because matter has been squeezed into a tiny space. If the same were to happen to Earth, our planet would fit inside a coin or a water bottle cap. The Sun would only be six kilometres (a few miles) in diameter.



What are gravitational waves generated by black holes?

Gravitational waves are 'ripples' in space-time caused by some of the most violent and energetic processes in the Universe, such as, a merger of two or more blackholes.

These gravitaional waves can be captured using LIGO detectors. LIGO stands for "Laser Interferometer Gravitational-wave Observatory". LIGO currently consists of two interferometers, each with two 4 km (2.5 mile) long arms arranged in the shape of an "L". These instruments act as 'antennae' to detect gravitational waves.

2. Motivation

Black Holes and the uncertainity they bring to perspective is simply wonderful. We do not know enough about blackholes but whatever is known so far instils an immense sense of wonder.
There have been new revelations and discoveries regarding black holes of late and many properties of these giant phenomenans have come to light - one being the fact that they produce gravitational waves.These waves are captured and presented as sounds. **It is quite interesting to note that theses sounds produced by the merger of two or more blackholes is called "chirping".**

From communication design prespective as well, its fascinating to observe how we name these concepts in such elementary ways. Even the term "Black hole" was coined in very snappy way by American Scientist John A. Wheeler, to encompass the heavy definition of it - **"gravitationally completely collapsed stars".**

The use of such analogous words, in order to concise information into smaller easliy 'digestable' terms is quite insightful. And this project brings to me the opportunity of disecting and simplifying the concept of Black holes and Gravitaional waves for students in a story format. It is definitely a design challenge and I am totally up for it!

3. Primary Study

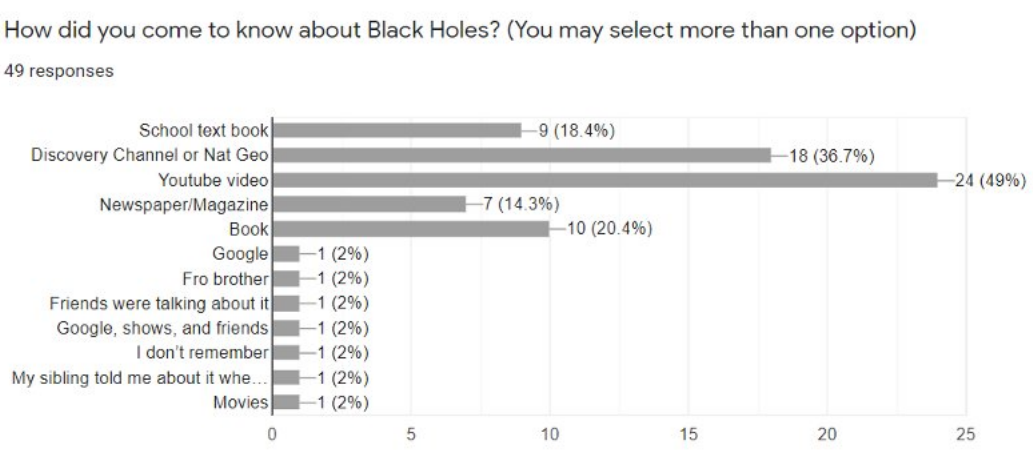
A very basic google form was circulated amongst 49 students (Urban, Secondary + Senior secondary, CBSE board) consisiting of questions as follows:-

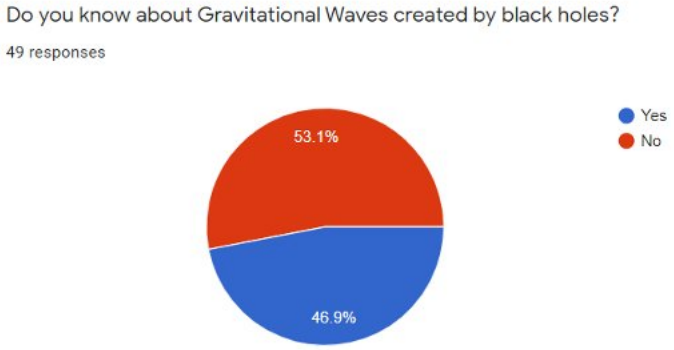
1. What class are you in?
2. Do you know about blackholes?
3. How did you come to know about blackholes?
4. Do you know if two or more black holes can merge into each other?
5. Do you know about gravitational waves produced by blackholes?
6. If given a comic book on blackholes, would you like to read it?

Insights from the response

The biggest insight recieved was that more than 90% students know about blackholes but when asked about gravitational waves produced by them, more than 50% were not aware about it.
This implies that they know about black holes as a term but not in great detail.

Another insight was that the main source of information regarding black holes for this set of students was Youtube -49%. School textbooks comprised of 18.4% of the total percentage.





4. Secondary Study

Following are the sources used for secondary research :-

4.1 School Textbooks (SSC, NCERT)

4.2 Youtube Videos

-Black Holes and Neutron Stars: A Merger in Space
-Sound of Two Black Holes Colliding
-Real Sound of Two Black Holes Colliding
-Sound Of Two Black Holes Colliding Explained
-The Sound of Two Black Holes Colliding
-What are gravitational waves? - Amber L. Stuver
-Does time exist? - Andrew Zimmerman Jones
-The Invisible Reality: The Wonderful Weirdness of the Quantum World
-Black Holes and Holographic Worlds
-What If You Fall into a Black Hole?
-Black Holes Explained – From Birth to Death
-The Largest Black Hole in the Universe - Size Comparison
-The Most Massive Black Hole Merger is 'Impossible'
-Interstellar - Orbiting Gargantua
-Artist's Impression of the Black Hole Concentration in NGC 6397
-Hubble Uncovers Concentration of Small Black Holes.

4.3 Books on Black holes

- Black holes and time warps by Kip S. Thorne
- Stephan Hawking Black Holes (The BBC Reith Lectures)
- A blackhole is not a black hole by Carolyn Cinami DeCristofano
- A kid's guide to Black Holes : Astronmy book for garde 6 by Baby Professor.

4.4 Articles & News clippings

- Google news
- Instagram pages dedicated to Astronomy updates
- Nasa website, etc.

4.1 School Textbooks (SSC, NCERT)

To know the pre-requiste knowledge to further understand the complex concept of a Black hole, we analysed the following school books issued by **SSC & NCERT.**

SSC (Maharasthra State Board)

Age	Std.	Subject	Chapter	Keywords
8	III	EVS	Direction and Maps	Identifying our address
			Understanding Time	Ways to measure time
			Changes in our surroundings	Physical Changes in Sky & temperature
9	IV	EVS	Day and Night	Connection of the earth's rotation with seasons
10	V	EVS (Part 1)	Our Earth & Our Solar System	Stars, Planets, Solar System, Satellites, Dwarf Planets, Asteroids, Gravity
			Motions of the Earth	Earth's Rotation, Sunrise & Sunset, Year, Leap Year, Phases of the Moon, Lunar Month & Tithis
		EVS (Part 2)	History and the Concept of Time	Division of Time & Timeline, BCE (BC), CE (AD), Prehistoric / Historic, Carbon Dating
11	VI	Geography	The Earth and The Graticule	Angular Distance, Parallels of Latitudes, Meridians of Longitudes, Equator, Graticule
			Let us use the Graticule	Familiarizing with the Graticule, Importance of Tropic of Cancer & Tropic of Capricorn
		Science	Light and the Formation of Shadows	Reflection of Light, Pinhole Camera, Formation of Shadow, Sundial, Newton's Disc
			The Universe	Milky Way, Types of Galaxies & Stars, Facts & Figures about our Planets, Comet, Meteor

SSC (Maharasthra State Board)

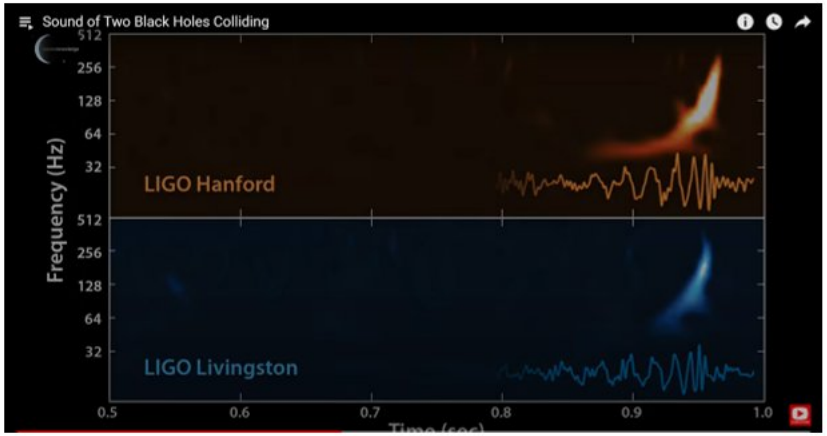
Age	Std.	Subject	Chapter	Keywords
12	VII	Geography	How Seasons Occur - Part 1	Measuring Sunrise, Sunset, Duration of Day & Night (During June - Summer Solstice)
			The Sun, the Moon and the Earth	Motions & Phases of the Moon, Solar Eclipse, Lunar Eclipse, Occultation, Transit
			Tides	Centrifugal & Gravitational Force, Occurence & Effects of Tides, Timings of Tides
			How Seasons Occur - Part 2	Apparent Movement of Sun, Uttarayan, Dakshinayan, Vernal & Autumnal Equinox, Cycle of the Seasons
		Science	Effects of Light	Scattering of Light, Formation of Shadows, Solar Eclipse, Lunar Eclipse, Zero Shadow Day
			In the World of Stars	Lifecycle of Stars, Horizon, Zenith, Nadir, Celestial Poles, Celestial Equator, Constellations, Zodiac Signs, Nakshatras
13	VIII	Geography	Local Time and Standard Time	Local Time, Indian Standard Time, GMT, Universal Standard Time, Jantar Mantar
		Science	Life Cycle of Stars	Birth of Stars, their properties, Stability & Evolution of Stars, End-stages of stars (3)
14	IX	Science	Observing Space: Telescopes	Scientists, Different Forms of Light, Optical (Refracting) Telescope, Reflecting Telescopes, Radio Telescope, Telescopes in Space, ISRO
15	X	Science	Space Missions	Need & Importance of Space Missions, Artificial Satellites & their types, HEO, MEO, LEO (Low Earth Orbit), Satellite Launch Vehicles; Missions to Moon, Mars, other planets; Space Debris & their management

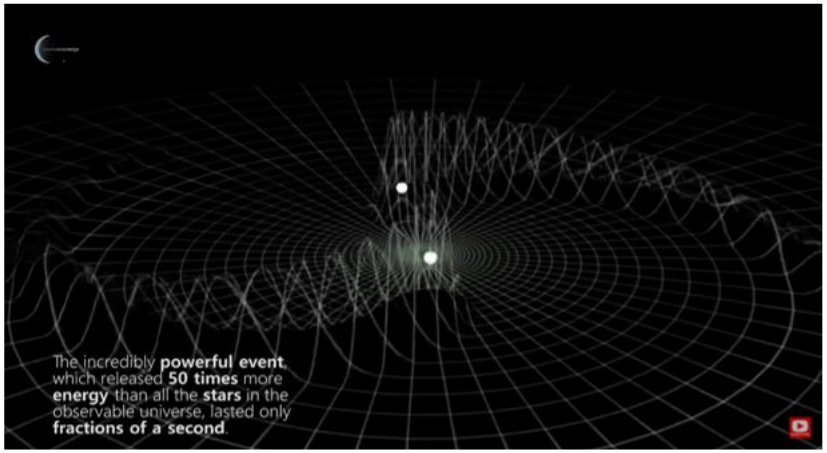
NCERT (National Council of Educational Research and Training)

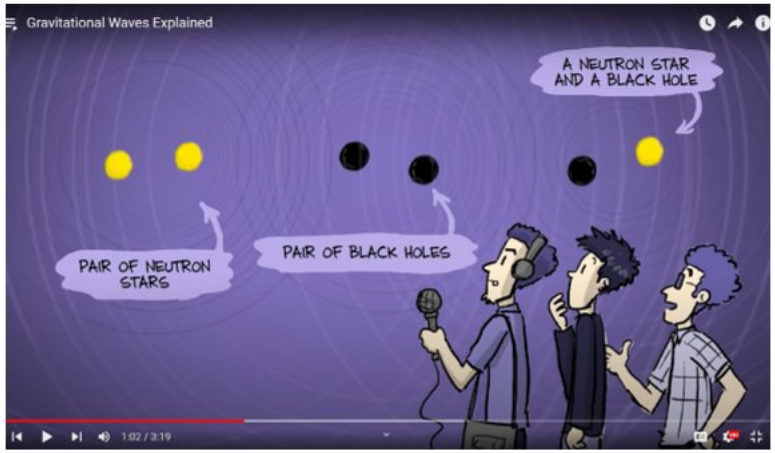
Age	Std.	Subject	Chapter	Keywords
10	V	EVS	Sunita in Space	Globe, 3-D structure of Earth, Space missions (national, international) 3-d structure of Moon, Sun, Gravity.
11	VI	Social Science	The Earth in the solar system	Self, Earth, Solar system, Milky way galazy, the universe. Longitude/Latitude, Motions of earth, landforms, climate (Vegetation& wild-life), concept of countries.
12	VII	Science	Motion and Time	Speed, Measurement of Time, Jantar Mantar, Oscillation, Unit of time
			Light	Light as a cocncept, Laws of reflection
13	VIII	Science	Sound	Vibration, medium of propogation, amplitude
			Stars and the solar system	Positions of moon, Surface of moon, Stars (sun, pole, etc), Light year, Constellations, Solar system and all planets, Astronomy in ancient India, Meteroites and Meteors, Superstitions about comets, Meteor showers, Artificial satelites.
14	IX	Science	Sound	Sound Production, Propagation, Waves, Speed of sound in different mediums, ultrasound, sonar.
			Matter in Our surroundings	Particles and their charachteristics, states of matter.
			Atoms and Molecules	Atom, Atomic mass
			Structure of atom	Different models of atom, Neutrons.
			Gravitaion	Universal Law of Gravitation, mass, weight, Relation between gravity and mass.
15	X	Science	The Human Eye and the co-lourful world	Atmospheric Refraction, Twinkling of stars, Ad-vance sunrise and delayed sunset, etc.

4.2 Youtube Videos

Youtube has abundant videos on blackholes, speculative theory videos and even live event videos where astrophysists like Stephan Hawking describe black holes. The most interesting one so far was about the Chirping sounds of Blackholes merging! Following are 4 thumbnails out of the 18 videos I have referred to so far.



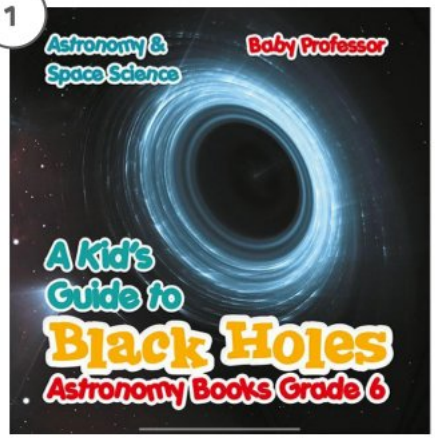




4.3 Books & Podcasts on Black holes

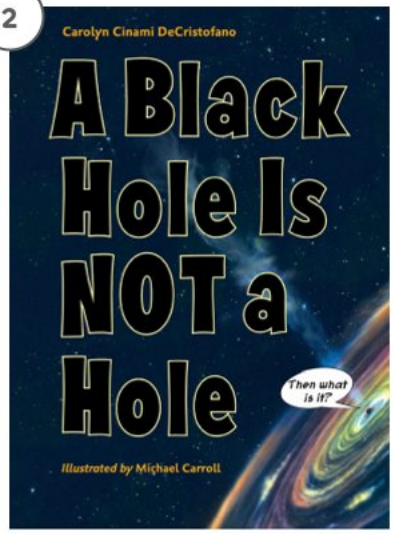
The following books are for different target audiences :-
1. Upper Primary (age 11-12)
2. High (age 13 -15)
3. Higher Secondary (age 17 -18)
4. Graduation/Post Graduation (above 18)

1



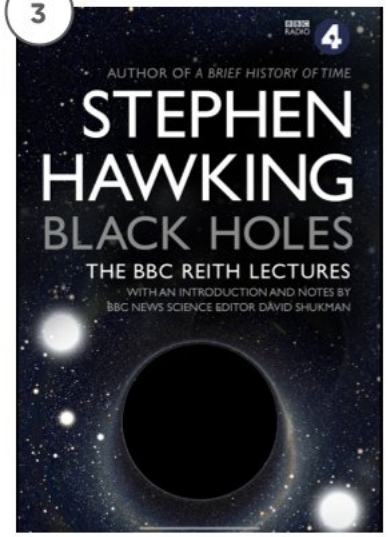
-Astronomy
-Solar system
-Big Bang Theory
-Black hole

2



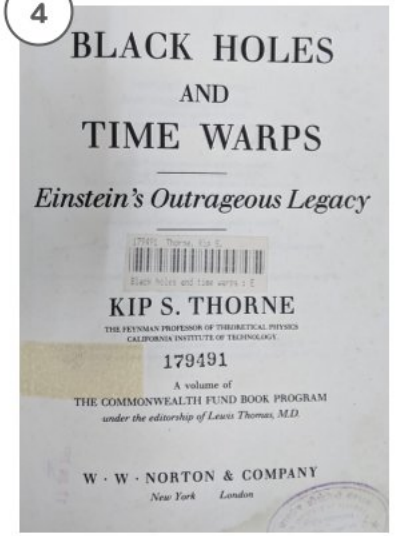
-Gravitaional Force
-Gravitaion in Black holes
-Formation of Black hole
-Fun Facts here and there
-Space-time fabric
-Black hole discovery timeline

3



- Definition of Blackhole
- Falling down in a black hole
- Event Horizon
- Uncertainity principle of quantum mechanics
- Black holes aren't black
-Properties of black holes
- Rotation in blackholes

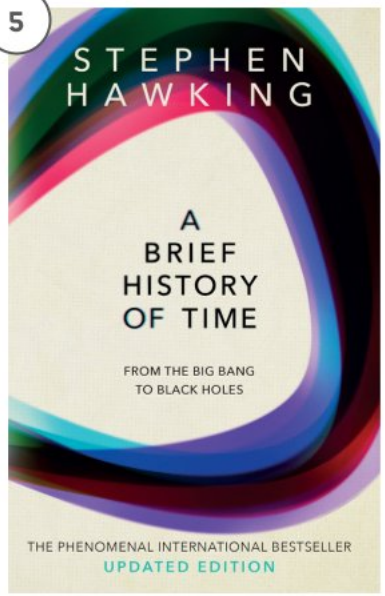
4



-Explanation of concpets through Space voyage setup
- Definition of Blackhole
-Other analogies for BH
- Event Horizon
- Time warps
- Wormholes
- Many other theories.

5. Graduation/Post Graduation (above 18)
6. UG / PG / PHD (above 18)

5



- History of blackhole discovery
- Blackhole definition
- Analogies
- Hawking Radiation
- Blackholes myths unproved
- Types of blackholes, etc

6

- Gravitaional waves
- what creates detectable waves
- Ligo
- How Ligo functions

4.4 Articles and News Clippings

Online articles from various sources about the pheomenan of gravitational waves and other updates on blackholes offered new information that can be added.

To date, the only way astronomers have conclusively witnessed the merging of black holes is through their emission of gravitational waves – subtle ripples in the fabric of spacetime. Those mergers lacked any counterpart in the electromagnetic spectrum: no boom, no flash, no supernova, no lights whatsoever.

Indian researchers discover three supermassive black holes

Supermassive black holes are difficult to detect because they do not emit any light, but can reveal their presence by interacting with their surroundings

IANS

Taking photos

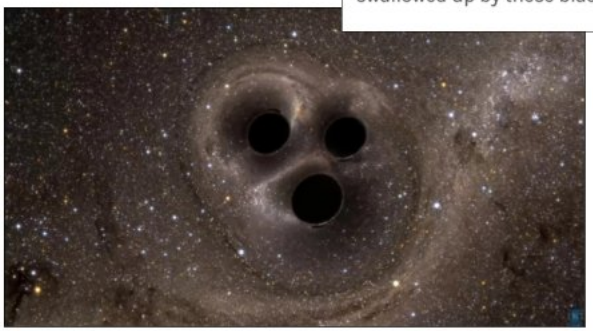
In 2019, a collaboration of eight radio telescopes located in different parts of the world was able to take the first photo of a gigantic black hole (6.5 billion times more massive than our Sun). It is located about 55 million light years from us (a light-year corresponding to a distance of about 9.5 trillion kilometers) at the center of the Messier 87 galaxy.

The italics of the word *photograph* is no coincidence: how can a photograph be taken of an object that catches light and, therefore, would not be able to be seen by cameras, which use light to create a picture? The answer is simple: we are not observing the object itself, but the remains of star that are being swallowed up by these black holes.

nasa You're about to enter another dimension 🌀 Our @NASAChandraXray space telescope captured a spectacular set of rings around a black hole, revealing new information about dust located in our galaxy! On June 5th, 2015, a burst of X-rays created high-energy rings within a system, a phenomenon known as light echoes. Similar to the way sound waves bounce off a canyon wall, light echoes are produced when a burst of x-rays from the black hole's system bounce off dust clouds between the system and Earth. Located 7,800 light-years away, this black hole actively pulls material away from a companion star into a disk around the invisible object. This material glows in X-rays, allowing astronomers to refer to these systems as "X-ray binaries." In this composite image X-rays from Chandra (light blue) are combined with optical data from the Pan-STARRS telescope, showing the stars in the field of view. Each ring is created by X-rays from the flares in 2015 reflecting on different dust clouds. Cosmic dust is not like household dust, it is similar to smoke and consists of tiny, solid particles. These

Up until now, scientists had only ever proven Hawking's Area Theorem through mathematics. For the first time, researchers from the Massachusetts Institute of Technology (MIT), California Institute of Technology, Cornell University, and Stony Brook University have confirmed it observationally by studying two "inspiraling" black holes (meaning they're spiraling inward into one another) that created an altogether new black hole. They published their findings earlier this month in the journal *Physical Review Letters*.

Those merging black holes were relatively small affairs, with the black holes no bigger than a few dozen times the mass of the sun. However, mergers of much larger black holes, the supermassive ones, might be accompanied with a fantastic light show. If we could capture both the gravitational and electromagnetic waves from the same event, it would open up a whole new window into studying the nature of extreme gravity.



One of Einstein's weirder predictions from the General Theory of Relativity is that if two masses orbit each other, **they literally shake the fabric of spacetime**, creating ripples in it that expand outward at the speed of light. It's a bit like grabbing the corners of a towel and flapping it; ripples move away from you as they travel through the fabric.

Space does this too. The more massive and faster the objects move, the more powerful the ripples. Black holes are incredibly massive and also small, meaning their gravity is intense, and can accelerate objects near them to almost the speed of light. That makes very powerful ripples indeed. We call these *gravitational waves*.

5. Concept

5.1 Information Chunks

5.1.1 Black Holes

- Definition of Black Hole
- Types of Black Hole & how they are formed
- Properties of Black Holes
- Technology used to study Black Holes

5.1.2 Gravitaional waves

- Introduction to gravitaional waves
- How do black holes generate waves or chirps?
- Technology : LIGO Interferometers

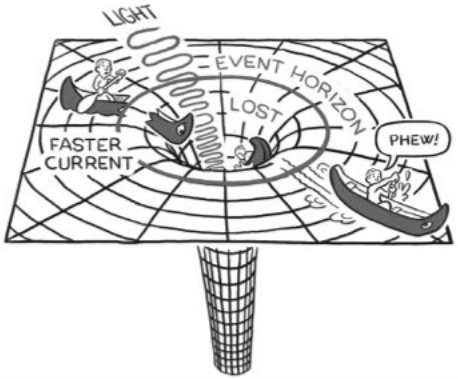
5.2 Target Audience : 13-18 years

The set target is High School Students of VIII & above standard (13 -18 years and above). This is in order to keep the student informed and interested in astronomy so that they can pursue it further if they want, considering the fact that X, XI and XII are crucial for students to decide their career paths.

5.3 Analogies

To understand the gravitational waves of blackholes, it is a must to understand blackholes in the first place and the best way to do that would be coming up with relatable and somehwhat accurate analogies that run parallel to the concept of blackhole. So far, there have been many analogies that I read and heard, but the best way to explain blackholes would be to be near one for sure. And this is exactly what happens in the following story synopsis!

You can imagine what a black hole is when you try using a vacuum cleaner. Once you turn on the vacuum, you will see that all the dirt and dust are sucked by the vacuum cleaner. The vacuum cleaner uses suction to get everything inside the vacuum cleaner while a black hole uses gravity to pull objects towards it.



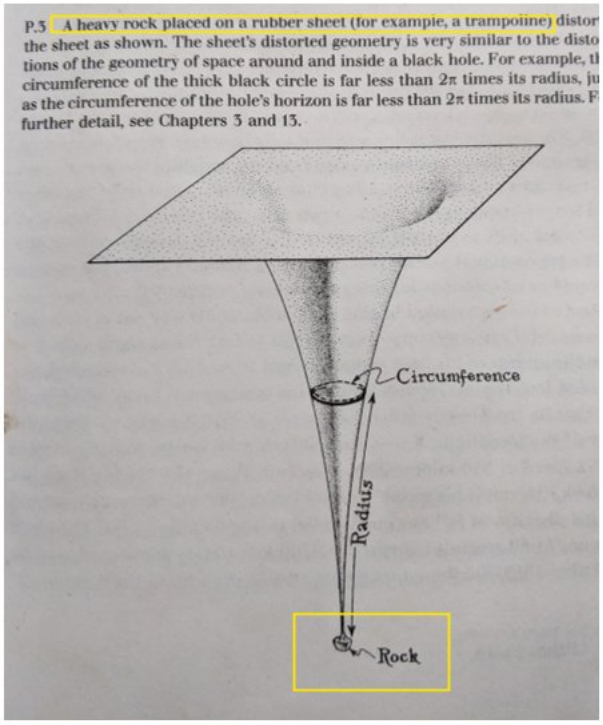
A black hole is like a giant whirlpool.

Have you ever pulled out a sink stopper and watched water swirl down the drain? Spirals of water flow toward the center. You've made a small whirlpool.

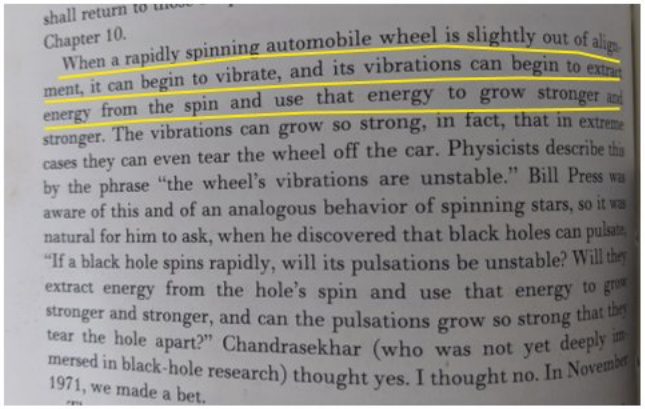
Imagine a bigger whirlpool in a river. Far away, nobody knows it's there. Boats chug and sail along. Schools of fish dart by, following their fishy urges. Closer to the whirlpool, it's a different story.

A fish swimming near the whirlpool's edge feels a gentle tug as the current drags it toward the spinning center. No problem. With a little swish, the fish can speed up, giving itself the oomph to swim away. After putting some distance between itself and the whirlpool, the fish no longer feels the current's inward pull.

But what if the fish drifted farther in?



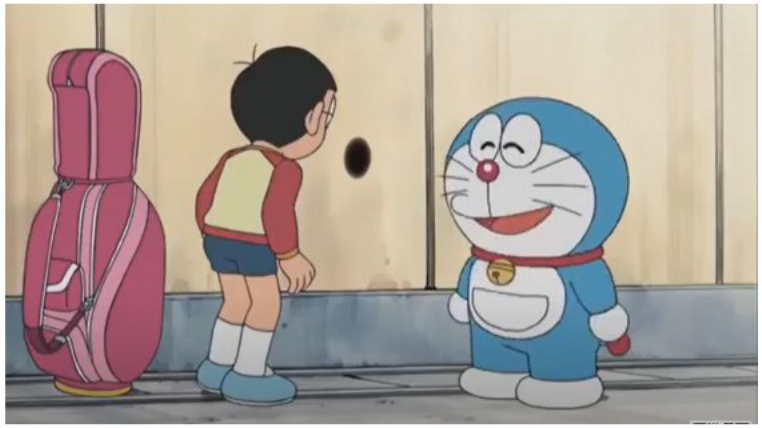
DS: The phrase 'black hole' is simple enough, but it's hard to imagine one out there in space. Think of a giant drain with water spiralling down into it. Once anything slips over the edge – what is called the 'event horizon' – there is no way back. Because black holes are so powerful, even light gets sucked in, so we can't actually see them. But scientists know they exist because they rip apart stars that get too close to them and because they can send tremors through space. It was a collision between two black holes more than a billion years ago that triggered what are called 'gravitational waves', the recent detection of which was a hugely significant scientific achievement.

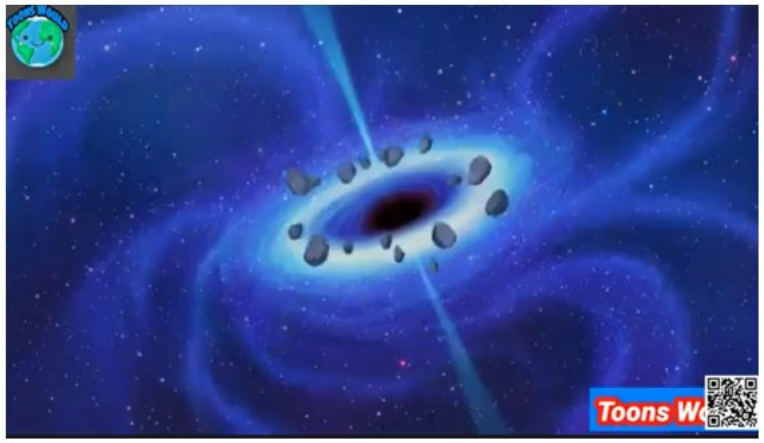

shall return to
Chapter 10.

When a rapidly spinning automobile wheel is slightly out of align-
ment, it can begin to vibrate, and its vibrations can begin to extra
energy from the spin and use that energy to grow stronger and
stronger. The vibrations can grow so strong, in fact, that in extreme
cases they can even tear the wheel off the car. Physicists describe this
by the phrase "the wheel's vibrations are unstable." Bill Press was
aware of this and of an analogous behavior of spinning stars, so it was
natural for him to ask, when he discovered that black holes can pulsate,
"If a black hole spins rapidly, will its pulsations be unstable? Will they
extract energy from the hole's spin and use that energy to grow
stronger and stronger, and can the pulsations grow so strong that they
tear the hole apart?" Chandrasekhar (who was not yet deeply im-
mersed in black-hole research) thought yes. I thought no. In November
1971, we made a bet.

Many analogies exist already in popular media like cartoons consumed by children in school. But often they are just simple introduction, for instance the concept of blackhole in terms of gravity in one of the episodes in Ben 10.
But many times they lead to misinformation just like in one episode of Doremon where there are two gadgets that doremon uses to help Nobita transport a heavy bag from one place to another. The two gadgets are white pen and black pen which stand of white hole and black hole, respectively. But stating that what ever goes into a black hole comes out of a white hole is wrong, infact the very existence of white hole is wrong.

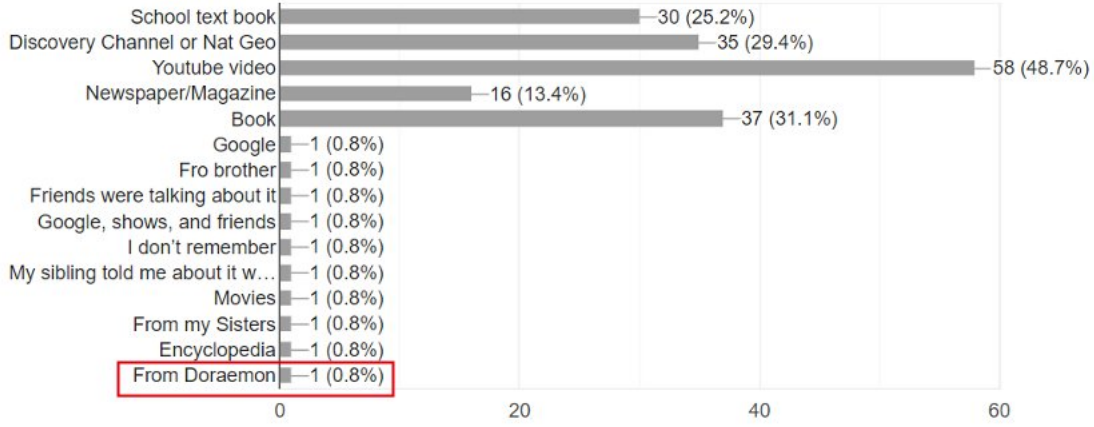
Therefore the aim is to create something analogical yet direct, a balanced mix of imagination and factual information.





How did you come to know about Black Holes? (You may select more than one option)

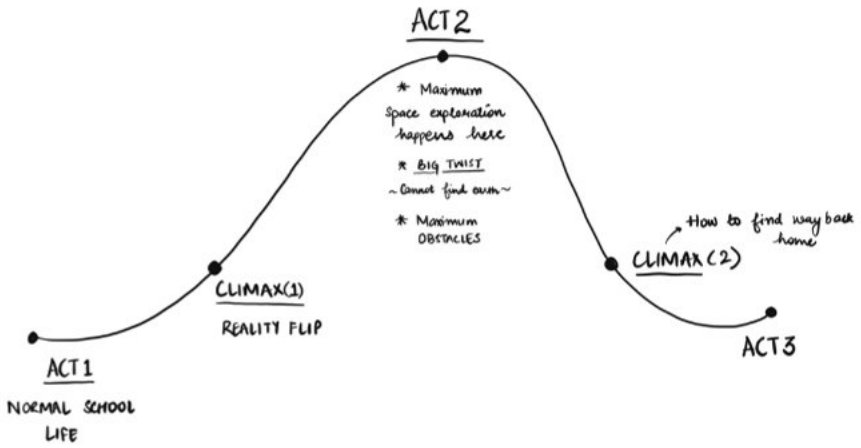
119 responses



5.4 Story Architecture

5.4.1 Story Synopsis

A group of teenagers enter a twisted reality after a powerful gravitational wave ripple hits and shakes up the entire solar system. This New reality has scaled down everything in the universe to Earth size and scaled up everything on the earth to universe size. It is as if things have turned inside out! The floor is the fabric of spacetime and invisible blackholes are lurking everywhere. Will the three teens find their way back home? Let's find out!



5.4.2 Story Arc : 3 act structure

Act 1 : Normal School Life

- Charachter Introduction
- Introductory conversation about blackholes
- Seminar of three Indian scientists who recently discovered blackhole mergers.
- Climax of act 1: Gravitational waves hit earth

Act 2 : Flipped reality

- Familiarity build up with new reality
- Space-time fabric, Gravity, other concepts of general relativity introduced here
- Obstacles
- Unpredictable charachter introduction
- LIGO introduction

Act 3 : Return to Normality

- Communication through gravitational waves
- Another merger : Return to normalacy

5.5 The Story

ACT 1

It's a half day at school and everyone is very happy about that. Three friends - Pragya, Gagandeep and Shehbaz catch up with each other at the cycle stand to discuss the most happening thing - the recent discovery of three black holes merging together. Shehbaz doesn't know what the other two are talking about, so they take him to the main corridor and show him the poster of an online seminar on the recent discovery of three black holes merging. Gagandeep, excitedly points to the timing of the seminar, which is that day itself. He says that it'll be best to stay back and attend the seminar rather than go home! Shehbaz is a bit reluctant but Pragya convinces him by saying that maybe he'll learn something new today, to which he shrugs his shoulders and sort of agrees. And so the three stay back and attend the Online seminar. Swiftly do they run towards the computer lab, oblivious to that adventure that lies ahead!
No one has come to the lab and it's just the three of them who stayed back. Shehbaz rolls his eyes at Gagandeep and says that this is definitely going to be boring. Pragya convinces them that they'll attend for five minutes, if it turns out to be boring they will leave and if not….and they all are interrupted when suddenly the tv screen comes to life and the seminar starts. Apparently, one of the research students who discovered the merger, is their alumnus and therefore to honour her achievement, the school held this seminar. The three look up in awe at the screen, as the research students tell about their wonderful discovery! Their alumnus starts to explain what blackholes are and how her team observed three of them merge, creating ripples of gravitational waves across space and time. She further explains that this is a new and exciting way of observing the universe.

Act 1 Climax

Suddenly the lights start to flicker and the internet disconnects and the screen is glitched and frozen. Everything starts floating - the three of them along with chairs, computers, keyboards, etc. Panic-struck, the three friends try to reach out to each other and hold hands until everything turns into nothing in a jiffy. ZWOOP! News reporter on the television explains how multiple blackholes mergers caused multiple gravitational waves that impacted the solar system in mysterious ways. Many objects and people from earth have collectively gone missing. A shocked couple couldn't find their house, after coming back from the office. In the background, A ladakhi woman cries for her yak, who apparently vanished into thin air. So far, the most significant object that went missing remains the torch in the hand of the Statue of Liberty. Pragya's parents who are watching the tv exchange concerned glances. Their daughter usually returns home after playing, before dark. They look back at the open door… where the twilight turns into a dark night. They whisper her name, with a sigh.

ACT 2

Pragya opens her eyes to realise that she is in a different environment. Everything is quite dark. There is some light coming from a faraway source. The surface that holds her up

is bouncy and water-like. She wonders if she is dreaming but soon finds out that she is not, when Gagandeep and Shehbaz show up. All three of them get very excited to be in this new strange place. They jump around, walk and trip on the bouncy surface. Gagandeep spots a circular rock a bit far away. Upon close inspection, it turns out to be a gulak. The gulak has a ring of small rocks revolving around it. He picks it up, it's quite heavy. The little rocks that were revolving around the gulak start revolving around him, which confuses him. He looks back at the two and says that they are either dreaming together or are in grave danger. Suddenly a big gas-cloud floats by them. They all cough and squeeze their eyes to see whats going on. A lot of dust and debris from that cloud accumulates to form a ring around each of their tummies. They all are very surprised and confused when suddenly Gagandeep and Pragya exchange shocked glances.
They squeal with excitement and tell Shehbaz that they are in outer space because their bodies are now behaving like celestial bodies. Pragya further adds what and how their gravity bends space time and why the rings of dirt are revolving around them, because they are like new planets in space. They run and run to confirm and find an exoplanet almost their size. Gagandeep explains briefly what an exoplanet is. They continue to walk and explore everything around them and find more exoplanets only to realise that they are all walking on an orbited path... however there is no star in sight since it is quite dark with a little bit of light from some very far away source.

Act 2 climax

They try to analyse the source of light only to realise that it is not a star, but a supermassive blackhole! And those are not exoplanets but Blanets (blackhole + planet) !
Shehbaz is surprised about how they were not gobbled up by the blackhole. Pragya explains the structure of the blackhole and how there is a safe space for celestial objects to orbit around blackholes from afar. She also mentions that there is a blackole in the center of their milky-way galaxy, which keeps stars and other celestial bodies going around it.
They level down a bit to see the 2-dimensional structure of the blackhole from far away. Gagandeep insists on going a bit closer to which Pragya explains what the event horizon is and that anything close to the event horizon of a blackhole cannot get back to safety and would be consumed by the blackhole.
Shehbaz insists that they should try to find the solar system, because that's the only way to go back to their planet.
Pragya sadly points out the fact that they could be way too big for Earth now because magically they have scaled up.
Gagandeep is saddened by the news and exclaims that he only wanted to study planets...not become one!?!

ACT 3

The other two look at each other and burst into laughter. Gagandeep joins in. Pragya sits down for a while. Gagandeep also lies down and falls asleep in a jiffy. Shehbaz starts doing some somersaults on the bouncy surface. Pragya notices the ripples forming. She suddenly gets up to shout " EUREKA!"
The other two look at each other. She then describes the concept of gravitational waves and how they are captured by the LIGO on Earth. If they all jump enough, they could send wave ripples signals to earth. As she is explaining, a yak floats by in the background. All three look at it in complete shock. Gagandeep mutters loud enough, what a Yak out of all the creatures or objects is doing there.
The yak, absolutely unbothered by their presence, says that he is very happy to be here since outer space temperature is much cooler than temperature on Earth. His clan is in danger of extinction there because of global warming, so he'd rather be here than anywhere on Earth.

He asks the three if they even know how they came there, to which they say no. A sly smile dawns upon his face as he says that maybe the human species is not the only intelligent species on the planet. He further adds that they all are here because of the recent collision of blackholes that happened and how some specific objects and creatures from earth got teleported magically into space. Shehbaz is not buying any of it and asks Pragya to continue sharing her plan of return. Pragya starts telling her plan, but the yak scoffs and calls her silly. He says that their cute little taps and jumps won't make much of a difference since they are many many light years away from the solar system and the waves may settle down before reaching Earth. Gagandeep interrupts him to tell Shehbaz what light years mean. Only Extremely Strong waves from very powerful Black hole mergers reach earth, even if they are happening a lot of light years away. Besides, they need to return in the same way they came here in the first place.

Act 3 climax

The three agree and Pragya asks what the plan is. The yak dramatically bellows in a strong voice that he, the ancient symbol of Survival and Wisdom, will lead them back to their planet safely.
They begin their journey to the nearest blackhole merger that the yak had previously sensed and was travelling towards. From far off they can see three blackholes that have come spiralling towards each other and are about to merge. When they merge, very strong gravitational waves start rippling up the fabric of spacetime and send everything around flying and bouncing away, including the three kids and the yak. Holding hands and hooves, they all look at each other and close their eyes. ZWOOP! Everything goes black, yet again.

Resolution

3 days later at the LIGO (California Institute of Technology in Pasadena, California) new gravitational waves are detected by yet another blackhole merger. Missing things and people return back to earth. The torch of the statue of liberty appears back in place and everyone celebrates.The couple move back to their old house, tears of joy in their eyes.The old lady hugs her yak on the news, while Pragya watches it on TV giggling and eating samosas with Gagandeep and Shehbaz.

5.5 Charachters

Three main charachters with three different qualities- Intelligence, kindness and most importantly courage were thought to be apt for this story since they would be required for the kind of journey these charachters take up in the story.

Final Charachter and their charachteristics

Since the medium is Graphic Novel, there will be subplots and charachter developmemnts along with the progression of the main plot.

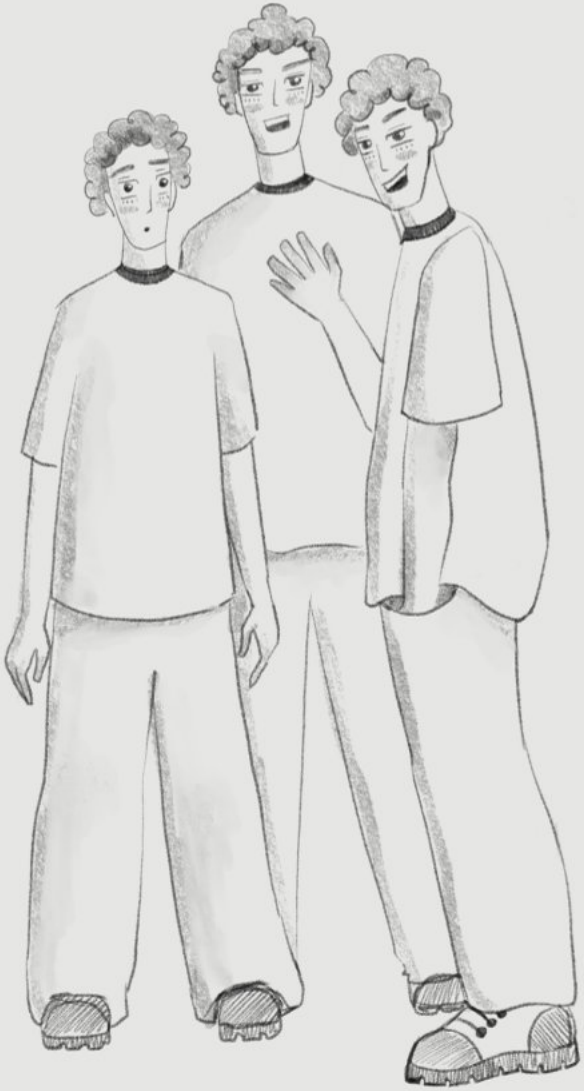
Following are the 3 main caharchters :-

Pragya is an intelligent girl whose wit is incomparable and knowledge is always up to date. Thanks to her observation and deduction, the trio are able to recognize that they are in outer space. However she is also stubborn, because she thinks she is always right. But her intelligence is challenged in the end and she becomes more accepting of other's viewpoints.

Shehbaz is a reserved human being and doesn't want to get out of his comfort zone. Contradictory to that, he also doesn't want to get bored. In an attempt to try something "new" yet "boring" with his friends, he ends up experiencing the biggest adventure of his lifetime.

Pragya

Shehbaz



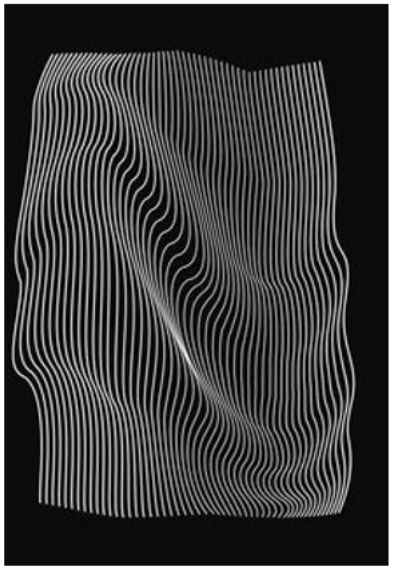
Gagandeep is very enthusiastic and passionate about his interests. He finds fun and joy in every possible situation. However, his dedication to his interests are challegened in the story. Thanks to his intutuion and gut feeling, the trio reach home safely.

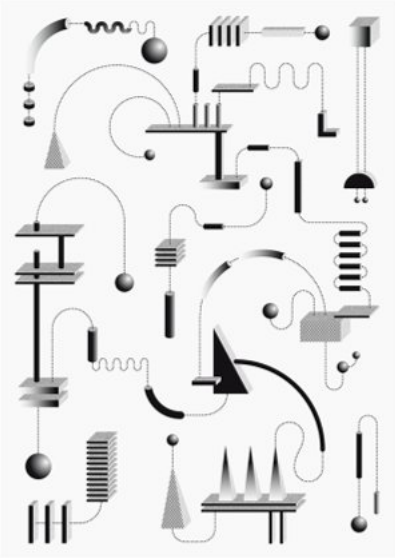
Gagandeep

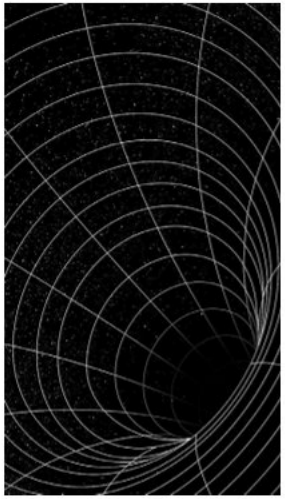
The Yak

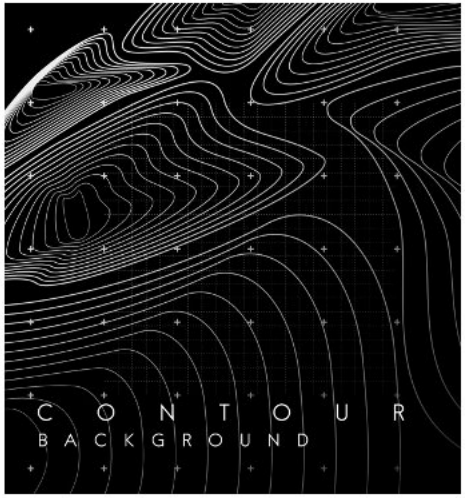
The Yak is an unexpected guest charachter, which was also misplaced along with the other charachters.
The symbol of Survival and Wisdom, the yak saves the trio in the end by guiding them in the right direction.

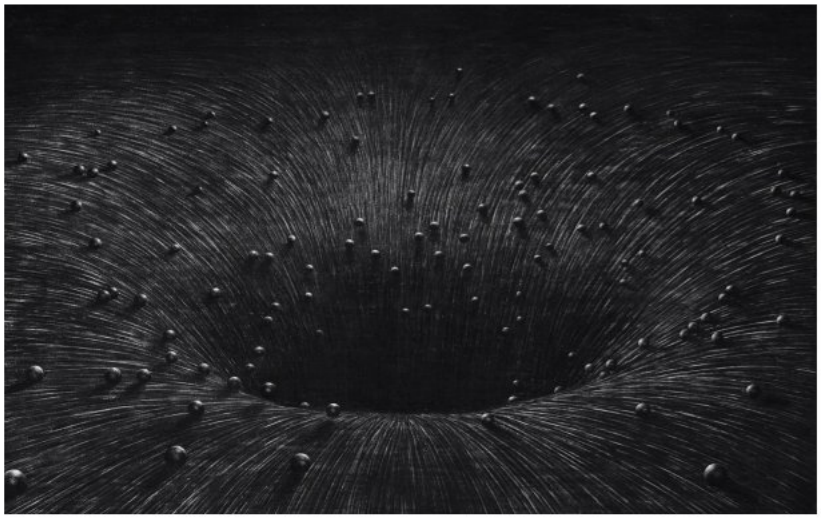
5.6 Inspiration Board

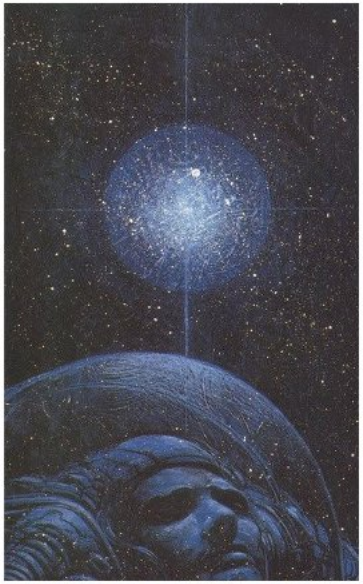


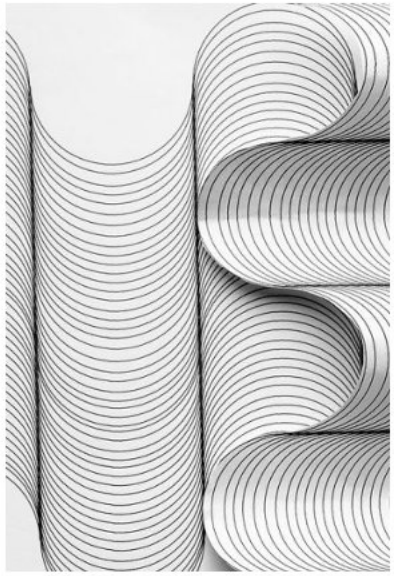






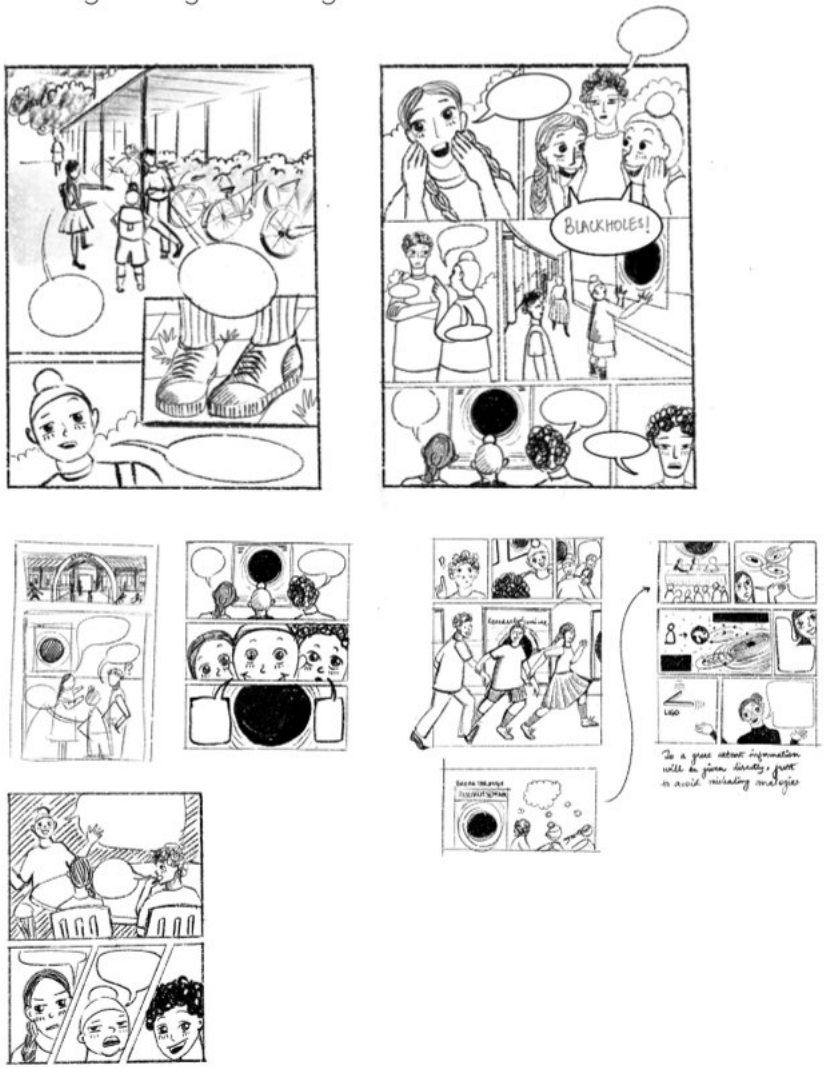




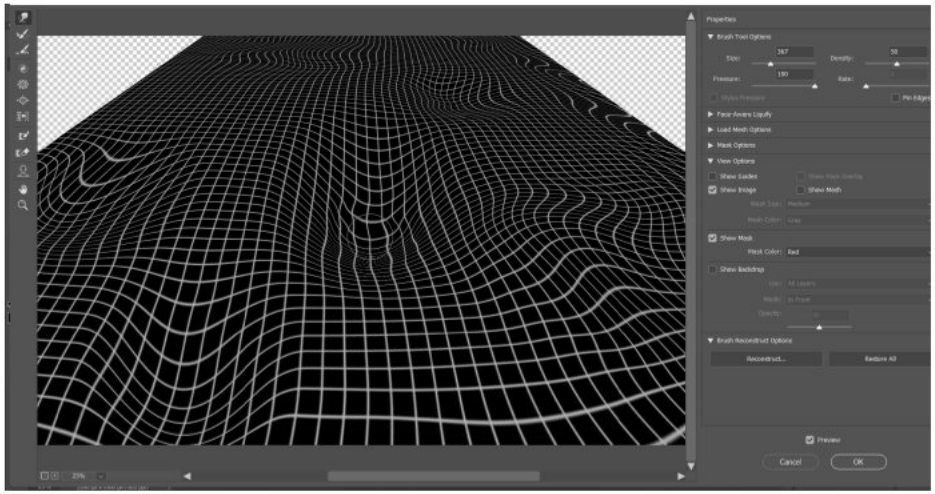


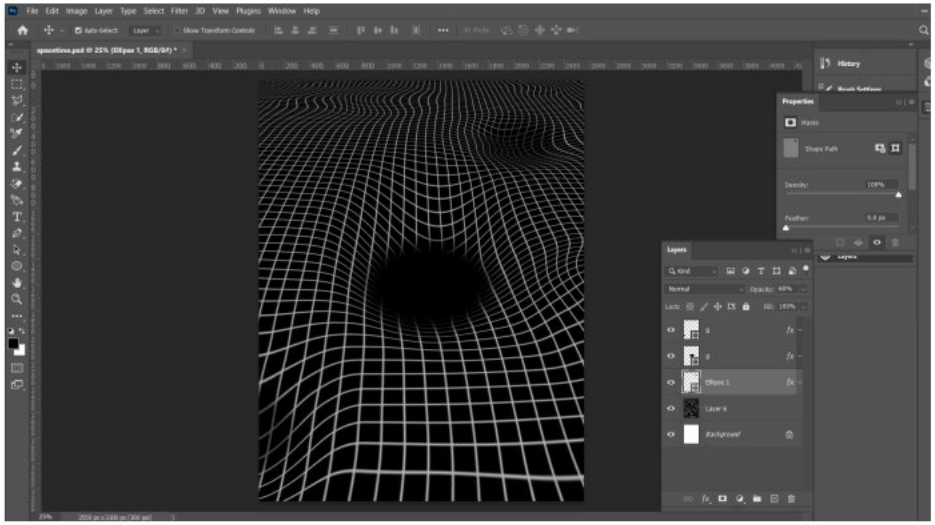
5.7 Process

1. Rough story Boarding

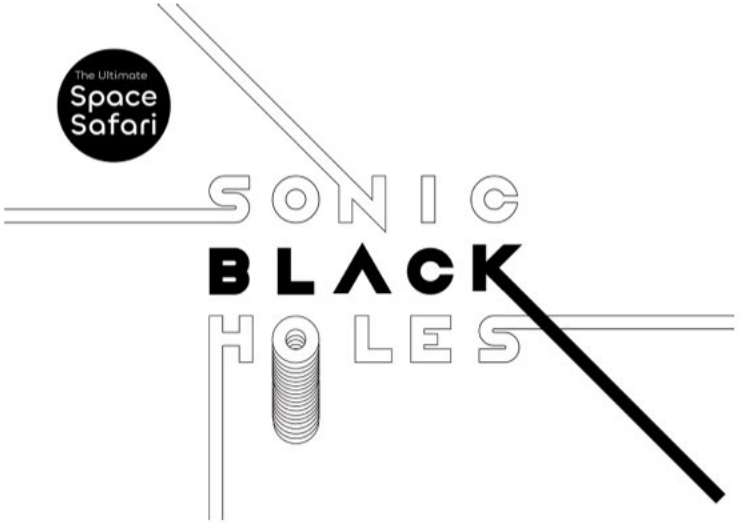


2. Background construction on photoshop



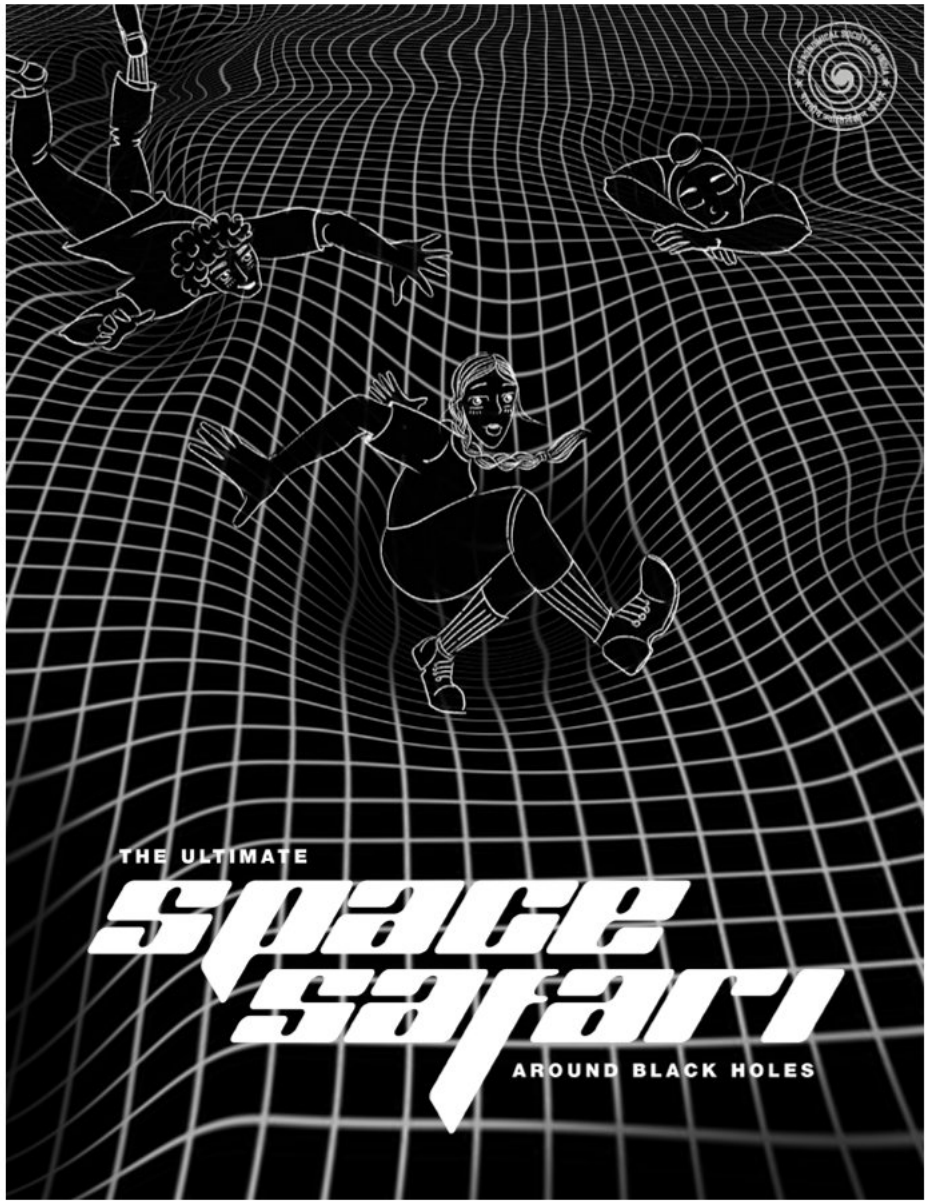


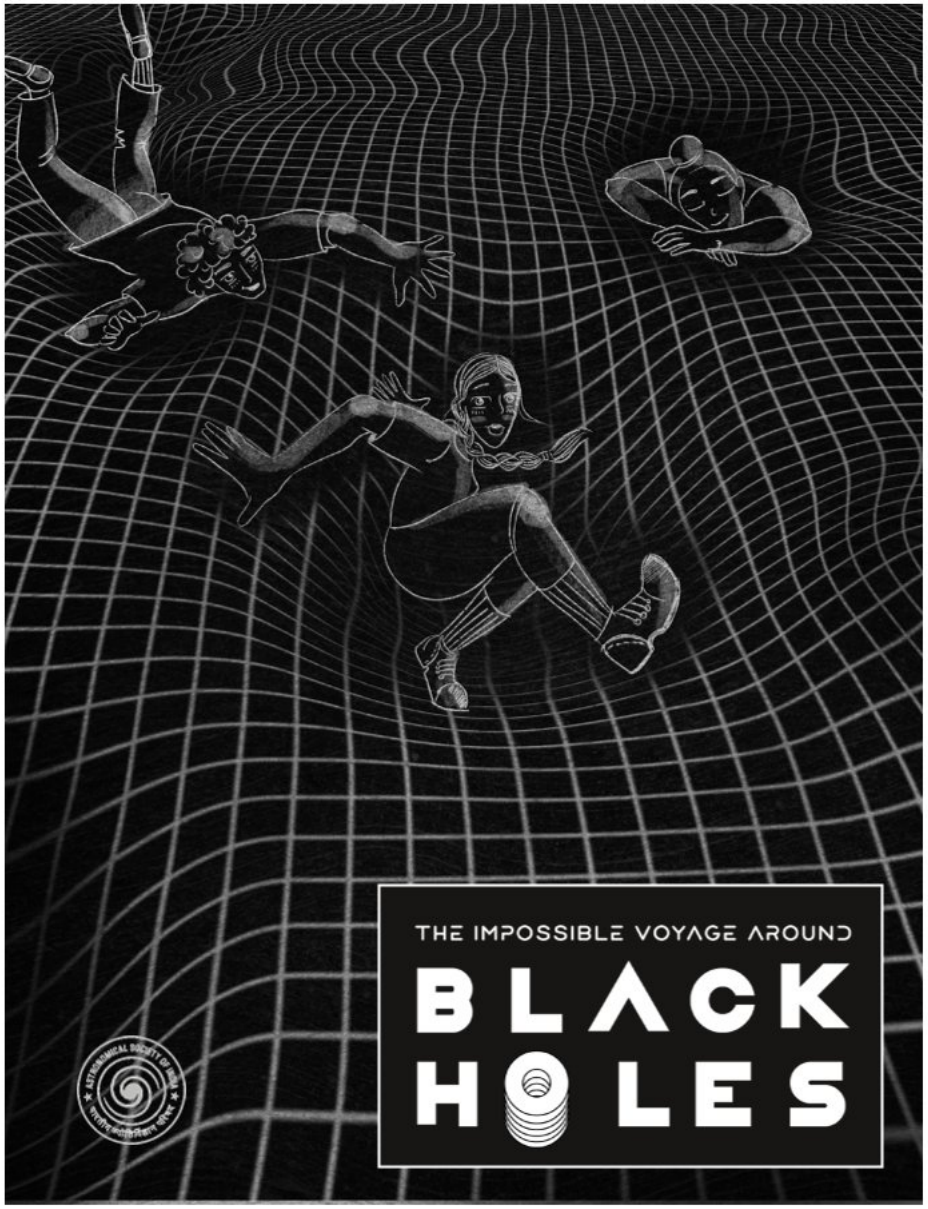
5.8 Book Title explorations



Since the term “sonic black holes” refers to a very different scientific phenomenan, it can be Highly misleading.Therefore,”The ultimate Space Safari around Black Holes is apt. It is also simple and clearly tells what to expect from the book.

5.9 Book Cover explorations





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6. Conclusion

1. It takes a lot of time to process the information on a concept like Blackhole. Even though it was readily available on the internet, in books, podcasts and videos in a simplified format, to understand it completely required many re-visits.

2. Narrowing down during the research stage for such topics is next to impossible because so many topics are interrelated. One cannot simply just understand about one phenomenon without knowing the other! Therefore giving more time to research helped me a lot in narrowing down information and also writing the story in a short crisp format. I knew what exactly to include only when I was aware of what I should exclude.

3. Initially, I did think of including character developments and subplots along with the progression of the main plot, but due to the illustration side of the project being heavy, some concepts had to be dropped.

4. Some imaginary ideas were completely striked off due to them adding to the fictional side of the story (for instance, one of the three kids returning back to earth with a souvenir from space, most probably, a small planet).

5. The balance between fiction and science for a perfect soft science-fiction is quite a task to achieve. Also, during feedback sessions it was emphasised that at least visually, a distinction be made between what is factual information and what is not. This would help the reader separate the two kinds of information easily.

6. At least, I am just amazed that after all this, Black holes still continue to amaze me and there is so much not discovered, not read, not heard of for a newbie like me. I would continue to learn more about Black holes and imagine more possible stories around them because why not!?

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