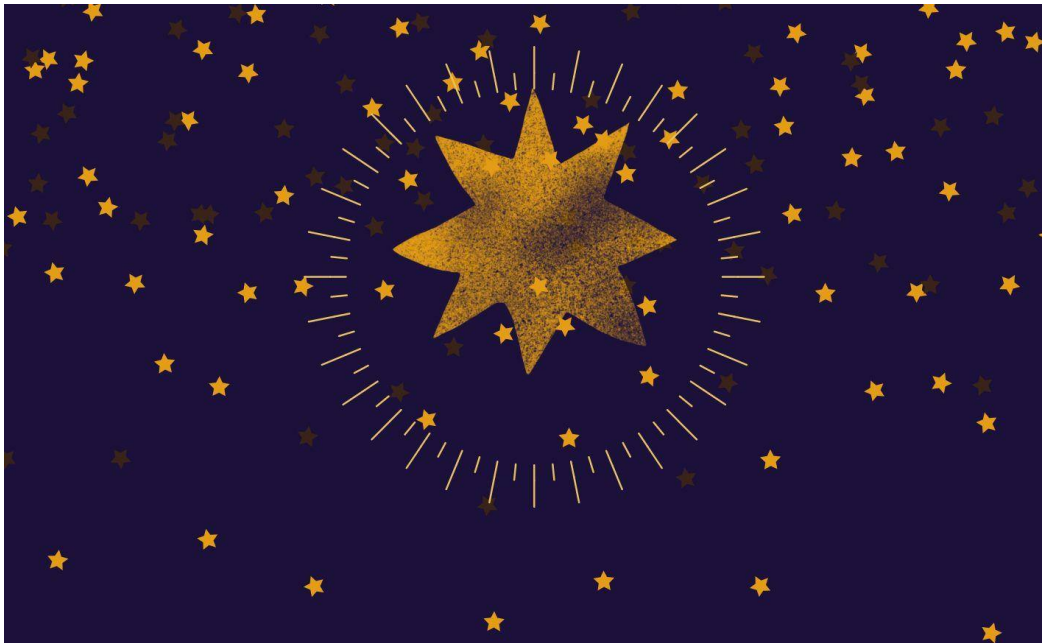

SURPRISING THINGS ABOUT THE UNIVERSE

COLLECTION OF FASCINATING AND ENIGMATIC FACTS ABOUT THE UNIVERSE, SPACE, AND PLANETS

MANJUNATH.R

Surprising Things About the Universe:

Collection of fascinating and enigmatic facts about the universe, space, and planets

"The only true wisdom is in knowing you know nothing."

– Socrates

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Disclaimer

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For any suggestions or concerns, please write to me: **manjunath5496@gmail.com**

Dedication

I **dedicate** this book to everyone who has contributed significantly to our understanding of the universe as a whole, why it is the way it is, and why it even exists.

Acknowledgements

Without the amazing work of some renowned cosmologists and physicists, their creativity, and their inventiveness in thefield of cosmology, this book would not have been accomplished. I would like to use this opportunity to thank my dearest friend and well-wisher "**Lawrence**" for his unwavering support during the **COVID crisis** and for giving me access to all the resources I needed to finish this book. I want to express my gratitude to my family for their support and encouragement as I wrote this book, especially to my **mother**, who has been a tremendous source of inspiration in my life. I owe a lot of gratitude to my mother for teaching me how to be perseverant and strong in life. Finally, I want to emphasize how crucial patience is when writing a book or taking on any other project in life.

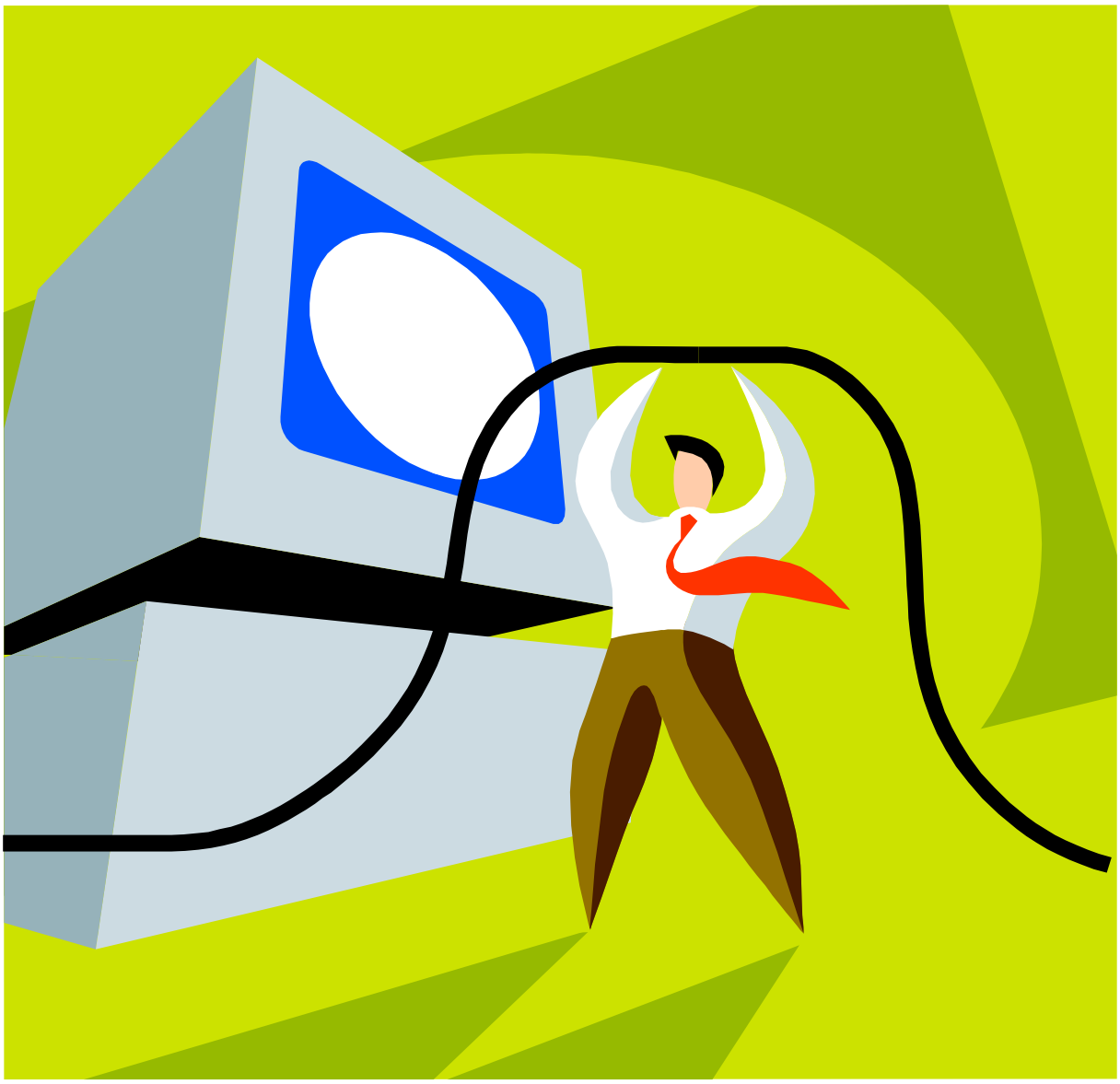
"My goal is simple. It is a complete understanding of the universe, why it is as it is and why it exists at all."

– Stephen Hawking

Introduction:

The size of universe itself is beyond comprehension. We human beings − **who are ourselves mere collections of fundamental particles of nature** – are in a time of scientific advancement. We have accomplished several marvels in our generation that our ancestors would have thought impossible. The **Andromeda Galaxy**, which is more than 1.5 million light years away, contains the furthest star that can be seen with the bare eyes. Telescopes can detect 6,500 million light years away galaxies that are even further away. Exploring 14 billion years of cosmic evolution and gazing at the immense heavens above, we have always asked a multitude of questions: What is the currently most accepted theory for the Universe? **What is the proof for the Big Bang?** What happened before the Big Bang? What is anti-gravity? How vast is space? How old is our Universe? What impact does energy have on spacetime itself? Many others! These questions continue to trouble scientists despite the massive amounts of data coming in from observatories around the globe and from particle physics experiments like the **Large Hadron Collider** in Switzerland, as well as despite the countless hours that astronomers and physicists spend in front of a blackboard or running computational simulations.

This book is a glimpse into the living story of our universe and a clear, readable and self-contained introduction to the story of **how our understanding of the cosmos has evolved significantly over time**. It fills the gap and addresses the issues that are important to everyone, or at least to everyone reading this book, and it inspires us to explore the entire cosmos from creation to ultimate destruction, with a wealth of secrets at every turn. This book concentrates on presenting the subject from the understanding perspective of cosmology and brings the reader right up to date with **curious aspects of cosmology** established over the last few centuries. This book assumes cosmology a journey not a destination and the advance of knowledge is an infinite progression towards a goal that forever recedes. Students, professors, and general science readers interested in the fundamental concepts of cosmology from the Big Bang to the present and into the future will find this book of astounding knowledge about our bizarre and wonderful universe interesting.



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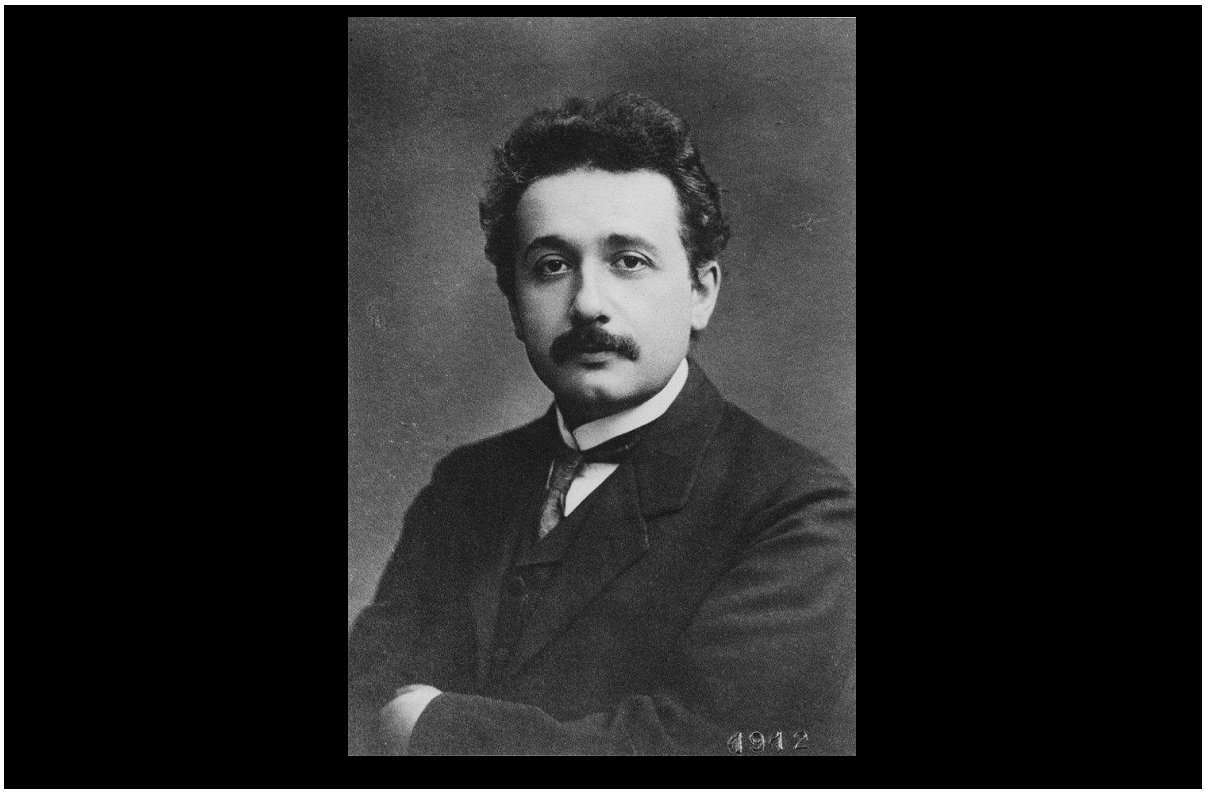
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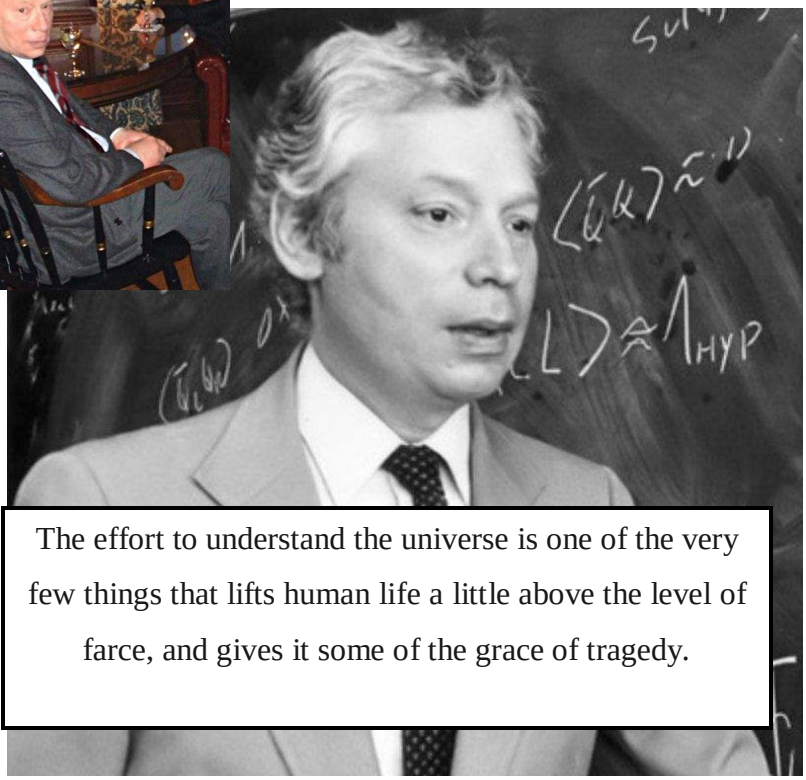
Through our perceptions, Universe shapes itself.

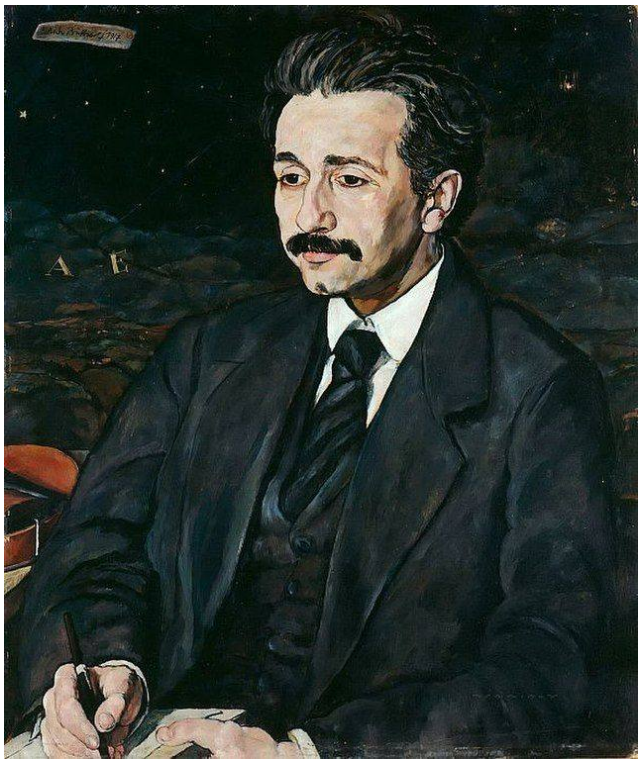
Through our thoughts, Universe is delivering its glories.

We are medium through which Universe becomes conscious of its existence.

A lot of prizes have been awarded for showing the universe is not as simple as we might have thought.



The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce, and gives it some of the grace of tragedy.



The most beautiful experience we can have is the mysterious. It is the fundamental emotion that stands at the cradle of true art and true science.

Cosmological Principle:

The universe is the same everywhere.

Homogeneous:

The universe looks the same from every point.

Isotropic:

The universe looks the same in every direction.

The **Compton wavelength of a particle** $\frac{h}{m_0 c}$ characterizes the length scale at which the wave property of a given particle starts to show up. In an interaction that is characterized by a length scale larger than the Compton wavelength, particle behaves classically (i.e., no observation of wave nature). For interactions that occur at a length scale comparable than the Compton wavelength, the wave nature of the particle begins to take over from classical physics.

- Mercury and Venus are the only two planets in our solar system that orbit closest to the Sun and have no moons.
- Because:

  $r = \frac{3GM}{c^2}$, the photon spheres can only exist in the space surrounding an extremely compact object (a black hole or possibly an "ultracompact" neutron star).
- The hottest planet in our solar system is Venus and is named after the Roman goddess of love and beauty.

- A light-year is the unit of length used to express astronomical distances and is the distance covered by light in a single year and is equal to 9.46×10^{12} km.
- The Sun accounts for 99.86% of the mass in the solar system and weighs about 330,000 times more than Earth.
- Our solar system is 4.568 billion years old formed from the gravitational collapse of a giant interstellar molecular cloud.
- The highest mountain discovered is the **Olympus Mons**, which is an enormous shield volcano on the planet Mars.
- Because of lower gravity, a person who weighs 100kg on Earth would only weigh 38 kg on the surface of Mars.
- The Sun has a north and south pole, just as the Earth does, and makes a full rotation once every 25 – 35 days.
- Earth is the third planet from the Sun and the only planet not named after a God.
- The surface of Venus is dominated by volcanic features and has more volcanoes than any other planet in the Solar System.
- Uranus ' blue glow is due to the cold methane gas in its atmosphere.
- In our solar system that are 4 planets which don't have hard surfaces and instead have swirling gases above a solid core − known as gas giants: Jupiter, Saturn, Uranus and Neptune.
- Uranus is an Ice Giant planet and nearly four times larger than Earth and has 27 moons that have been discovered so far.
- When an electron and a positron approach each other, they annihilate i.e., destroy each other. This process what a quantum physicists call the mass annihilation. During the process their masses are converted into energy in accordance with $E = mc^2$. The energy thus released manifests as γ photons.
- A photon of energy $h\upsilon = mc^2$ generated at the center of the star makes its way to the surface. It may take up to several million years to get to the surface.
- Because of its unique tilt, each season on Uranus lasts 21 earthly years and makes a huge difference between winter-summer and autumn-spring.
- Triton is the largest of Neptune's 13 moons and orbits the planet backwards.

- There are more stars in space than there are grains of sand in the world and there exist roughly 10,000 stars for each grain of sand on Earth.
- As photon travel near the event horizon of a black hole they can still escape being pulled in by gravity of a black hole by traveling at a vertical direction known as exit cone. A photon on the boundary of this cone will not completely escape the gravity of the black hole. Instead it orbits the black hole.
- **Tachyons** are theoretically postulated hypothetical particles that always travel faster than light and have 'imaginary' masses.
- Neptune is 17 times the mass of Earth and takes nearly 165 Earth years to make one orbit of the Sun.
- Pluto's largest moon, Charon − also known as Pluto I, is half the size of the dwarf planet Pluto.
- A day on Pluto is 6.4 Earth days or 153.3 hours long.
- Saturn is the second largest planet in our solar system and a gas giant with an average radius of about nine times that of Earth.
- The inner planets or rocky and terrestrial planets − Mercury, Venus, Earth and Mars are the four planets that orbit closest to the Sun.
- Only 5% of the universe is visible from Earth.
- It takes sunlight an average of 8 minutes and 20 seconds to travel from the Sun to the Earth.
- There are three main types of galaxies: elliptical, spiral and irregular.
- There are about 100 thousand million stars in the Milky Way alone.
- The Andromeda Galaxy is a barred spiral galaxy approximately 2.5 million light-years from Earth and the nearest major galaxy to the Milky Way.
- The warp and twist of space-time near the earth. The Moon follows this warp of space-time as it orbits Earth.
- The astronomical unit is a unit of length, roughly the distance from Earth to the Sun and equal to about 150 million kilometers (93 million miles) or ~8 light minutes.
- Astronauts can grow approximately two inches (5 cm) in height when in space.

- Kuiper belt is a region of the Solar System extending from the orbit of Neptune (at 30 AU) to approximately50 AU from the Sun (consists mainly of small bodies or remnants from the Solar System's formation).
- Exoplanets or extrasolar planets are planets that orbit around other stars.
- The Enormous dust cloud at the center of the Milky Way smells like rum and tastes like raspberries.
- Our only proper natural satellite **moon** is being pushed away from Earth by 1.6 inches (4 centimeters) per year.
- Saturn is the only planet that is lighter than water.
- Asteroids are the rocky planetoids revolving around the sun and the byproducts of formations in the solar system − more than 4 billion years ago.
- The Earth weighs about 81 times more than the Moon. The moon's density is 3.34 grams per cubic centimeter. That is about 60 percent of Earth's density.
- Mercury is the hottest planet in our solar system and has no atmosphere − which means there is no wind or weather.
- There are 88 recognized star constellations in our night sky.
- Due to the Sun and Moon's gravitational pull, we have tides.
- The five best known dwarf planets in our Solar System are: Ceres, Pluto, Makemake, Haumea and Eris.
- Mars is the second-smallest planet in the Solar System and the most likely planet (which carries the name of the Roman god of war) in our solar system to be hospitable to life.
- Pluto is smaller than Earth's moon and is only half as wide as the United States.
- Astronaut's footprint can last a million years on the surface of the moon as there is no wind.
- There are 79 known moons orbiting Jupiter.
- Most part of the atom is empty.
- Temperature > than Planck temperature cannot exist only for the reason that the quantum mechanics breaks down at temperature > than 10^{32}K.
- Since gravity weakens with distance, the earth pulls on your head with less force than it pulls on your feet, which are a meter or two closer to the earth's center. The difference is

so tiny we cannot feel it, but an astronaut near the surface of a black hole would be literally torn apart.

- The inherent goal of **unification** is to show that all of these forces are, in fact, manifestations of a single force. We can't perceive this unity at the low energies of our everyday lives, or even in our most **powerful accelerators** at **CERN**. But close to the Big Bang temperatures, at inconceivably high energies… If the forces unify, the proton can be unstable, and eventually decay …

Proton → positron + neutral pion

Neutral pion → 2 gamma ray photons

- **Sun** emits 2×10^{38} neutrinos per second but only 30 neutrinos are interacting in a person per year.
- The entire **electromagnetic spectrum** —from radio waves to **gamma ray**s, most of the light in the universe — resembles nothing but transverse waves of energy $E = h\upsilon = \frac{\mathbf{hc}}{\boldsymbol{\lambda}}$, which in turn are vibrating **Maxwell force fields** differing only in their wavelength $\boldsymbol{\lambda} = \frac{\mathbf{h}}{\mathbf{p}}$.
- The different frequencies of light appear as **different colors**.
- **Gravity waves** are vibrations in the 4 dimensional fabric of space-time. Gravitons are their quanta.
- DNA carries information but cannot put that **information to use**, or even copy itself without the help of RNA and protein.

Earth is 4.54 billion years old, and Asia is home to 60% of the planet's population.

We would weigh less if we measured our weight at the equator than at one of the Earth's poles.

- Africa, the second-biggest continent, is home to the world's largest hot desert.
- About 90% of the freshwater on Earth is trapped in ice, with 70% of it being in the Antarctic Ice Cap.
- The largest rainforest on Earth is found in the Amazon, and the ocean's deepest point is 36,200 feet below sea level.
- A honey fungus that can cover thousands of acres is the largest living organism in the world.
- A Greenland shark is the world's oldest shark and Greenland has the planet's lowest population of any nation.
- With a lifespan of more than 5,000 years, the Great Basin Bristlecone Pine **(Pinus longaeva)** has been recognised as the oldest tree in the world ever.
- Libya is the hottest region on Earth, and the moon also experiences moonquakes, just like the Earth experiences earthquakes.
- The Pacific Ocean is the world's largest ocean basin, and Japan receives the most snowfall annually.
- **On May 22, 1960, the greatest earthquake ever recorded with a magnitude of 9.5 devastated Bio-Bio, Chile.**
- The most active volcano in the world is the Stromboli Volcano, and over 20% of the United States is a coastline.

The air is heated to nearly 54,000 degrees Fahrenheit by a single lightning strike.

- There is no escape from a **black hole in classical theory**, but quantum theory enables energy and information to escape.
- If not for a **force** called gravity, we would all go zinging off into outer space.
- The more massive a star, the more luminous it will be. This rule is called the **mass-luminosity law**.
- The unification of so called weak nuclear forces with the Maxwell equations is what known as the **Electro-weak theory**. And the electro-weak theory and QCD together constitutes the so called Standard Model of particle physics, which describes everything except **gravity**.
- What goes up need not come down — if it is shot upward faster than the **escape velocity**

$$v_{\text{escape}} = \sqrt{\frac{2GM}{r}}.$$

- When 2 similar waves are added, the resultant wave is bigger (**constructive interference**) and when 2 dissimilar waves are added, they cancel each other out (**destructive interference**).
- The objects of **different masses** are accelerated towards the earth at the same rate, but with different forces.
- Observations of **galaxies** indicate that the universe is expanding: the distance D between almost any pair of galaxies is increasing at a rate $\mathbf{V = \frac{dD}{dt} = HD}$.
- When we place two long parallel uncharged plates close to each other, virtual particles outside the plates exerts more pressure than the virtual particles inside the plates, and hence the plates are attracted to each other, which we call the **"Casimir effect."**

- **Quantum mechanics** says that the position of a particle is uncertain, and therefore that there is some possibility that a particle will be within an energy barrier rather than outside of it. The process of moving from outside to inside without **traversing the distance between** is known as quantum tunneling, and it is very important for the fusion reactions in stars like the Sun.
- Newton rings is a phenomenon in which an interference pattern is created by the reflection of light between two surfaces — a spherical surface and an adjacent flat surface. It is named after **Isaac Newton**, who first studied them in 1717.
- **Electric** and **magnetic** forces are far stronger than gravity, but remain unnoticeable because every **macroscopic body** contain almost equal numbers of positive and negative electrical charges (i.e., the electric and magnetic forces nearly cancel each other out).
- By analyzing the stellar spectrum, one can determine both the temperature of a star and the composition of its atmosphere.
- If the leptons would have felt the strong force, then they would have combined to form different particles. The entire picture of Particle Physics would have been quite different.
- Long-duration gamma ray bursts are associated with the deaths of **massive stars** in a specific kind of explosion called a **supernova**.
- As mercury repeatedly orbits the sun, the long axis of its **elliptical path** slowly rotates, coming full circle roughly every **360,000** years.
- Because the **square of the time** it takes for the planet to complete one revolution around the sun is proportional to the **cube of its average distance** from the sun, the mercury move rapidly in its orbit and Venus, Earth and Mars move progressively less rapidly

about the sun and the outer planets such as Jupiter, Saturn, Uranus, Neptune and Pluto move stately and slow.

Energy budget of the universe:

13.7 Billion Years ago (when the Universe was 380,000 years old)

- Dark Matter: 63%
- Neutrinos: 10%
- Photons: 15%
- Ordinary Matter: 12%

Today

- Dark Matter: 23 %
- Dark Energy: 73%
- Ordinary Matter: 4%
- Out of 4% we only make up **0.03% of the ordinary matter**.

Quantum mechanics (the theory of subatomic physics and one of the most successful theories of all time) is based on three principles:

1. Energy is found in discrete packets called **quanta**.
2. Matter is based on point particles but the probability of finding them is given by a wave, which obeys the **Schrödinger wave equation**.
3. A measurement is necessary to collapse the wave and determine the final state of an object.

- The discovery and confirmation of the **cosmic microwave background radiation**, or **CMBR**, in 1965 secured the Big Bang as the best theory of the origin and evolution of the universe.
- If the two quarks would have occupied precisely the same point with the same properties, they would not have stayed in the same position for long. And quarks would have not formed separate, well-defined protons and neutrons. And nor would these, together with electrons have formed separate, well-defined atoms. And the world would have collapsed before it ever reached its present size.
- Neither of these extremes would have allowed for the existence of stars and life: A slightly stronger weak force, all the neutrons in the early universe would have decayed, leaving about **100 percent hydrogen**, with no deuterium for later use in the synthesizing elements in stars. A slightly weaker weak force, few neutrons would have decayed, leaving about 100 percent helium, with no hydrogen to fuel the fusion processes in stars.
- Matter bends the fabric of space and time. The **distortion of the space-time** affects the path of light.

"Matter tells space how to curve, and curved space tells matter how to move."

Matter → curvature of space-time

- The ultimate fate of the universe is determined by whether the **density parameter** $\Omega = \frac{8\pi G\rho}{3H^2}$ is less than, equal to or greater than 1.
- When two **black holes** collide, they merge, and the area of the final black hole is greater than the sum of the **areas of the original holes**.

- Because **E = mc^2** the energy which an atom has due to its motion add to its rest mass and as an atom approaches the speed of light, its mass raises ever more quickly, it acquire **infinite** mass and since an infinite mass cannot be accelerated any faster by any force, the issue of infinite mass remain an intractable problem. For this reason all the atoms are forever confined by relativity to move at speeds slower than the speed of light. Only radiation that has no intrinsic mass move at the speed of light.
- The two neutron stars that are orbiting each other continually emit gravitational waves. These waves carries energy at the speed of light and are now considered as fossils from the very **instant of creation** . . . . since no other signal have survived from that era.
- The quarks are much smaller than the wavelength of **visible light** and so they do not possess any color in the normal sense.
- Linking the two chains in the DNA, are pairs of nucleic acids (**purine**s + pyrimidines). There are four types of nucleic acid, **adenine** "A", cytosine "C", guanine "G", and thiamine "T." An adenine (purine) on one chain always matches with a thiamine (pyrimidine) on the other chain, and a guanine (purine) with a cytosine (pyrimidine). Thus DNA exhibits all the properties of genetic material, such as replication, mutation and recombination. Hence, it is the **molecule of life**.
- The natural selection is a choice of stable forms and a rejection of unstable ones. And the variation within a species occurs randomly, and that the **survival** or **extinction** of each organism depends upon its ability to adapt to the **environment**.
- **Surface gravity** $g = \frac{GM}{R^2}$ is the same at all points on the **event horizon** of a black hole, just as the temperature is the same everywhere in a body at thermal equilibrium.

- Every living organism is endowed with two elements "**genes**" − a set of instructions that tell them how to sustain and multiply themselves and "**metabolism**" − a mechanism to carry out the instructions.
- Every living cell of **cyanobacteria**, and eventually higher plants (including flowering angiosperms, orchids, **conifers** and other cone bearing gymnosperms, **ferns**, club mosses, **hornworts**, mosses and the multicellular eukaryotes of the kingdom **Plantae**) possess tiny **molecular factories**, called **chloroplast**s, which are in charge of a dye sensitized **photochemical redox** process - the conversion of sunlight, water and carbon dioxide into carbohydrates and oxygen.

$$6CO_2 + 6H_2O + \text{Sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$$

- Inside the **nucleus** of an atom, a proton is never permanent a **proton** and a neutron is never permanently a **neutron**. They keep on changing into each other. A neutron emits a pi meson and become proton and a proton absorbs a pi meson and become a neutron.

$$\text{Neutron} \rightarrow \text{proton} + \pi^-$$

$$\text{Proton} + \pi^- \rightarrow \text{neutron}$$

- The proton and neutron masses are so similar; they differ only by the replacement of an **up quark** with a **down quark**.
- The forces that bind the quarks together to form a proton or a neutron are so strong that it is proved very difficult if not impossible to obtain an **isolated quark**. As we try to pull them out of the proton or neutron, it gets more and more difficult. Even stranger is the suggestion that the harder and harder if we could drag a quark out of a proton **the strong**

force gets bigger and bigger – rather like the force in a spring as it is stretched causing the quark to snap back immediately to its original position. However, now it has been revealed that experiments with large **particle accelerator**s indicate that at high energies the strong force becomes much weaker, and one can observe an isolated quark.

- **The faster you move, the shorter and heavier you are. And that is the theory of relativity.**
- Space has three dimensions, we mean that it takes **three numbers** to specify a point. If we add the time, then space becomes **space-time**, with four dimensions.
- When a wave source moves toward an observer, its waves appear to have a **shorter wavelength**. If the wave source moves away, its waves appear to have a **longer wavelength**. This is called the **Doppler effect**.
- Ordinary **matter** is made of atoms; atoms are made of **nuclei**, nuclei made of **quark**s.
- Gravitational force $F_G = \frac{GMm}{R^2}$ is a **purely attractive force** which keeps the planets in orbit around the **sun** and the moon in orbit around the Earth.
- All the known particles in the universe belong to one of two groups, Fermions or bosons. **Fermions** are particles with integer spin ½ and they make up ordinary matter. Bosons are particles with integer spin 0, 1, 2 and they act as the **force carriers** between fermions.
- Sun and other stars all emits approximately a black body radiation filling up the universe giving a concrete evidence for the Stefan - Boltzmann law i.e., power radiated per unit area is proportional to the fourth power of their temperature and the proportionality constant is **Stefan's constant**.

$$\frac{P}{A} = \sigma T^4$$

- Since $\frac{E}{c^2}$ is mass, a little mass goes an extremely long way in producing large energy.
- The **biological oxidation** of organic molecules results in the formation of utilizable energy molecules (**adenosine tri-phosphate**) in all living cells.
- Since the **graviton** has no mass of its own, the gravitational force of attraction between the sun and every planet is long range.
- A force (proportional to a quantity called their **charge** and inversely proportional to the square of the distance between them) pulls the electrons towards the nuclei to form **neutral atoms**.
- Each quark possess baryon number = $\frac{1}{3}$: the total baryon number of the proton or the neutron is the sum of the baryon numbers of the quarks from which it is composed.
- Among the **leptons** the electron is a stable object and **muon** (that has a mass 207 times larger than an electron) and the **tauon** (that has a mass 3,490 times the mass of the electron) is allowed to decay into other particles.
- The uncertainty in the position of the particle times the uncertainty in its velocity times the mass of the particle is never smaller than a certain quantity, which is known as **Planck's constant**.

$$\Delta x \times \Delta v \times m \geq \frac{\hbar}{2}$$

- **A rotating neutron star** (a tiny, burnt out star) generates regular pulses of radio waves.

- Any light from a distant object would converge as it passes around the galaxy. When we gaze at the distant galaxy, we see a ring like pattern called **Einstein ring**, an optical illusion caused by **general relativity**.

The **Four Fundamental Forces** of Nature are Gravity, Electromagnetism, Weak Nuclear **force** and Strong Nuclear **force**.

1. **Gravity:** This is the weakest of the four; it acts on everything in the universe as an attraction. And if not for this force, we would go zinging off into outer space and the sun would detonate like trillions upon trillions of **hydrogen bomb**s.
2. **Electromagnetism:** This is much stronger than gravity; it acts only on particles with an electric charge, being repulsive between charges of the same sign and attractive between charges of the opposite sign. **More than half the gross national product** of the earth, representing the accumulated wealth of our planet, depends in some way on the electromagnetic force.
3. **Weak nuclear force:** This causes radioactivity and plays a vital role in the formation of the elements in stars. And a slightly stronger this force, all the neutrons in the early universe would have decayed, **leaving about 100 percent hydrogen**, with no deuterium for later use in the synthesizing elements in stars.
4. **Strong nuclear force:** This force holds together the protons and neutrons inside the nucleus of an atom. And it is this same force that holds together the quarks to form protons and neutrons. Unleashed in the hydrogen bomb, the strong nuclear force could one day end all life on earth.

- Since the **Planck's constant (h** = 6.625 × 10 $^{-34}$ Js**)** is almost infinitesimally small, quantum mechanics is for little things.
- Associated to each **charged lepton**, there are three distinct kinds of neutrinos:

1. the electron neutrino
2. the muon neutrino
3. the tauon neutrino

- The 4 dimensional fabric of space-time is simply the **lowest energy state** of the universe. It is neither empty nor uninteresting, and its energy is not necessarily zero As a remarkable consequence of the **uncertainty principle** of **quantum mechanics** (which implies that certain pairs of quantities, such as the **energy and time**, cannot both be predicted with complete accuracy) the empty space is filled with what is called **vacuum energy**.
- No spatial or time interval shorter than the **Planck values** exists:

1. length → **Planck length** = $\sqrt{\frac{\hbar G}{c^3}}$
2. time → **Planck time** = $\sqrt{\frac{\hbar G}{c^5}}$

- c is **not just the constant** namely the maximum distance a light can travel in one second but rather a fundamental feature of the way space and time are married to form **space-time**.
- In any closed system like universe: randomness or entropy never decreases with time.

- **Neutrinos** only feel the weak force.
- By the **wave-particle duality of quantum mechanics**, light can be regarded as both a wave and a particle.

In phase → wave crests and **troughs** reinforce each other.

Out of phase → wave **crests** and troughs cancel out.

- Light waves are emitted or absorbed only in discrete quanta, whose **energy** is proportional to their **wavelength**.

$$mc^2 = \frac{hc}{\lambda}$$

- Black hole is a region of **space-time**. According to the **theory of relativity**, nothing can travel faster than light. Thus if light cannot escape, neither can anything else; everything is dragged back by the gravitational field.
- **Energy** can neither be created nor destroyed; it can only be transferred from one form to another.
- Chandrasekhar limit (**1.4 times the mass of the sun**) is the maximum possible mass of a **stable cold star**, above which it collapses into a cosmic body of extremely intense **gravity** from which nothing, not even light, can escape.
- The energy above which (**Grand unification energy**), the **electro-magnetic force**, weak force, and strong force become indistinguishable from each other.
- The **distance** — and the **path** — that a body travels, looks different to different observers.

- The wavelength of a wave is the distance between successive peaks or troughs.
- Faint light means fewer **photon**s.
- Wormholes provides shortcuts between distant points in space.
- In more than three **spatial** dimensions, **planetary orbits** would be unstable and planets would either fall into the sun or escape its attraction altogether.
- **Neutron stars** are the fastest spinning objects known in the universe.
- The decrease in frequency of light from distant galaxies due to the **Doppler effect**, indicate that they are moving away from us.
- The universe was in **perfect symmetry** before the big bang. Since then, the universe has cooled and expanded, and hence the **four fundamental forces of nature** and their symmetries have broken down. Today, the universe is horribly broken, with all the forces split off from each other.
- **Electric and magnetic fields** turn into each other in a wavelike motion, creating an electromagnetic field that travels at the speed of light.
- At **Planck length** $\sqrt{\frac{\hbar G}{c^3}}$, space-time becomes "**foamy**," with tiny bubbles and **wormholes** appearing and disappearing into the vacuum.
- The information swallowed by a black hole is forever hidden from the outside universe, and is never revealed until the black hole evaporates and completely disappears (i.e., All one could say of the gravitational monster what the **poet Dante** said of the entrance to Hell: "**All hope abandon, ye who enter here**." Anything or anyone who falls through the black hole will soon reach the region of infinite density and the end of time).

The oceans of Earth may contain up to 20 million tons of gold, and there are three explosive, fatal lakes on the planet.

- The 65,000-kilometer-long **Mid-Ocean Ridge**, the longest mountain range on Earth, is almost fully beneath the ocean.
- The ocean produces more than 70% of the oxygen on our globe, and it is probable to find rivers and lakes beneath the ocean.
- The ocean is home to the largest animal, the blue whale, and the largest ocean waves exist inside the ocean rather than on the ocean's surface.
- On the ocean floor, there are millions of shipwrecks, and the majority of volcanic eruptions take place underwater.
- 12,100 feet is the average depth of the ocean. Since light waves can only travel 330 feet under water, the remaining depth of water lacks light penetration. Due of this, the ocean's bottom is dark.
- About 75% of deep-sea organisms generate their own light. Bioluminescence is the name of this phenomenon.
- The term **"ocean acidification"** describes a long-term decrease in the pH of the ocean that is principally brought on by the absorption of carbon dioxide **(CO_2)** from the atmosphere.
- **Every year, tons of plastic enter the ocean. Marine creatures are being killed by plastic in our oceans.**
- The only species in which the male gives birth is the seahorse and Sponges are older than dinosaurs.
- An octopus has three hearts and Seahorses don't have stomachs.
- Nearly five times faster than the speed of sound in air, the speed of sound in water is 1,435 m/s.
- The largest known **tsunami**, which was triggered by an 8.9-magnitude earthquake in the Gulf of Alaska in 1899 and moved at speeds of hundreds of kilometers per hour, measured 60 meters above sea level.
- A mouthful of seawater may include tens of thousands of zooplankton, hundreds of thousands of phytoplankton, and millions of bacterial cells.

Ships carry more than 90% of international trade, while underwater cables are used in around 50% of international communications.

- Because $dM = \frac{k}{8\pi} dA + \Omega dJ + \Phi dQ$ the size and shape of the black hole depends only on its mass, charge and rate of rotation, and not on the nature of the star that had collapsed to form it.
- The gravitational force of attraction between the sun and every planet is due to the exchange of a particle of spin 2 called the **graviton** between the particles that make up these two bodies. And this exchange makes the planets orbit the sun with a velocity = $\sqrt{\frac{2GM}{r}}$.
- Accelerated massive bodies give off **gravitational waves** just as bound electrons in an atom emit electromagnetic radiation.

- The laws of physics **remain unchanged under the combination of operations** known as C, P, and T (C → changing particles for antiparticles. P → taking the mirror image so left and right is swapped for each other. T → reversing the direction of motion of all particles — in effect, running the motion backward).
- Speed of light is the **limiting velocity in the universe**, unaffected by the movement of its source and independent of all observers.
- Solids, liquids, and gases frame up the three familiar states of matter, but plasma (a gas of ionized atoms) form the fourth state of matter.
- The laws of physics in an accelerating frame remain equivalent to the laws in a gravitational field.

On Mars, a year lasts 687 days. That is 1.9 Earth years.

Mars takes longer to orbit the sun since it is farther from it.

- Mercury does not have any moons or rings.
- Venus is named after the Roman goddess of love and beauty and rotates in the opposite direction to most other planets.
- The standard gravitational parameter μ of a Planck mass is given by:

$$\mu = Gm_{Planck} = \sqrt{\hbar \times c \times G}$$

- The proton is composed of two up quarks and one down quark. The neutron is composed of two down quarks and one up quark.
- Friction takes place when one object tries to slide over the surface of another.
- Quarks feel the strong force, leptons do not.

Intrinsic energy of proton = KE of quarks+ PE of quarks + Intrinsic energy of quarks

Something the size of a stone travelling at 50 m s^{-1} would have a quantum wavelength of

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{0.2 \times 50} = 6.63 \times 10^{-35} \text{ m}$$

m = 0.2 kg

which is far too small for any wave effects to be observed.

- All antiquarks have baryon number = $-\frac{1}{3}$
- All reactions must conserve energy, momentum and electrical charge.
- For each particle species there is a threshold temperature:

$$T = \frac{mc^2}{k_B}.$$

Once the universe drops below that temperature the species is effectively removed from the universe.

Two moons orbit Mars. Deimos and Phobos are the names of the two.

- The first object considered to be a black hole is Cygnus X-1.
- Little black holes may have formed immediately after the cosmic explosion that marked the beginning of the universe. Quickly growing space may have crushed some regions into tiny, dense black holes less massive than the sun.
- If a star moves too close in proximity to a supermassive black hole, the star can be torn apart.
- Because a black hole is a region of space having a gravitational field so intense that no matter or radiation can escape — it's impossible for us to see them with the naked eye or sense the hole directly through our instruments.
- Black holes distort time and space around them.
- There is a supermassive black hole at the heart of the **Milky Way** (the galaxy that contains our Solar System) — it is four million times more massive than the sun.
- Nothing can travel faster than light, but that doesn't apply to the stretching of space. During the universe's inflationary phase, space expanded much faster than light.
- Both space and time were created at the Big Bang. Before that, neither time nor space existed.
- It is believed that all the 4 basic forces of nature (gravity, strong nuclear, weak nuclear and electromagnetic) were combined into a single "super" force prior to 10^{-43}s after the Big Bang. At the Planck time $\sqrt{\frac{\hbar G}{c^5}}$, gravity is thought to have separated from the other forces.
- The lowest mass atom is the hydrogen atom, with one electron and a nucleus consisting of just one proton.
- The electron-Volt is a very small energy unit: 1 eV = 1.602×10^{-19} joule.
- The neutron has a mass of 939.57 MeV and it decays into a proton, an electron and an antineutrino: **neutron→ proton + electron + antineutrino**
- Antineutrinos colliding with a proton may produce a neutron and a positron:

  antineutrino + proton→ neutron + positron
- Free antineutron decays into an antiproton, a positron and a neutrino:

  antineutron→ antiproton + positron + electron–neutrino

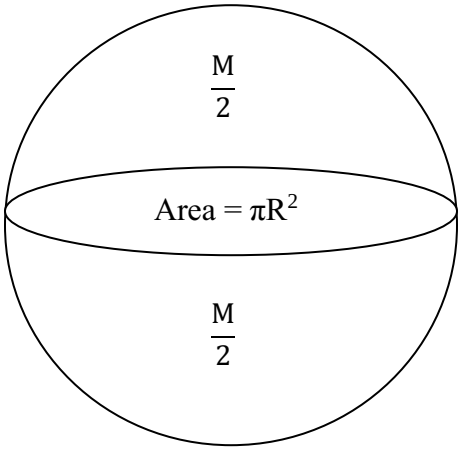
- The more inertia that a body has, the more mass that it has.
- Because $F_G = \frac{GMm}{d^2}$: the force of gravitational attraction decreases as we move away from the earth by distance squared.
- Gravitational potential energy (PE = mgh) increases as height increases.
- Light slows down, bends toward the normal and has a shorter wavelength when it enters a medium with a higher index of refraction.
- A prism produces a rainbow from white light by dispersion.
- The period of a wave is the inverse of its frequency. So waves with higher frequencies have shorter periods.
- Only waves show diffraction, interference and the polarization.
- Whenever charged particles are accelerated, electromagnetic waves are produced.
- It takes 225 million years for our Sun to travel round the galaxy.
- Only one two-billionth of the Sun's energy hits the Earth.
- Earth is the only known planet with plate tectonics.
- The planet with the hottest surface temperature is not Mercury, but Venus, because of the Greenhouse Effect of its atmosphere.

"For millions of years, mankind lived just like the animals. Then something happened which unleashed the power of our imagination. We learned to talk and we learned to listen. Speech has allowed the communication of ideas, enabling human beings to work together to build the impossible. Mankind's greatest achievements have come about by talking, and its greatest failures by not talking. It doesn't have to be like this. Our greatest hopes could become reality in the future. With the technology at our disposal, the possibilities are unbounded. All we need to do is make sure we keep talking."

— Stephen Hawking

Because it is red, Mars is sometimes known as the "Red Planet." Iron oxide, often known as rust or iron, is a chemical that is abundant in the rocks and soil of this planet and is responsible for giving it its distinctive color.

- You could fit 1.3 million Earths in the Sun
- It takes 8 minutes for the Sun's light to reach Earth
- The Sun is about 4.5 billion years old and is 92,960,000 miles away from Earth
- The Sun can appear blue when viewed at a wavelength of about 475 nm.
- The gravity of the Sun is 28 times larger than Earths and there are thousands of colder patches on the Sun − they are called '**Sunspots**'. These sunspots form in areas of strong magnetic activity that inhibit heat transfer.
- The Suns magnetic polarity reverses every eleven years.
- **The atmosphere of the Sun is composed of three layers**:
    i. the photosphere (**layer at which the Sun becomes opaque to radiation**)
    ii. the chromosphere (**emits a reddish glow as super-heated hydrogen burns off**)
    iii. the corona (**the Sun's outermost layer that merges with the solar wind**)
- To match the energy of the Sun, it would take 100 billion tons of dynamite exploding every second.
- **The Sun rotates in the opposite direction to Earth** with the Sun rotating from west to east instead of east to west like Earth.
- **Helium** is the only element that was not first discovered on Earth. Instead, it was discovered in 1868 in the form of previously unknown spectral lines in the light of the sun.
- Going as fast as the Earth we could reach the reach the moon in 3.5 hours.
- The Earth Isn't a Perfect Sphere − It Has a 27 Mile Tall Bulge at Its Belly



Subdividing the **Star** of **radius** R into two halves (each of mass $\frac{M}{2}$) and the gravitational force of the two halves on each other is given by:

$$F_G = G\,\frac{\frac{M}{2}\times\frac{M}{2}}{R^2}$$

$$F_G = \frac{GM^2}{4R^2}$$

The gravitational binding energy of a star is given by:

$$U = -\frac{3GM^2}{5R}$$

$$U = -\frac{12}{5}\,(F_G \times R)$$

$$F_G = \frac{M^2c^4}{4R^2}\times\frac{G}{c^4}$$

$$Mc^2 = 2R\sqrt{F_G \times \text{Planck force}}$$

If F_G = Planck force:

$$R = \frac{GM}{2c^2}$$

When the radius of the star approaches $\frac{\text{Schwarzschild radius of the star}}{4}$, the gravitational force of the two halves on each other equates the Planck force.

For a star in hydrostatic equilibrium:

The force from gas pressure equates the gravitational force ' $\mathbf{F_G}$'

$$P_{gas} \times \pi R^2 = \frac{GM^2}{4R^2}$$

$$P_{gas} = \frac{GM^2}{4\pi R^4}$$

For sun:

$$M = 2 \times 10^{30}\ kg$$

$$R = 7 \times 10^{8}\ m$$

$P_{gas} = 9 \times 10^8$ atmospheric pressure

→ Less than the central pressure in the Sun (3×10^{11} atmospheric pressure)

$P_{gas} = nk_BT$

$$nk_BT = \frac{GM^2}{4\pi R^4}$$

$$T = \frac{GM^2}{4\pi n k_B R^4}$$

For sun:

Number density of particles (n) = 1.6×10^{30} particles/ m^3

$T = 4 \times 10^6$ Kelvin

→ Less than the central temperature in the Sun (1.5×10^7 Kelvin)

- If you leave at Age of 15 in a **Spaceship at Speed of Light** and Spends 5 Years in Space, when you get back on Earth you will 20 Years old. But all of your Friends who were 15 when you Left, will be 65 Years Old at that Time.
- There's a highway in Space, called the **Interplanetary Superhighway**. It is used to send spacecraft around the solar system with least resistance using gravity.
- If you fall into black hole, you will able to see both the Universe beginning and ending due to **Time Dilation**.
- **Time** slows down at high speeds and around massive objects. It completely stops at the speed of light and at the event horizon of a black hole and does not exist at the center of a black hole.
- Like a black hole, a white hole is a prediction of **Albert Einstein's theory of general relativity**. It is essentially a black hole in reverse: if nothing can escape from a black hole's event horizon, then nothing can enter a white hole's event horizon.
- Quark matter is an extremely dense phase of matter made up of subatomic particles called **quarks**. This theoretical phase would occur at extremely high temperatures and densities. It may exist at the heart of neutron stars. It can also be created for brief moments in particle colliders on Earth, such as **CERN's Large Hadron Collider**.

- Without the **discovery of wormholes**, there is no scope for interstellar travel. Even if we travel at the speed of light, it would take millions of years to get to the nearest galaxy.
- Because of **time dilation**:
    i. Your head is older than your feet
    ii. The earth's surface is 2.5 years older than its core
    iii. Clocks placed at higher altitudes run faster than the clocks at lower altitudes

Because:

$$\text{observer time} = \frac{\text{proper time}}{\sqrt{1-\frac{v^2}{c^2}}}$$

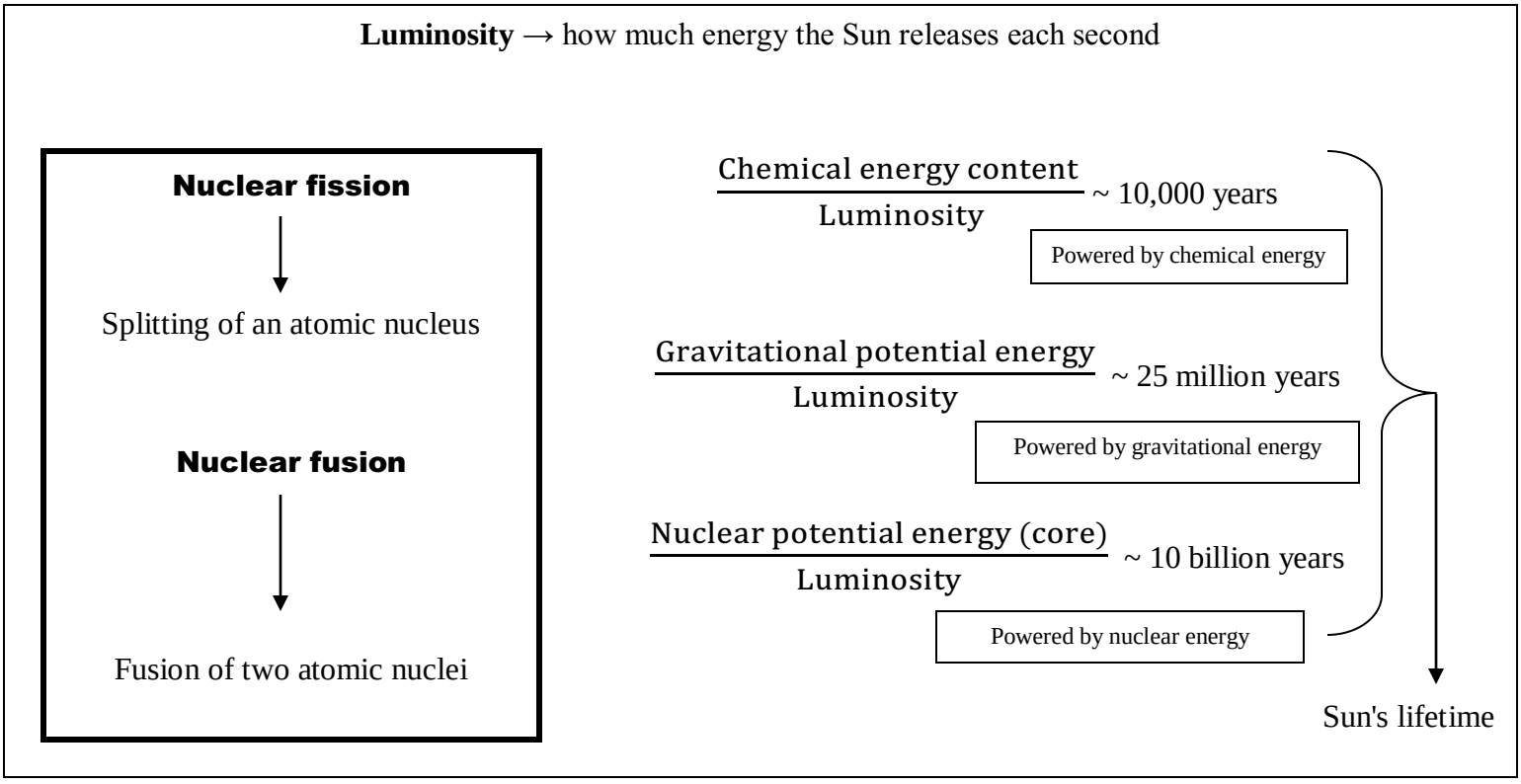
The faster you move through space, the slower you move through time.

Three physicists flew around the world twice in 1971 with synced atomic clocks to test out the **time dilation theory**. Upon meeting up, they found that all 3 of the clocks disagreed with each other.

YOU CANNOT CRY ON SPACE BECAUSE YOUR TEARS WON'T EVER FALL.

- The speed of a **meteoroid** traveling through the earth's atmosphere has speed at least 5 times of that of sound. Their mere passing by a building can lead to broken windows due to shock waves.

- According to astronauts, space smells like seared steak, hot metal and welding fumes.
- Astronauts on the international space station witness around 15 sunrises and 15 sunsets every day.
- 99% of matter is empty space. If you removed all the space within our atoms, then humanity (7 billion people) would fit into one sugar cube.
- The coldest temperature ever recorded in the known universe was in Massachusetts, MIT, where scientists attained temperatures 810 trillionths of a degree Fahrenheit above the absolute zero (-459.67°F).
- Plasma is actually the most common phase of matter in the universe (**consists of a gas of ions – atoms or molecules which have one or more orbital electrons stripped, and free electrons**), despite being rare on Earth. The Sun, the stars, and most of the interstellar matter in the universe are comprised of plasma.
- If astronauts traveled in a spaceship at a constant **1g of acceleration**, they could travel the entire universe in their own lifetime, while billions of years would have passed by on earth.



- If an astronaut in Earth's orbit fired a bullet at the Sun at **1500ft/sec** it would take roughly 10.4 years to hit its target.

YOU ARE THE SAME AGE AS THE UNIVERSE BECAUSE MATTER CAN NEVER BE CREATED OR DESTROYED.

- Because the period of a planet's orbit increases with increasing distance from the sun:
  i. Mercury (**the innermost planet**) takes only 88 days to orbit the Sun.
  ii. The earth takes 365 days, while Saturn requires 10,759 days to do the same.

- **period** → the time a planet takes to complete one orbit around the sun
- **semimajor axis → size of orbit**
- **eccentricity** → how elongated the orbit is
- **perihelion** (position of smallest distance to sun)

  ↓

  The point in the orbit of a planet that is nearest to the sun
- **aphelion** (position of greatest distance to sun)

  ↓

  The point in the orbit of a planet most distant from the sun

Geocentric model (Ptolemy) → planets and Sun orbit the Earth

Heliocentric model (Copernicus) → planets and earth orbit the Sun

- Half the atoms in our galaxy − including the atoms in our body − likely came from outside the Milky Way (i.e., came from across the universe).
- The largest galaxy in the observable universe is an elliptical galaxy, **IC 1101**. It has 100 trillion stars and is 6 million light years across. By comparison, the Milky Way has a mere 100 billion stars and is 120,000 light years across.
- When a ball is dropped to the ground, it experiences Earth's gravitational force. According to **Isaac Newton's third law of motion**, the ball exerts equal and opposite force on the ground. Even though both the ball and ground experience the same force, their acceleration is different. The mass of ground is enormous compared to that of a ball. So a ball experiences larger acceleration and the ground experiences almost negligible acceleration. Due to the negligible acceleration, ground appears to be stationary when a ball is dropped to the ground.

Doppler Effect:

$$\frac{\text{observed wavelength}}{\text{true wavelength}} = 1 \pm \frac{\text{speed of object}}{\text{speed of light}}$$

where:

- + sign → if object is moving away from us (redshift, longer wavelength)
- − sign → if object is moving toward us (blueshift, shorter wavelength)

- Only Earth has oxygen in its atmosphere and liquid water on its surface.
- **Conservation of angular momentum:**

radius × rotation rate = constant

Large radius → slow rotation

Small radius → rapid rotation

- There are a trillion stars in the known universe for every human on Earth.

- Astronauts in space need to sleep near fans so that when they exhale, there isn't a CO_2 cloud in front of their face causing them to potentially suffocate.

Stellar Sizes	
Giant stars	radius between 10 and 100 times the Sun's
Dwarf stars	radius equal to or less than the Sun's
Supergiant stars	radius more than 100 times the Sun's

Carbon-detonation supernova

If the mass of white dwarf exceeds 1.4 solar masses, electron degeneracy can no longer keep the core from collapsing. Carbon fusion begins throughout the star almost simultaneously, resulting in a **carbon explosion**.

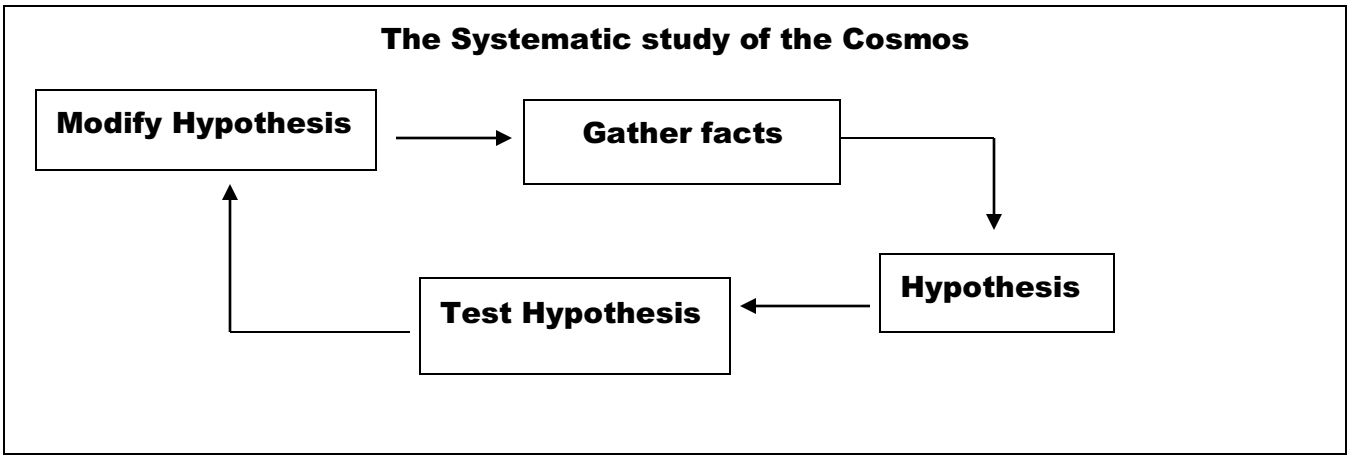
- We cannot see 80% of stars in the universe. If we could, the sky would look extremely cluttered. The reason why we can't see 80% of the stars is that 80% of the stars in the universe are **Red Dwarfs**. Red Dwarfs are dim and give off red light. Their luminosity is only 0.1% of that of the sun.
- Every star in the night sky is larger than the sun.
- There are 200 billion to 400 billion stars in our galaxy, but the naked eye can't spot more than a few thousand of them.
- The twinkling of stars (**stellar scintillation**) is caused by the refraction of light as it passes through the Earth's atmosphere.

"Space is big. You just won't believe how vastly, hugely, mind-bogglingly big it is. I mean, you may think it's a long way down the road to the chemist's, but that's just peanuts to space. "

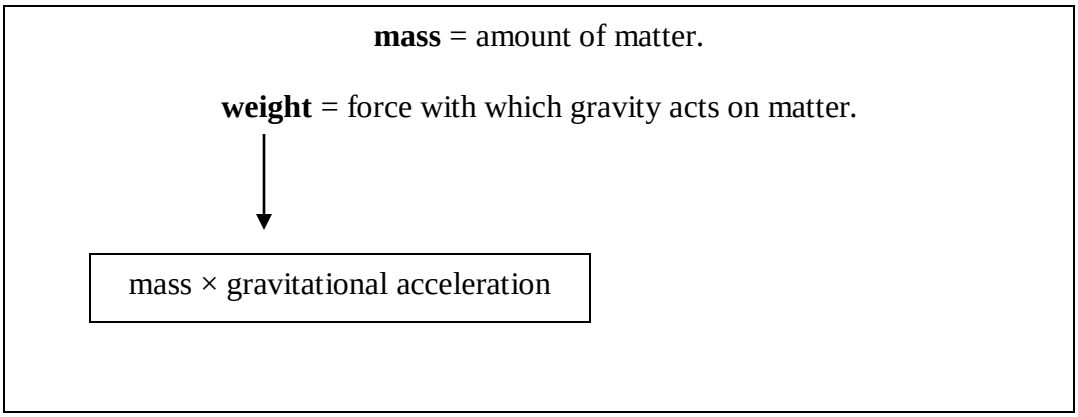
– Douglas Adams, The Hitchhiker's Guide to the Galaxy (1978)

- Cool objects radiate at long wavelengths, hot objects at short wavelengths.
- Photons can pass around objects which are much **smaller** than their wavelength.
- As the earth rotates more slowly around the sun from year to year, 2016 was one second longer than 2015.
- The planet Uranus was **discovered** in 1781, while the Antarctica was not discovered until 1820.
- Each year the moon moves 3.8 cm further from the Earth.
- Every minute, you travel over 12,000 miles in space. That's just while standing still.
- The reason why space is cold even if there is sun at the center is simply because there is no matter to absorb that heat.
- Unprotected exposure to outer space can kill us in less than 30 seconds.
- A **cosmic year** is the amount of time it takes the Sun to revolve around the center of the Milky Way... about 225 million years.
- **The Outer Space Treaty**, signed by all major space faring nations, prohibits claiming territory in space or on celestial bodies. Space is considered "**the shared heritage of mankind**".
- If the Sun was scaled down to the size of a white blood cell, the Milky Way would be the size of the continental United States.

- There is a **mass reservoir** of water floating in space that is 100,000 times bigger than our sun and holds 140 trillion times more water than all of our oceans.
- Due to the **highly elliptical orbit** of Pluto, it sometimes gets closer to the Sun than Neptune. In fact during the years 1979 to 1999, Neptune was the 9th Planet and Pluto was the 8th Planet from the Sun.



- Mass and weight are not the same thing.



Earth	Mars
mass = 50 kg	mass = 50 kg
weight = 110 lbs	weight = 42 lbs

images	the shape of an astronomical object
spectra	what it's made of (its **structure**, its temperature and density), how fast it's moving...
multi-wavelength images	how it works

- On average a meteor the size of a car enters the Earth's atmosphere about once per year. Most burn up before hitting the ground.
- The core of a star reaches **16 million degrees Celsius**. A grain of sand this hot would kill someone from 150 kilometers away.

In 2012, the Quantum Physicists **Dr. S. Haroche** and **Dr. D. Wineland** received Nobel Prize for their experiments which showed that "**A Particle can be at two different locations at the same time**". These Experiments indirectly showed that "Parallel Universe does Exist!"

3 different types of spectra:

Continuous spectrum	arise from hot, high pressure gas or solid
Bright emission lines	arise from hot, low pressure gas which radiate heat
Dark absorption lines	arise from cool, low pressure gas

- In 1954, Man arrived from Tokyo Airport. He had Passport issued by a Country named as "**Taured**" which did not exist. He had Visa of all Countries and said **his Country is 1000 Years Old**. Police locked him in a High Secure Room and he vanished. Experts said, he came from Parallel Universe.
- The term "**astronaut**" comes from Greek words that mean "**star**" and "**sailor.**"
- Astronauts in space lose on average 1% of their bone mass a month. Most of which is excreted in their urine. They literally pee their skeleton out.

- Earth has a powerful magnetic field − this phenomenon is caused by **nickel-iron core** of the planet.
- Earth doesn't take 24 hours to rotate on its axis − it's actually 23 hours, 56 minutes and 4 seconds.
- There's a 30,000 kilometer hexagonal cloud at Saturn's North Pole.

$$4\ {}^{1}H \rightarrow 4He + \text{energy}$$

One fusion of 4 Hydrogen atoms to Helium releases 4×10^{-12} joules

$$E_{Fusion} = \frac{\text{number of H atoms} \times 4 \times 10^{-12}\ \text{joules per reaction}}{4\ \text{H atoms per reaction}}$$

Number of H atoms in sun = 1.2×10^{57} atoms

$$\mathbf{E_{Fusion} = 1.2 \times 10^{45}\ joules}$$

Energy produced by nuclear fusion in the sun

Conduction	heat is transmitted by electrons moving in a medium
Radiation	heat is transmitted by photons
Convection	heat is transmitted by bulk motion of a gas or liquid

- There is a weird star that appears to be shooting giant balls of plasma into space. Scientists found the bloated red giant while using the Hubble telescope and described the blobs as "**cannon balls**" that are twice the size of Mars and two times hotter than the sun.

- Animals can sense when a **solar eclipse** is happening. Researchers found that when the moon passes between the Earth and Sun, cicadas stop singing, bees get restless, and squirrels run around non-stop during and for 2 hours after the eclipse.

Solar eclipse	**Lunar eclipse**
Occur when the Moon passes between Earth and the Sun − leaving a moving region of shadow on Earth's surface.	Occur when Earth passes between the Sun and the Moon − casting a shadow on the Moon.

- Lunar eclipse can only occur at full moon and solar eclipse can occur only at new moon.
- Because the Earth's orbit around the sun is not in the same plane as the Moon's orbit around the Earth − **eclipses don't occur every month**.

Polar orbit is the orbit where satellite goes over the Earth's pole.

Orbit	**Total energy**	
Circle, ellipse	E<0	PE > KE (gravitationally bound to the Sun)
Parabola	E=0	PE = KE $\frac{GMm}{r} = \frac{mv^2}{2}$ $v = v_{escape} = \sqrt{\frac{2GM}{r}}$ The speed that an object needs to be traveling to break free of a sun's gravity
Hyperbola	E>0	KE > PE (gravitationally not bound to the Sun)

Electromagnetic Spectrum:

Region	Wavelength (Angstroms)	Frequency (Hz)
Radio	$> 10^9$	$< 3 \times 10^9$
Microwave	$10^9 - 10^6$	$3 \times 10^9 - 3 \times 10^{12}$
Infrared	$10^6 - 7000$	$3 \times 10^{12} - 4.3 \times 10^{14}$
Visible	$7000 - 4000$	$4.3 \times 10^{14} - 7.5 \times 10^{14}$
Ultra-violet	$4000 - 10$	$7.5 \times 10^{14} - 3 \times 10^{17}$
X-Rays	$10 - 0.1$	$3 \times 10^{17} - 3 \times 10^{19}$
Gamma Rays	< 0.1	$> 3 \times 10^{19}$

→ The waves on the Electromagnetic spectrum are different than sound waves because they do not require a medium to travel through.

Kinetic energy of a thermal particle:

$$\frac{mv^2}{2} = \frac{3k_B T}{2}$$

$$v_{thermal} = \sqrt{\frac{3k_B T}{m}}$$

$$v_{escape} = \sqrt{\frac{2GM}{R}}$$ } Escape velocity of a particle

$v_{thermal} = v_{escape}$ ⟶ a condition where the thermal particle could escape.

"Roche Limit"

If a "moon" gets closer to the "planet earth" than this, it will get broken apart by the so-called "**tidal forces**".

$$\sqrt{\frac{3k_BT}{m}} = \sqrt{\frac{2GM}{R}}$$

$$T_{escape} = \frac{2GMm}{3k_BR}$$

At this temperature, thermal particle overcome the gravitational pull provided by a massive object such as planets.

A **crater** is an approximately circular depression in the surface of a planet − produced by the impact of a meteorite.

$$\text{diameter of crater} = S\sqrt[3]{\text{Energy required to create a crater on a planet's surface}}$$

where: S is a scaling factor. If the energy required to create a crater 1 km in diameter on a planet's surface is 4.2×10^{15} joules, then

$$S = \frac{1\ \text{km}}{\sqrt[3]{4.2\times10^{15}\text{joules}}} = 6.2 \times 10^{-6}\frac{\text{km}}{\sqrt[3]{\text{joules}}}$$

The energy required to create a crater on a planet's surface = kinetic energy of the colliding meteorite

$$\text{diameter of crater} = S\sqrt[3]{\text{kinetic energy of the colliding meteorite}}$$

$$\text{diameter of crater} = S\sqrt[3]{\frac{mv^2}{2}}$$

- Earth's atmosphere is composed of about **78 % N_2, 21 % O_2, 0.9 % argon, and 0.1 % other gases**. Trace amounts of CO_2, methane, water vapor, and neon are some of the other gases that make up the remaining 0.1 %.
- **Chemical analysis of lunar rocks** revealed that these rocks are extremely similar in composition to Earth rocks.

Heat of accretion	• Colliding Planetesimals convert Planet's gravitational potential energy into kinetic energy. • Kinetic energy is converted into thermal energy
Heat of differentiation	Dense materials fall to the core, converting gravitational potential energy into thermal energy
Heat from radioactive decay	Heat released as a result of radioactive decay (**nuclear energy is converted into thermal energy**)

The **luminosity** generated by core cooling is given by:

$$L_{core} = c_v M_c \frac{dT_{core}}{dt}$$

$\frac{dT_{core}}{dt}$ → **core cooling rate**

where: c_v is the core specific heat capacity and M_c the core mass.

$$\frac{dT_{core}}{dt} \propto \frac{1}{M_c}$$

Small core mass cool more rapidly (**Large core mass take longer to cool**)

- According to the **NASA**, the speed of Earth rotation is gradually slowing and it's happening at a rate of 1.4 milliseconds per 100 years. We may think it's not a big deal.

But if we add up that small discrepancy every day for years and years, it can make a very big difference indeed. At this speed, the day may become 25 hours after 140 million years.

- **Planet Earth** is 93,225,926 miles from the sun. We could go from the Earth to the moon and back 195 times in that distance.

The total energy going into planet from accretion is $\frac{3GM^2}{5R}$

If ΔT is change in temperature of a planet of mass M due to E_{heat}, then

$$E_{heat} = C_P M \Delta T$$

where: C_P is the specific heat capacity of a planet and E_{heat} is the heat of formation.

Equating this to $\frac{3GM^2}{5R}$ yields:

$$\Delta T = \frac{3GM}{5C_P R}$$

The maximum temperature of a planetary interior that results from accretion

- Water covers 70% of the Earth's surface. Freshwater is about 2.5% of that total.

As Earth spins, gravity pushes inward and the centrifugal force pushes outward. However, due to the Earth's tilt, the forces are not exactly opposed, creating an imbalance at the equator and a "**spare tire**" around the planet.

- The Earth's orbit lasts approximately 365.2 days, and it is for this reason that every four years it takes an extra day: the February 29 that we have every leap year.
- The universe is 13.6 billion years old − whereas the Earth is only 4.5 billion years old.

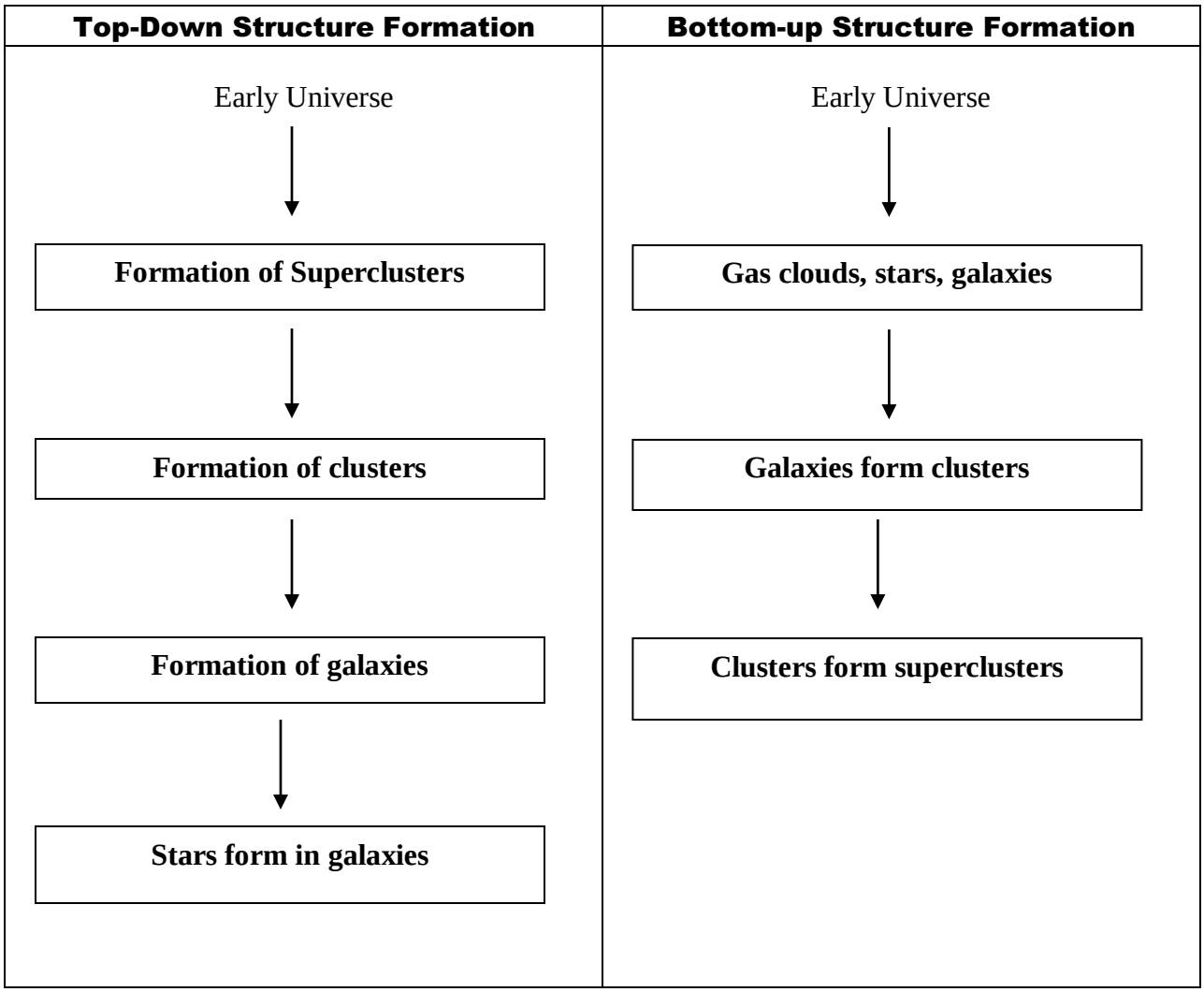
- Approximately 107 billion people are believed to have lived on earth, and an estimated 40% died before the age of 1.
- The Earth's day or night cycle is growing longer year-by-year and 620 million years ago, the Earth day was 21.9 hours.
- From 2000 BC until 1992 AD, astronomers had only discovered three new planets. In 2014, **NASA's Kepler space telescope team** announced the discovery of over 700 new planets.

iron meteorites	almost completely made of metal.
stony-iron meteorites	made of nearly equal amounts of metal and silicate crystals
stony meteorites	made of silicate minerals

- The Earth could eventually have a 1000-hour day in 50 billion years because the time it takes Earth to spin once on its axis keeps increasing.
- If you were on the moon, the Earth wouldn't actually move in the sky. It would appear to wobble a little because the moon is elliptical but it would never "**rise**" or "**set**".

The Composition of the Sun

ELEMENT	ABUNDANCE (percentage of total number of atoms)	ABUNDANCE (percentage of total mass)
Hydrogen	91.2	71.0
Helium	8.7	27.1
Oxygen	0.078	0.97
Carbon	0.043	0.40
Nitrogen	0.0088	0.096
Silicon	0.0045	0.099
Magnesium	0.0038	0.076
Neon	0.0035	0.058
Iron	0.0030	0.14
Sulfur	0.0015	0.040



- All the American flags placed on the moon are now white due to radiation from the sun.
- The earth's deepest known point is the size of 24.7 Empire State Buildings end to end.
- **Coronal loops** are structured arcs of glowing, electrified plasma that flow along the powerful, curved, magnetic fields above the Sun's surface. This one is roughly 4 times the size of Earth.

Type	Discoverers	Spatial Curvature	Volume	Density
Closed	Friedmann-Lemaitre	Positive	Finite	Density > critical density
Flat	Einstein-de Sitter	Zero	Infinite	Density = critical density
Open	Friedmann-Lemaitre	Negative	Infinite	Density < critical density

Spatial Curvature	Length of the path that a light ray will follow	Light dimming with distance
Negative	Longer than straight line	Faster than $\frac{1}{(\text{distance})^2}$
Flat	Straight line	$\frac{1}{(\text{distance})^2}$
Positive	Shorter than straight line	Slower than $\frac{1}{(\text{distance})^2}$

- Change in velocity of a object = acceleration → caused by force (mass of a object × acceleration)
- Inertia = resistance to change in velocity and is proportional to the mass of the object
- **Momentum** = quantity of motion associated with the moving object and is equal to mass times velocity
- Law of conservation of momentum = total momentum (mass × velocity) of an interaction is conserved → is the same before and after

When a peacock feather and a steel ball are dropped together − **air resistance** causes the feather to fall more slowly than a steel ball.

- Feather experiences a lot of air resistance.
- Steel ball experiences a very little air resistance.

minimum entropy (maximum order)

Solid → strong bonds

Liquid → weak bonds

maximum entropy (minimum order)

Gas → no bonds

The change from one state of matter to another is called a **phase transition**.

higher temperature → faster the motion of the gas atoms → more momentum the gas atoms possess

(hotter the gas atoms)

↓

more force exerted on the walls of the container

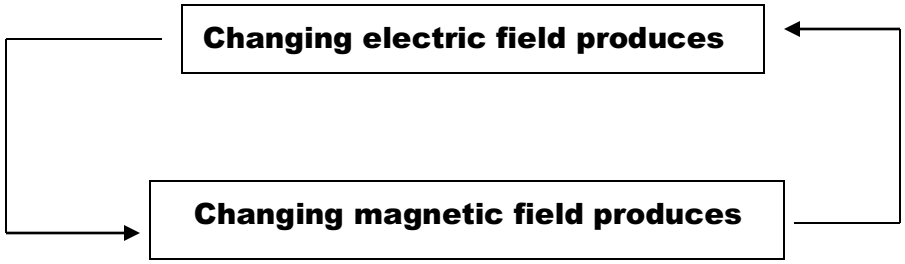
↓

higher pressure

- **macroscopic world** deals with concepts such as temperature, volume and pressure to describe matter.
- **microscopic world** deals with concepts such as position, velocity and mass to describe matter.

Because:

$$c = \frac{E}{B}$$



Electromagnetic wave = electric wave + magnetic wave

$$\text{Brightness} \propto \frac{1}{(\text{distance})^2}$$

The objects farther away are dimmer

- **Stefan-Boltzmann law:** the amount of energy emitted from a body increases with the fourth power of its absolute temperature.
- **Wien's law:** the peak of emission moves to bluer light as temperature increases
- The structure of our own bodies is determined by the **DNA molecule**. However, it has been theorized that protons within this molecule can experience **Quantum Tunneling** and therefore change our genetic makeup! These random genetic mutations caused by Tunneling may even be linked to the existence of Cancer, but more research is needed.

classical mechanics	**quantum mechanics**
objects exist in a specific place at a specific time	objects exist in a haze of probability

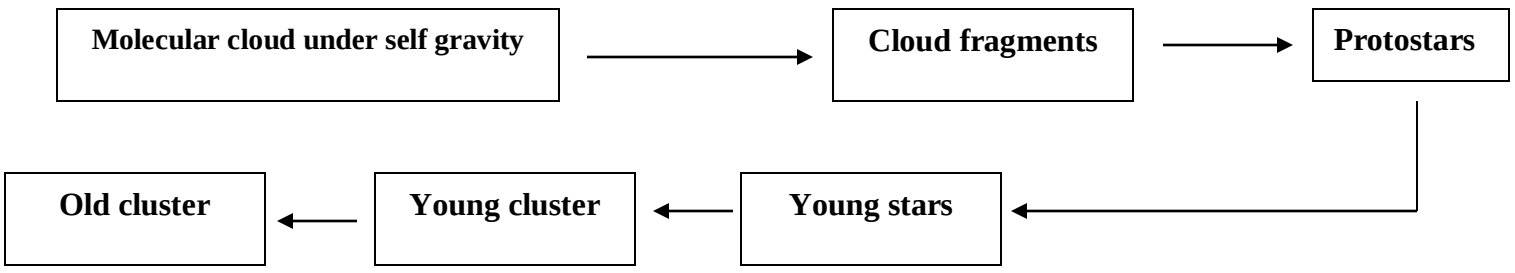
- Describes the motion of macroscopic objects such as spacecraft, planets, stars, and galaxies
- Failed to explain the phenomenon like **black body radiation**, photoelectric effect, the temperature dependence of heat capacity of the substance

Explains the behavior and nature of matter and energy on the atomic and subatomic level

Space is shorten in high velocity frames } **Lorentz contraction**

Massless bosons → moves at speed of light, long range

High mass bosons → moves at less than speed of light, short range



Distant galaxies are bluer since we are looking back in time, and are seeing them at a younger age:

younger stars → hotter stars → **bluer stars**

In expanding space, recession velocity keeps increasing with distance. Beyond a certain distance, known as the **Hubble distance**, it exceeds the speed of light. This is not a violation of Einsteinian relativity, because recession velocity is caused not by motion through space but by the expansion of space.

Big bang theory	Steady state theory
An expanding universe increases in actual volume with time – decreases in density	New matter is formed which pushes the galaxies apart while keeping the density of the universe constant

- According to **Quantum Mechanics**, reality does not exist when you are not looking at it. This means that the universe may not exist if there was no one born to observe it.
- According to the **No-Boundary proposal**, asking what came before the Big Bang is meaningless like asking what is south of the south pole, because there is no notion of the time available to refer to. The concept of time only exists within our universe.

High mass-to-luminosity ratio	most of the matter is in the form of dark matter
Low mass-to-luminosity ratio	most of the matter is in the form of baryonic matter, stars and stellar remnants plus gas

Massive neutrino	Exist but very low mass
Weakly interacting massive particles (WIMPS)	Little to no evidence of their existence
Cosmic strings	Little to no evidence of their existence

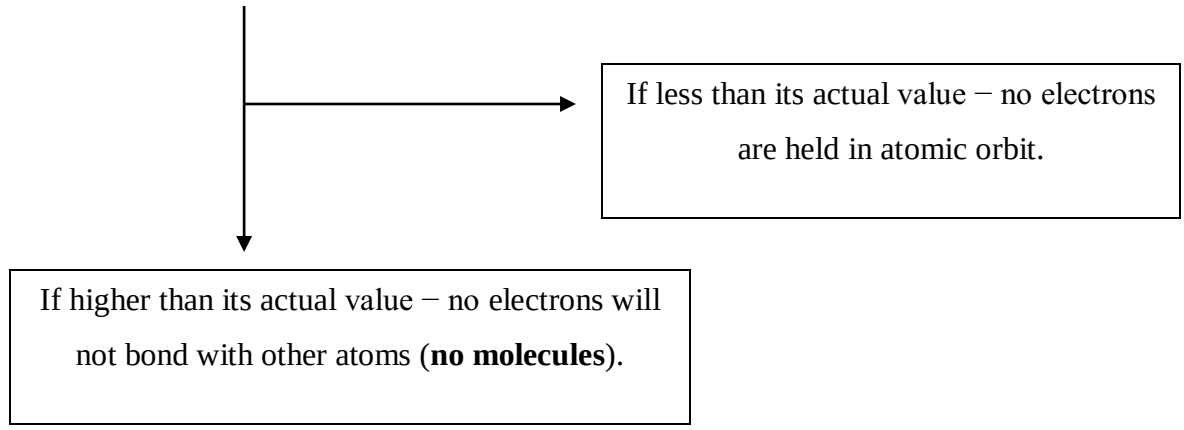
- Every particle will have a wave function from **quantum mechanics**, and every particle exerts a gravitational force. But when the particles are close enough so the wave functions of the particles overlap, the meaning of gravity breaks down.
- This is the "**law of everything else**". It underpins particle physics, and describes the theory that all forces between particles are carried out by other particles − that all forces basically are particles. It governs the way all matter interacts − from light entering your eye and electrons orbiting an atom, to the structure of DNA.
- **Carbon** (nonmetallic chemical element in the **Group 14 of the periodic table**) is the structural backbone of all the building blocks and material for life − including proteins and DNA.
- From **Albert Einsteinian special theory of relativity**, we know that the speed of light is a maximum transfer of information. So we have no information for timescales less than the **Planck length** divided by the speed of light.

gravitational constant	Determines strength of gravity
strong force coupling constant	Holds particles together in nucleus of atom
electromagnetic coupling constant	Determines strength of electromagnetic force that couples electrons to nucleus

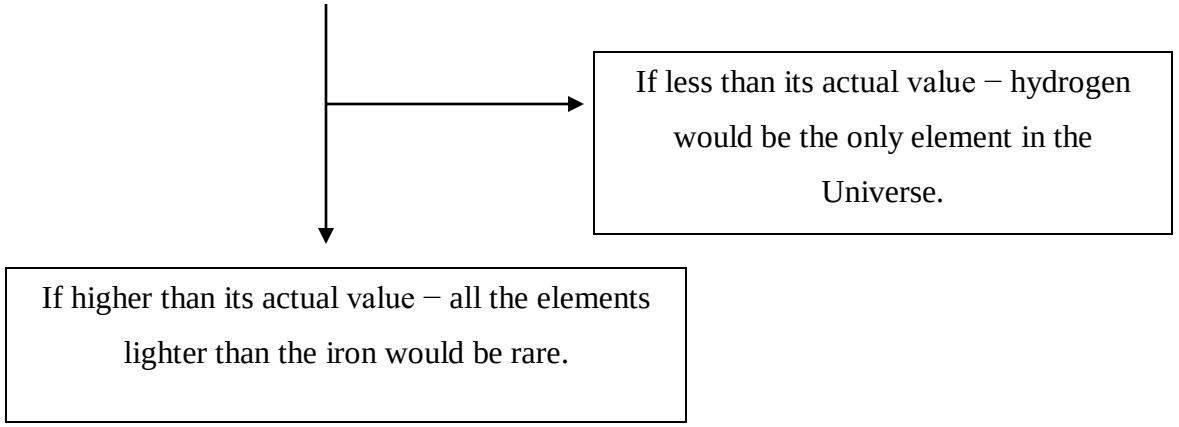
Multiverse (many universes)**:**

- Universe with life but no intelligence
- Universe with no atomic bonds
- Universe with weak gravity – no planets
- Universe with high gravity – all black holes
- Universe with no light
- Universe with strong weak force – too much radioactivity
- Universe with weak strong force – no nuclear fusion
- Universe with no matter
- **Universe with chemistry that builds and sustains intelligent life**

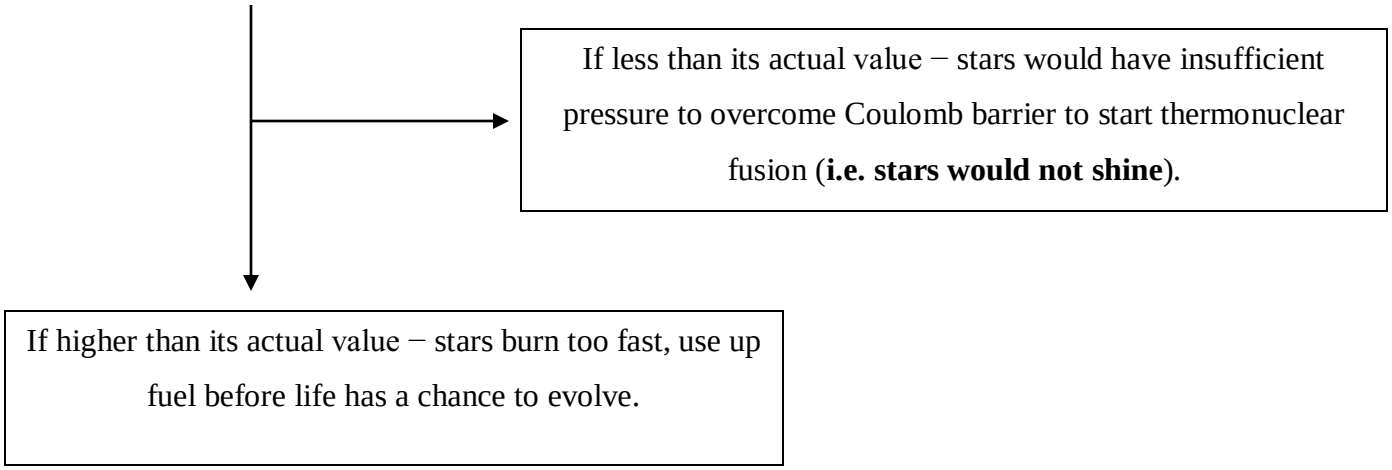
Electromagnetic coupling constant

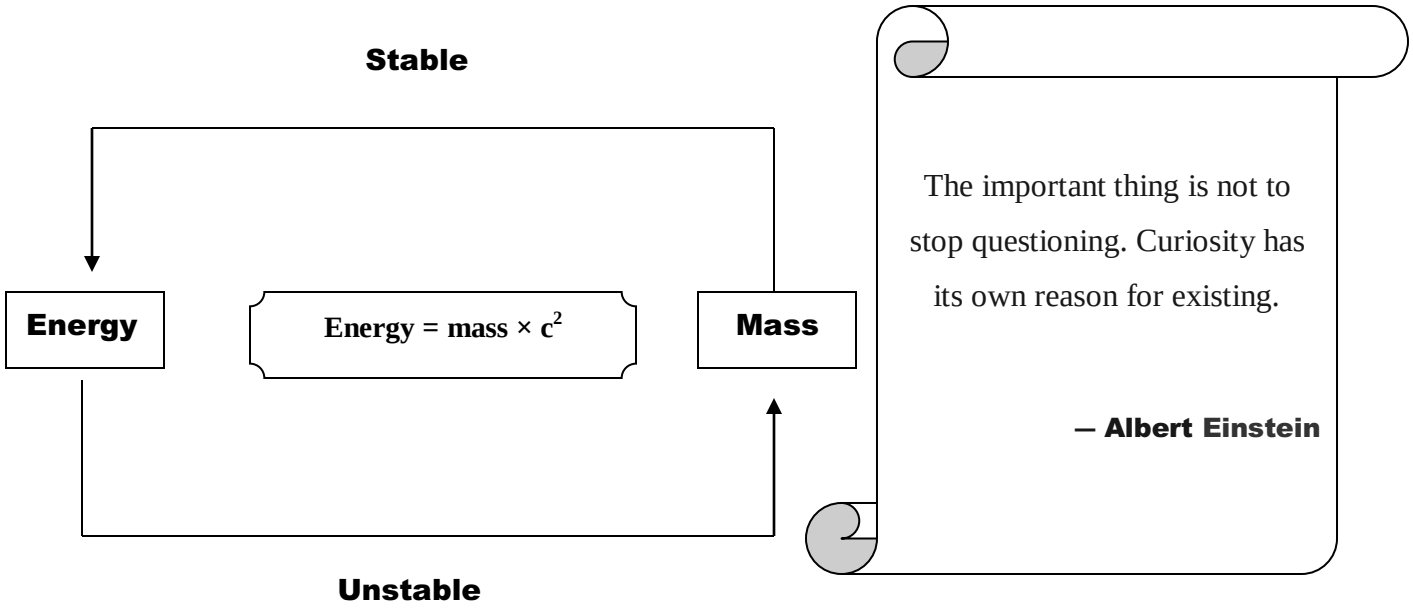


Strong force coupling constant



Gravitational constant





GUT Matter $\xrightarrow{\text{GUT symmetry breaking}}$ **Quark matter** $\xrightarrow{\text{Electroweak symmetry breaking}}$ **Quarks**

Each symmetry breaking produces a phase change and different forms of matter appear

- About 1 to 5% of matter in the Universe is made of baryons.
- Physicists have performed an experiment that shows how time emerges **from quantum entanglement**.
- If protons were **0.2% more massive**, then they would be unstable and decay into neutrons. That would put an end to life in the universe because there would be no **atoms**.

Quantum physics → reality changes with observation.

Quantum Bayesianism → reality is observation.

More order

Pure energy cosmos

Evolved to

with time

More disorder

(Energy + matter) cosmos

If the neutrino has mass, then it is a particle that moves with a velocity near − **but less than** − the speed of light.

$$v < c$$

If the neutrino is massless, then it acts like a **photon** and moves exactly at the speed of light since all massless particles always travel at the speed of light.

$$v = c$$

Earth's average distance to the Sun = 150 million kilometers

If much lesser than this value – oceans boil away, greenhouse effect kicks in.

If much higher than this value – temperature drops, rapid Glaciation.

CO_2 (gas) + H_2O (liquid) → **H_2CO_3 (carbonic acid)**

weathers the rocks on the Earth's surface − releasing ions of **calcium** (Ca^{2+}) and **bicarbonate** (HCO_3^-) into the oceans

Luminosity Class	Star
I	Supergiant
II	Bright Giant
III	Giant
IV	Subgiant
V	Dwarf (**Main Sequence**)
VI	Subdwarf

absorption	matter absorbs radiation
emission	matter releases radiation
scattering	matter and radiation exchange energy

Proton-Proton Chain:

$$\text{Energy production rate} \propto (\text{Core Temperature})^4$$

Carbon-Nitrogen-Oxygen (CNO**) Cycle:**

$$\text{Energy production rate} \propto (\text{Core Temperature})^{20}$$

Low mass stars
- radiative core
- convective envelope

High mass stars
- convective core
- radiative envelope

Depending on the **physical conditions around the Hydrogen atom in the star**, it can be either:

- neutral hydrogen (H)
- ionized hydrogen (H^+)
- molecular hydrogen (H_2)

Hydrogen is converted into helium, therefore the mean molecular weight μ increases in the core of the star.

$$\mu \text{ increases, so } P = \frac{\rho k_B T}{\mu m_H} \text{ drops.}$$

If Pressure drops, the core contracts and density rises.

Half of the gravitational energy released by contraction goes into heating up the star.

As the core heats up, energy generation rate increases with the fourth power of core temperature.

The star becomes more luminous

- The most expensive material in the World is Antimatter. It costs about $62.5 trillion for one gram.
- Just 17 grams of antimatter is sufficient enough to fuel a starship or a trip to Alpha Centauri which is 4.37 light years from the Sun. Sadly it would take 100 billion years to produce 1 gram of antihydrogen.
- **Neutrinos** are among the most abundant particles in the Universe, and yet are hard to detect. They're similar to electrons, but they have no electrical charge and their mass is almost zero, so they interact very little with normal matter as they stream through the Universe at near light-speed. Billions of neutrinos are zipping through our body right now. Hence, they are also called "**ghost particles**."

When the core is degenerate:

No temperature dependence!

$$\text{Electron degenerate pressure} = \frac{(3\pi^2)^{2/3}\hbar^2}{5m_e} \times (\text{number density of electrons})^{5/3}$$

so that when temperature rises, electron degenerate pressure does not.

- In **a low mass star** ($M < 8M_{sun}$): carbon burning cannot occur − temperature and density is too low.
- Iron won't undergo nuclear fusion reaction. The center of that iron core is squeezed down tightly and becomes degenerate − held up by **electron degeneracy pressure:** $\frac{(3\pi^2)^{2/3}\hbar^2}{5m_e} \times n_e{}^{5/3}$ − rather than gas pressure. But at the extremely high temperature in the core, the photons have enough energy to destroy nuclei:

$^{56}Fe + photon \rightarrow 13\ ^{4}He + 4\ neutrons$

$^{4}He + photon \rightarrow 2\ protons + 2\ neutrons$

This process is known as **photodisintegration**.

In the extreme conditions ($T \sim 8\times10^9$ Kelvin, $\rho \sim 10^{10}$ gm/cm^3), free electrons are captured by protons:

Protons + electrons → neutrinos + neutrons

For a non-relativistic degenerate gas:

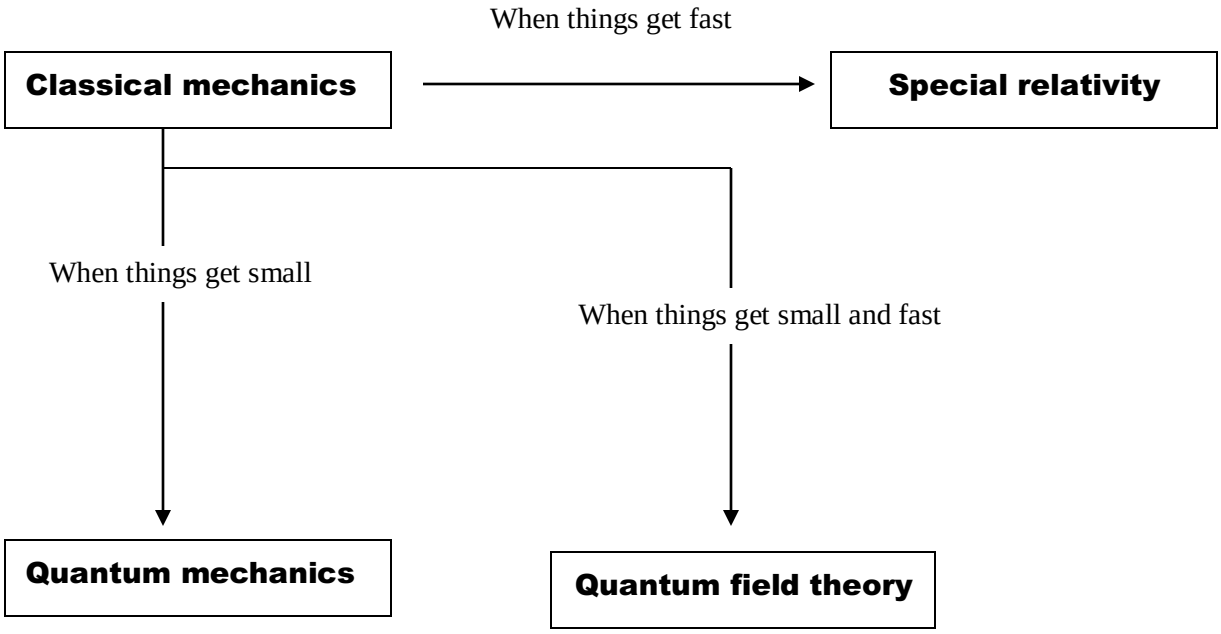
$$\text{Electron degenerate pressure} \propto (\text{number density of electrons})^{5/3}$$

For a relativistic degenerate gas:

$$\text{Electron degenerate pressure} \propto (\text{number density of electrons})^{4/3}$$

No two electrons can have the same energy level

Pauli Exclusion Principle

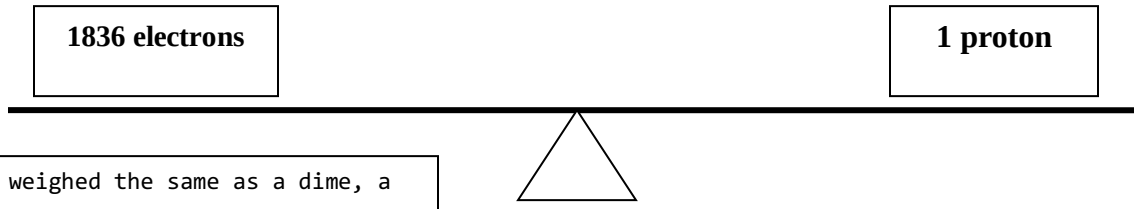


Of all objects, the planets are those which appear to us under the least varied aspect. We see how we may determine their forms, their distances, their bulk, and their motions, but we can never know anything of their chemical or mineralogical structure; and, much less, that of organized beings living on their surface.

Augustus Comte, 1840

variation + differential reproduction + heredity → **natural selection**

- The sun radiates as a 6000K blackbody in the optical range but can have a blackbody temperature of over 10^6K at radio frequencies.



If an electron weighed the same as a dime, a proton would weigh the same as a gallon of milk!

- There are over 100 different types of incredibly small building blocks of matter (**atoms**). Each one forms a different chemical element. These elements are listed in the **periodic table**.

Nuclear Fusion	Temperature
Hydrogen Fusion	15 Million ^{o}C
Helium Fusion	100 Million ^{o}C
Carbon Fusion	500 Million ^{o}C
Neon Decay	1.2 Billion ^{o}C
Oxygen Fusion	2 Billion ^{o}C
Silicon Decay	3 Billion ^{o}C
Only massive stars go beyond Helium Fusion	

- Most of us already know that darkness is the absence of light, and that light travels at the fastest speed possible for a physical object. So, what does this mean? In short, it means that, the moment that light leaves, darkness returns. In this respect, darkness has the same speed as light.

BIOLOGY TELLS US THAT WE ARE 7% BLOOD.

CHEMISTRY TELLS US THAT WE ARE 65% WATER.

PHYSICS TELLS US THAT WE ARE 99.99999999% EMPTY SPACE.

- If two pieces of the same type of metal touch in space, they will bond and be permanently stuck together. This amazing effect is called **cold welding**.
- There's a highway in Space called the **Interplanetary Superhighway**. It is used to send spacecraft around the solar system with least resistance using gravity.
- Both **photons and neutrinos** are created inside the core of the sun. While photons take tens of thousands of years to reach the edge of the sun, neutrinos just take 2.3 seconds.

- **Phosphorus** is a solid at room temperature but is self-igniting when in contact with oxygen. It becomes a liquid at 317 Kelvin.
- **Sulfur** is a solid at room temperature and becomes a liquid at 388 Kelvin.

For every action, there is an equal and opposite reaction

↓

Rockets eject material out the back at high speed to push the body of the rocket forward.

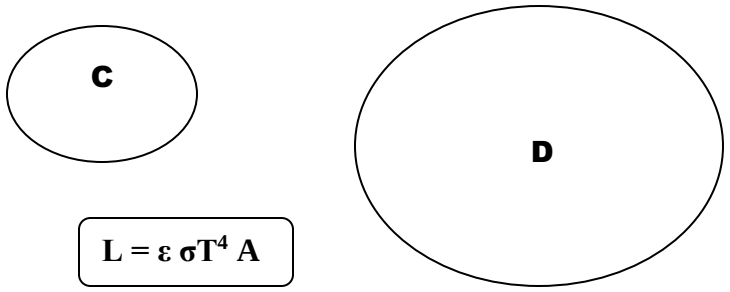
- Planets are common in the universe
- Earth like planets are likely to be common in the universe
- Life is likely on them
- Intelligence is a natural adaptation
- Many intelligent civilizations should exist….
- Where are they?

Fermi paradox

Solar luminosity will be

- 10% brighter in 1.1 Billion years
- 40% brighter in 3.5 Billion years
- 100% brighter in 4.5 Billion years

IN 1977, WE RECEIVED A SIGNAL FROM DEEP SPACE THAT LASTED 72 SECONDS. WE STILL DON'T KNOW HOW OR WHERE IT CAME FROM.



$$L = \varepsilon \sigma T^4 A$$

- Stars C and D have the same temperature.
- D is bigger than C **(D has greater surface area than C)**.
- D has greater intrinsic luminosity than C.

String Theory	Proposes higher dimensions at the atomic scale.
Black Hole cosmology	Every Black Hole has a Universe inside it.
Anthropic principle	Our Universe is a result of consciousness.
Occam's Razor	If our Universe can exist with so many constrains there might be other universes with relaxed constrains.

- Since there is no atmosphere in space, space is completely silent.
- In 3.75 billion years the Milky Way and Andromeda galaxies will collide.
- There is a volcano on Mars (**Olympus Mons**) three times the size of Mount Everest.
- It would take 450 million years for a modern spacecraft to reach the center of our galaxy.

Newton' s First law of motion	Inertia
Newton' s Second law of motion	Force
Newton' s Third law of motion	Action and reaction
Zeroth law of thermodynamics	Thermodynamic equilibrium and temperature
First law of thermodynamics	Work, heat and energy
Second law of thermodynamics	Entropy

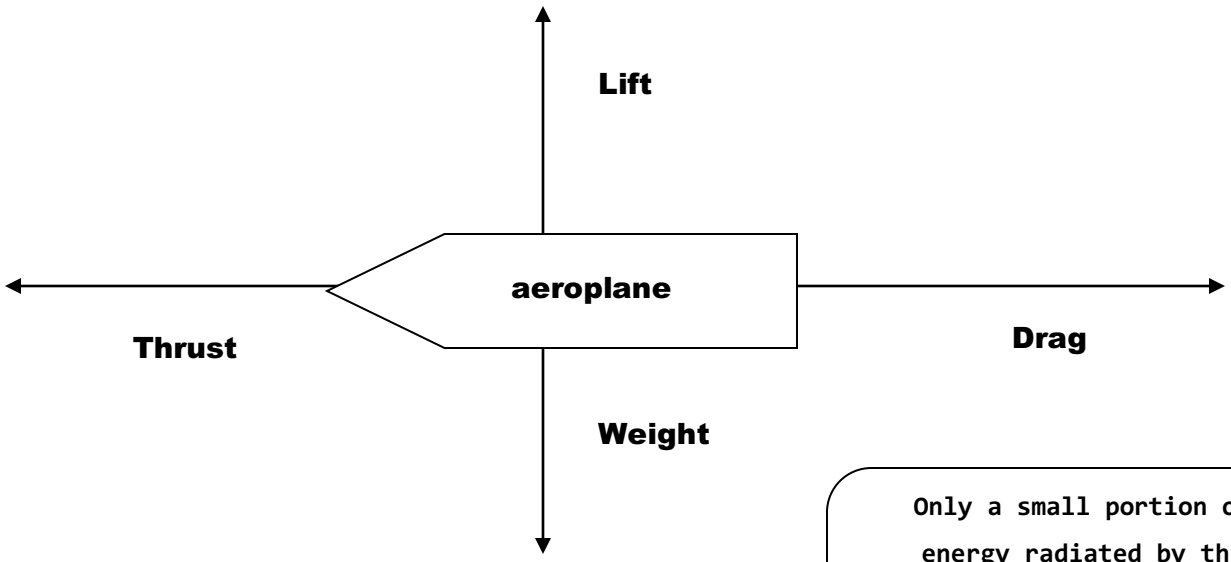
Viscosity → Stickiness

Compressibility → Springiness

Diffusion → random motion

Convection → ordered motion

- **Milky Way has two major spiral arms that start at the central bar of stars, and slowly taper off.** Our Solar system is located in one minor spiral arm called the Orion arm.
- Galaxies come in different sizes, but also different shapes.
- The first spiral galaxy we discovered, besides our own, is the **Whirlpool Galaxy** (M51).



Lift = weight

Thrust = drag

Only a small portion of the energy radiated by the sun into space strikes the planet Earth – one part in two billion.

Aeroplane moves in a straight line at constant air speed.

Interaction strength between Higgs boson and fermion ∝ fermion mass

- Most particles can only travel in the (**3 space + 1 time**) dimensions.
- Gravitons − the 2 spin bosons which propagate a force called **gravity** − can travel in the extra dimensions.
- The most luminous star visible to the naked eye − **34 Cygni** − outshines the Sun by 610,000 times.
- Jupiter could contain the other seven planets in just 70 percent of its volume.
- The process of falling into a black hole—getting more and more stretched out—is known as **Spaghettification**.

- The **moon** is the reason why we have tides and waves on Earth.
- The universe has no centre and is constantly expanding (**getting bigger**) every second – making it impossible to reach the edge.
- A **black hole** is created when big stars explode. Its gravitational force is so strong that nothing can escape from it – luckily the closest black hole is about **10,000 light-years** from Earth.

Schwarzschild radius of a black hole:

$$r_s = \frac{2GM}{c^2}$$

The distance **Large Hadron Collider** can probe:

$$R \approx \frac{\hbar c}{E} = \frac{196 \text{ MeV fm}}{2 \text{ TeV}} = 10^{-4} \text{ fm}$$

LHC can probe only **black holes** with radius $r_s > 10^{-4}$ fm.

→ decay very quickly (**lifetime ≈10^{-26} seconds**) via emission of thermal Hawking radiation.

Static Particle Properties:

- Mass and Charge
- Magnetic moment
- Spin and Parity

Lepton number = total number of leptons − total number of anti-leptons

Quark number = total number of quarks − total number of anti-quarks

John Michell – who first proposed the idea of massive bodies from which light cannot escape.

There might be a universe inside every black hole.

A black hole's formation looks a lot like the formation of the universe. In fact, they might be one and the same.

Noether's Theorem:

Every symmetry of nature has a conservation law associated with it and vice-versa.

Energy, Momentum and Angular Momentum	Conserved in all interactions
Charge	Conserved in all interactions
Lepton Number	Conserved in all interactions
Quark Flavor Number	• Conserved in strong and electromagnetic interactions • Violated in weak interactions

- **Quantum mechanics** describes momentum and energy in terms of operators:

$$p = -i\hbar\nabla \qquad E = i\hbar\frac{\partial}{\partial t}$$

Classical electromagnetism:	**Quantum Picture:**
Force between charged particles arise from the electric field	Force between charged particles arises from the exchange of virtual photons.

Quantum Electro Dynamics (QED) → quantum mechanical description of the electromagnetic force.

Quantum Chromodynamics (QCD) → quantum description of the strong force.

low photon energy (<100 keV)	Photoelectric effect
medium photon energy (~1 MeV)	Compton scattering
high photon energy (> 10 MeV)	Pair production in electric field of nucleus

- Photons no electric charge and gluons have colour charge.
- If we could squeeze the Earth down to the size of a wedding ring, it would become a black hole. We could even become a **black hole**, if we were squished down to the size of an atom.

	Atom	10^{-10} m
Nuclear Physics	Nucleus	10^{-14} m
	Protons and neutrons	10^{-15} m
Particle Physics	Quarks and electrons	10^{-18} m

- If we were to orbit a black hole in its photon sphere and look to one direction, we would see the back of our own head.
- Star orbiting the supermassive black hole at the center of the **Milky Way galaxy** moves just as predicted by **Albert Einstein's general theory of relativity**.
- The asteroid impact at **Chicxulub** ejected sulfur and carbon dioxide gases that cooled **Earth's average surface air temperature** by as much as 26°C. This event caused a **planetary mass extinction**, including that of non-avian dinosaurs.

Radioactive decay law:

$$-\frac{dN}{dt} = \frac{N}{\tau}$$

τ is the time taken for the number of radioactive atoms to reduce to $\frac{1}{e}$ of its initial value.

Decay width: $\Gamma = \frac{\hbar}{\tau}$

$$-\frac{dN}{dt} = \frac{\Gamma N}{\hbar} \Rightarrow N = N_0\, e^{-\frac{\Gamma t}{\hbar}}$$

If $N = \frac{N_0}{2}$:

$$\Gamma = \frac{0.693\hbar}{t_{1/2}} \Rightarrow \Gamma \propto \frac{1}{t_{1/2}}$$

Electron capture:

electron + proton → neutron + neutrino

electron + **X** (Z, N) → **X** (Z−1, N+1) + neutrino

- **Black holes** are smaller than we think. The radius of a typical black hole is only about 30 kilometers. If our sun were to shrink into a black hole, it would only have a radius of **3 kilometers**.

Suppose that the two masses are m_1 and m_2, and they are separated by a distance "r" orbiting each other in highly circular orbit about their center of mass. The **rate of loss of energy** from the binary system through gravitational radiation is given by:

$$P = -\frac{dE}{dt} = \frac{32G^4(m_1 m_2)^2}{5c^5}\,\frac{(m_1+m_2)}{r^5}$$

For the Earth-Sun system r is very large **(1.5×10^{11} m)** and m_1 **(2×10^{30} kg)** and m_2 **(6×10^{24} kg)** are relatively very small, yielding

$$P \approx 200 \text{ Joules per second}$$

Thus, the total power radiated by the Earth-Sun system in the form of **gravitational radiation** is truly tiny compared to the **total electromagnetic radiation** given off by the Sun − which is about 3.86×10^{26} Joules per second.

The gravitational wave signal was observed by LIGO detectors in Hanford and in Livingston on **14 September 2015**. An exact analysis of the gravitational wave signal based on the **Albert Einsteinian theory of general relativity** showed that it came from two merging stellar black holes with 29 and 36 solar masses, which merged 1.3 billion light years from Earth. Before the merger, the total mass of both black holes was 36 + 29 solar masses = **65 solar masses**. After the merger, the mass of resultant black hole was 62 solar masses.

What happened to three solar masses?

It was turned into the energy transported by the emitted gravitational waves. Using **Albert Einstein's equation** $E = mc^2$, where E is the energy transported by the emitted gravitational waves, m is the missing mass (**3 solar masses**) and c is the speed of light, we can estimate the energy released as gravitational waves:

$$E = (3 \times 2 \times 10^{30}\ \text{kg}) \times (3 \times 10^{8}\ \text{m/s})^{2}$$

$$E = 5.4 \times 10^{47}\ \text{J}$$

This is roughly 10^{21} more energy than the complete electromagnetic radiation emitted by our sun.

$$\upsilon = \frac{E}{h} = \frac{5.4 \times 10^{47}}{6.626 \times 10^{-34}} = 8.14 \times 10^{80}\ \text{s}^{-1}$$

Inertial frame → one in rest or uniform motion

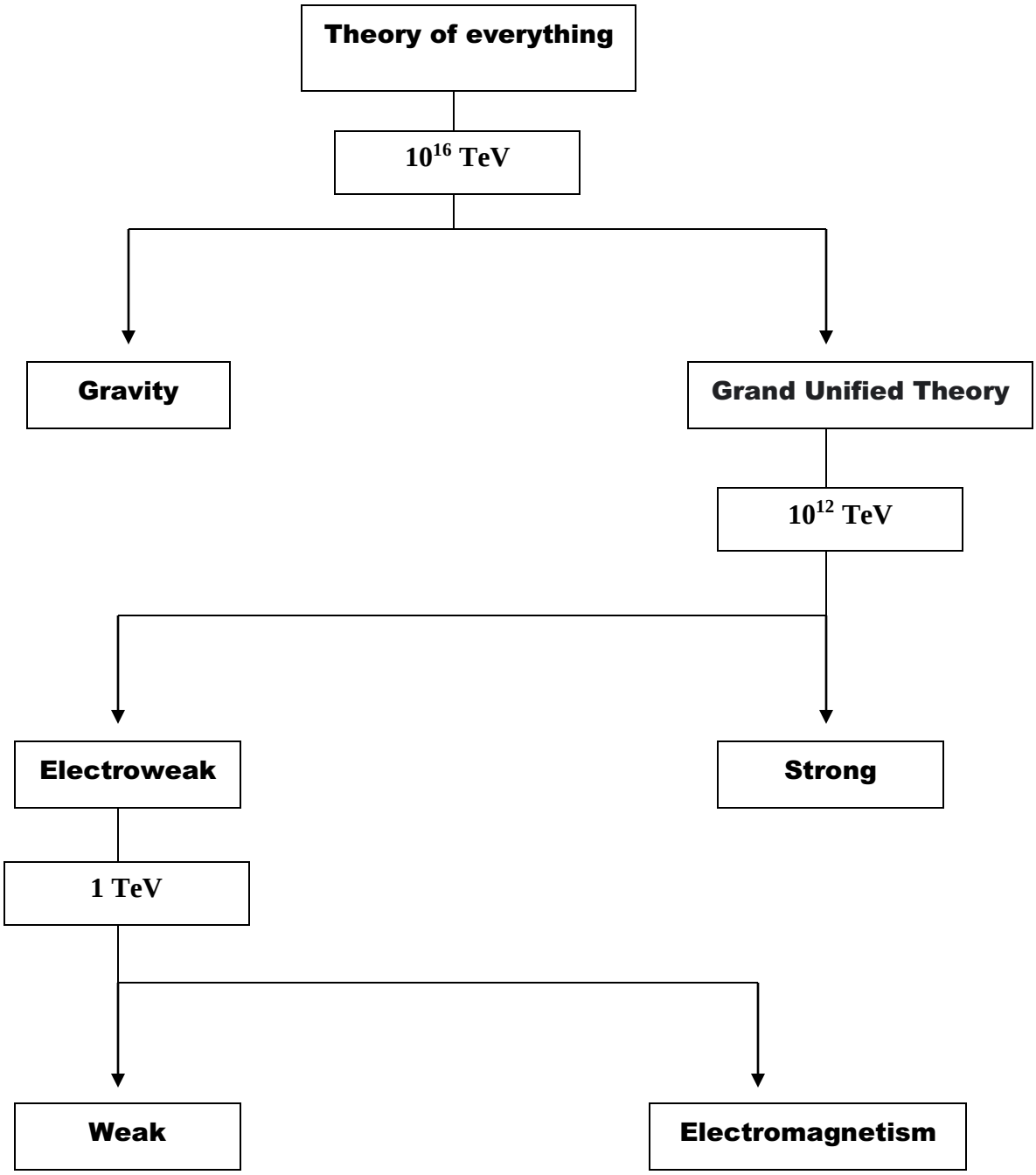
Special relativity

- mixes up space and time coordinates → **spacetime**
- moving clocks tick more slowly
- moving object appears shorter
- all inertial observers see same speed of light c
- spacetime interval $ds^2 = c^2dt^2 – dx^2 – dy^2 – dz^2$ same for all inertial observers
- physical laws are same for all inertial observers

General relativity

- Light bends in gravitational field
- Spacetime is curved by gravity

- **Hot dark matter candidate:** neutrino with mass ~ 2 eV/c^2
- **Cold dark matter candidate:** Weakly interacting massive particle with mass ~100 GeV/c^2
- In 1915, **Einstein's theory of general relativity** predicted the existence of Black Holes first.
- About 10^{40} years from now, matter in the Universe will be present only in the form of **black holes** and subatomic particles separated by huge distances.
- If you could produce a **sound louder than 1100dB**, you would create a black hole and ultimately destroy the galaxy.



Magnetar − one of the most powerful objects in the Cosmos. The biggest spinning magnet to ever exist. It's the cosmic equivalent of a great **white shark**. But it wouldn't eat us, it would just turn all our atoms to dust!

Why haven't we met Extraterrestrial beings?

- We are the only intelligent life in the Cosmos.
- Other Intelligent Extraterrestrial beings died in mass extinction events. We might even be the next!
- Other Extraterrestrial beings are too intelligent and we are simply not worth their time.
- Life first began on planet Earth. We are the most advanced beings.
- They are too far and out of our reach.

Extinction = Absorption + Scattering

Object	M	Schwarzschild radius = $\frac{2GM}{c^2}$
Earth	5.98×10^{27} g	0.9 cm
Sun	1.989×10^{33} g	2.9 km
5 Solar Mass Star	9.945×10^{33} g	15 km
Galactic Core	10^9 Solar Masses	3×10^9 km

- Main sequence stars with M < 0.5 **Solar mass** end up as **Helium white dwarfs**.
- Main sequence stars with M < 0.5 to 5 **Solar mass** end up as **carbon-oxygen white dwarfs**.
- Main sequence stars with M < 5 to 7 **Solar mass** end up as **oxygen-neon-magnesium white dwarfs**.

- **5.88 trillion miles are equal to one light year.**
- **The volume of Jupiter is 1,300 times greater than that of Earth.**
- **There are 285 Galaxies for every Person on Earth**
- **The Observable Universe has a Diameter of 93 Billion Light Years.**
- **Ninety percent of the Sun's light is reflected by Enceladus, one of Saturn's smaller moons.**

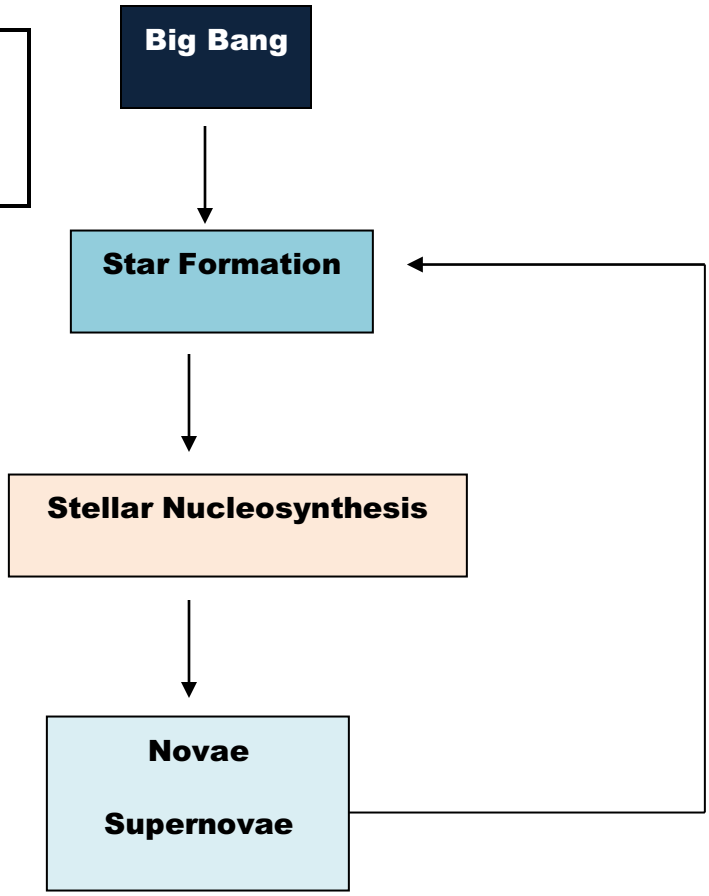
- Black holes are black. So is space. The EHT will image the "**shadow**" of the black hole's event horizon (**the point where light can no longer escape**), which should be visible against the glowing superheated material falling headlong into the black hole.
- A black hole 35,000 light-years from Earth is spinning more than 950 times per second.

CHUNKS OF GALAXY ARE BEING PULLED AWAY INTO COMPLETE DARKNESS IN A PHENOMENON KNOWN AS **'DARK FLOW'**

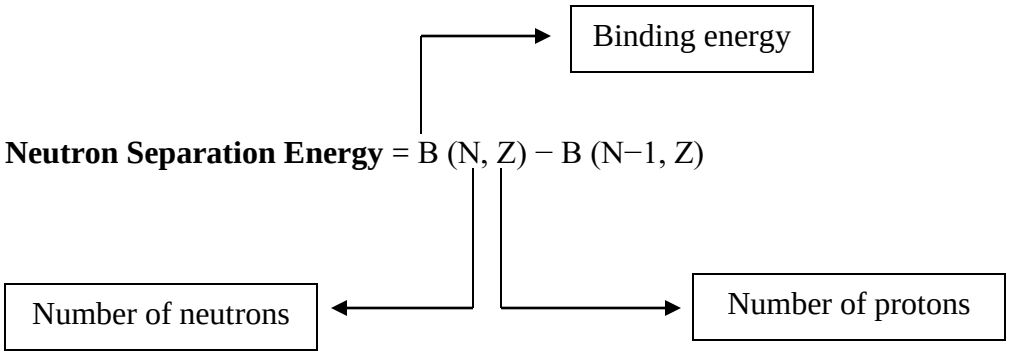
- **Age of Universe:** 13.7 Gyr
- **Age of Solar System:** 4.5 Gyr

There is no wind on the Moon; therefore any footprints you leave behind won't vanish.

Any fluid that is moving freely in outer space will compress itself into a sphere.



Slow neutron capture	Rapid neutron capture
There is sufficient time for the radioactive decay to occur before another neutron is captured	**There is no sufficient time** for the radioactive decay to occur before another neutron is captured



Two Neutrons Separation Energy = B (N, Z) − B (N−2, Z)

Proton Separation Energy = B (N, Z) − B (N, Z−1)

Two Protons Separation Energy = B (N, Z) − B (N, Z−2)

Like electromagnetic radiation:

- Gravitational radiation is characterized by a wavelength λ and a frequency υ
- Gravitational radiation travel at the speed of light, where $c = \lambda \times \upsilon$
- Gravitational radiation come in **two polarization states** (called + **[plus]** and × **[cross]**)

Hydrodynamic time = $\sqrt{\frac{R^3}{GM}}$

Time required for the star to collapse if its internal pressure were suddenly set to zero.

Big bang nucleosynthesis: Hydrogen, Helium, Deuterium, no elements heavier than Lithium

- If reaction products have larger binding energy than reactants, reaction is **exothermic** and releases energy (**heat**)

- A **meteor shower** is a phenomenon in which many meteors fall through the atmosphere in a short period of time.
- **Meteorites** are the rocks that survive the fiery descent through Earth's atmosphere.

bound-free absorption	The absorption of light during ionization of a bound electron
free-free absorption	The absorption of light when scattering a free ion

Kramer's opacity $\propto \text{density} \times (\text{temperature})^{-3.5}$

→ **Opacity of Solar Composition Material**

Beta decay	neutron → proton + electron + antineutrino
Electron capture	electron + proton → neutron + neutrino
Positron capture	positron + neutron → proton + antineutrino
Neutrino capture on nuclei	neutrino + **X (Z, N) → X (Z+1, N−1)** + electron
Antineutrino capture on nuclei	antineutrino + **X (Z, N) → X (Z−1, N+1)** + positron

A star at a distance of **one parsec** (1 pc) will have a parallax angle of **one arcsec** (1″)

In thermal equilibrium, the emissivity of a body is equal to its absorptivity.

Kirchhoff's law of thermal radiation

- **Internal Energy:** U
- **Enthalpy:** H = U + PV
- **Helmholtz Free Energy:** F = U – TS
- **Gibbs Free Energy:** G = H – TS

For radiation:

$$u_{radiation} = aT^4 \qquad P_{radiation} = \frac{aT^4}{3}$$

For ideal gas:

$$u_{gas} = \frac{3}{2} n k_B T \qquad P_{gas} = n k_B T$$

Coulomb Barrier:

$$E_{Coul} = \frac{e^2}{4\pi\varepsilon_0 r}$$

→ Distance of separation between two nuclei

→ Energy required to overcome **Coulombic repulsion** and bring two hydrogen nuclei into contact

- Nuclear forces dominate for $r < 1.44 \times 10^{-13}$cm
- **Coulombic repulsion** dominate for $r > 1.44 \times 10^{-13}$cm

Sometimes comets are referred to as "**dirty snowballs**" or "**cosmic snowballs**". This is because they are composed mostly of ice, rock, gas and dust.

Carbon-Nitrogen-Oxygen Cycle

Dominant mechanism for Hydrogen fusion reaction in stars with mass > 1.3 solar mass

Relativity	Quantum mechanics
$E = \sqrt{p^2c^2 + m_0^2c^4}$	$i\hbar\frac{\partial\Psi}{\partial t} = \sqrt{-\hbar^2\nabla^2c^2 + m_0^2c^4}\,\Psi$

At **core temperature** → 10^8Kelvin,

Helium burning begins by **triple alpha process**:

$$^4He + {}^4He \rightarrow {}^8Be + \text{energy}$$

$$^8Be + {}^4He \rightarrow {}^{12}C + \text{energy}$$

Some scientists believe it is possible that there is more water under the crust of the Earth than there is in all of the rivers, lakes, and oceans on the surface.

- In high mass stars (Mass >2 to 3 Solar mass), He burning begins gradually.
- In low mass stars, He burning is explosive resulting in a **Helium flash**.

For solar mass stars:

During Helium core burning:

Stars become smaller and hotter but luminosity ≈ constant

- 60 % of Earth's Population Lives on 30% of Earth's Landmass
- **Earth's Tilt** − The Reason For Change In The Seasons

- **For low mass stars**, temperature never reaches that required for Carbon burning

Thermonuclear reactions

Quiescent processes

(Hydrostatic equilibrium)

Temperature ~ 10^6 to 10^8 Kelvin

Unstable Nuclei do not play significant role

Explosive burning

Temperature > 10^8 Kelvin

Unstable nuclei govern nuclear reactions

Non-resonance Raman scattering

Occurs

When the radiation interacts with a molecule resulting in polarization of the molecule's electrons

- There are 45 miles of nerves in the body.

- **Number of bones in arms** → 6
- Number of bones in human foot →33
- **Number of bones in each wrist** → 8
- Number of bones in hand → 27
- **Number of bones in each human ear** → 3

For a system of 3 particles:

Velocity of the center of mass of 3 particles	$v_{CM} = \frac{m_1 v_1 + m_2 v_2 + m_3 v_3}{m_1 + m_2 + m_3}$
Acceleration of the center of mass of 3 particles	$a_{CM} = \frac{m_1 a_1 + m_2 a_2 + m_3 a_3}{m_1 + m_2 + m_3}$ $a_{CM} = \frac{F_1 + F_2 + F_3}{m_1 + m_2 + m_3}$

The amount by which Earth's orbital path deviates from the shape of a circle.

The aphelion distance = semimajor axis × (1+ **eccentricity**)

The perihelion distance = semimajor axis × (1− eccentricity)

eccentricity = 0	circular orbit
eccentricity > 0 and < 1	elliptic orbit
eccentricity = 1	parabolic escape orbit
eccentricity > 1	hyperbola

- Human fingers can detect **nano-size objects**. This means we not only have the ability to feel a tiny bump the size of a large molecule, but if our finger was the size of Earth, we could determine the difference between a house and a car.
- The human brain (when awake) produces enough electricity to power a 40 watt light bulb for 24 hours.
- **Biology** is the only branch of science in which multiplication means the same thing as division.
- Even though our brain is only about 2% of our body's weight, about 3 pounds, it uses 20-30% of the calories we consume.

In 1933: **Fritz Zwicky** claimed the existence of "**dark matter**" based on observed speeds of cluster galaxies

Stars form from gas in galaxies

↓

Interstellar medium

- Hot ionized gas (<15%)
- Neutral atomic gas (≈ 65%)
- Cold molecular gas (≈ 20%)
- Dust (<5%)

curvature parameter > 0	The total energy is negative and the universe is bounded or closed. The expansion will someday halt and reverse itself
curvature parameter < 0	The total energy is positive, and the universe is unbounded or open. The expansion will continue forever (but at a decreasing rate)
curvature parameter = 0	The total energy is zero and the universe is flat. The expansion will continue at a decreasing rate and will come to a halt as time goes to infinity.

- An average human produces enough saliva in a lifetime to fill two swimming pools.
- The name virus was coined from the Latin word meaning slimy liquid or poison.
- When **eyelashes are disturbed**, the nerve at its bases initiates reflex action to close the eyelids.
- The acid in our stomach is strong enough to dissolve **razor blades**.

EVERY NUCLEUS IN THE HUMAN BODY HAS DNA OF 6 FEET LONG.

- A piece of brain tissue **the size of a grain of sand** contains 100,000 neurons and 1 billion synapses, all "talking" to one another.

positron: like an electron, but with positive charge

neutrino: very light, hard-to-detect particle

1 MeV = 1.6021917 × 10^{-6} erg

- Honey is the only food that doesn't rot. A **Honey pot** can remain edible for more than 3000 years.
- A **chicken egg** is one giant cell. One chicken egg is about **1000 times larger** than the average cell in your body.
- **Butterflies** taste something not with their mouth but with their feet.
- The average human body contains 10 times more bacterial cells than human cells.
- The **number of bacteria** in a **person's mouth** is equal to the number of people living on earth, or even more.
- More than 100000 chemical reactions occur every second in our brain.

A NEW BORN CHILD RESPIRES 32/MIN

A FIVE YEAR OLD CHILD RESPIRES 26/MIN

A FIFTY YEAR OLD MAN RESPIRES 18/MIN

- If even a Small amount of Liquor is put on a **Scorpion**, it will go mad and Sting itself.
- If we pour cold water into a person's ear, his eyes will move in direction of the opposite ear. If we pour warm water into his ear, his eyes will move towards that ear. This is used to test for brain damage and is called **'Caloric Stimulation.'**
- In 2015, scientists sent flatworms to the **International Space Station** for five weeks, to see how space affected their growth. One of the worms grew a second head. Scientists

later amputated the heads, and both of them grew back, showing that space had permanently changed the worm.

- The longest bone in an **adult human** is the thighbone, measuring about **18 inches** (46 cm). The shortest bone is in the ear and is just **0.1 inches** (0.25 cm) long, which is shorter than a grain of rice.

(number of electrons = number of protons) in universe

Just what it should be if total electrical charge of the universe is zero.

Nearest star: 4.22 light-years

Nearest galaxy: 2.44 million light years

Galaxies within our horizon are now **40 billion light-years** away

Universe beyond horizon: 10 to the 10 to the 100 times bigger

Universe is 13.7 billion years old

Planet Earth is 4.5 billion years old

Modern humans are 150 thousand years old

Helium has two protons, two neutrons and two electrons. Together, helium and hydrogen make up 99.9 percent of known matter in the universe

Rare Earth hypothesis

↓

Complex extraterrestrial life is improbable and extremely rare.

Abiogenesis

↓

Life arose from nonlife more than 3.5 billion years ago on Earth.

Biogenesis

↓

Life is derived from the reproduction of other life.

- A person's feet has about 500,000 sweat glands and can produce about a pint of sweat a day.

There are more than a trillion life forms living on our skin.

Today there are eight billion people living on the planet earth.

In other words, there are 100 times more life forms living on our skin than the number of humans living on the planet!

- Only one letter doesn't appear in the **periodic table**. It's the letter **J**.
- If a human being's DNA were uncoiled, it would stretch 10 billion miles, from Earth to Pluto and back.
- **Lithium** is the most reactive metal in the entire periodic table.
- The taste cells in our taste buds live for only about two weeks.
- There are **90 elements** on the periodic table that occur in nature. All of other elements are artificially synthesized in laboratory.

Nuclides with the same mass number were termed isobars.

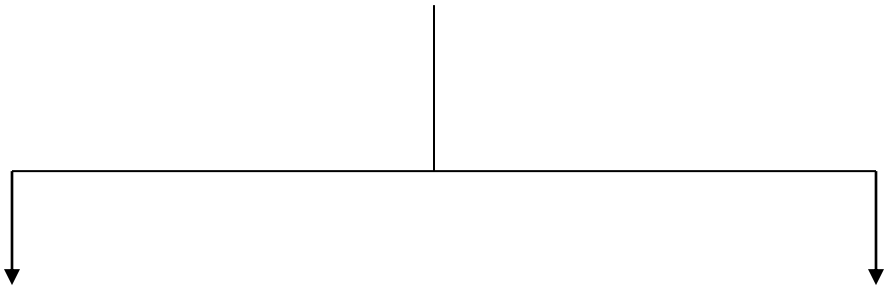
Nuclides with the same atomic number were termed isotopes.

Nuclides with the same neutron number were termed isotones.

- **One ampere** = one coulomb of electrical charge (**$6.24150974 \times 10^{18}$ electrons**) moving through a specific point in one second.

Solar wind

(Stream of **electrons and protons** with energies usually between 1.5 and 10 keV ejected from the upper atmosphere of the Sun)



Slow solar wind

- velocity ≈ 400 km/s
- number density ≈ 10 cm^{-3}
- electron temperature ≈ 1.3×10^5 K
- proton temperature ≈ 4×10^4 K

Fast solar wind

- velocity ≈ 750 km/s
- number density ≈ 3 cm^{-3}
- electron temperature ≈ 1×10^5 K
- proton temperature ≈ 2×10^5 K

A chargon possesses the charge of an electron without a spin.

A spinon possesses the spin of an electron without charge.

Geomorphology

The study of landforms, their classification, origin, development and history

Neutron energy

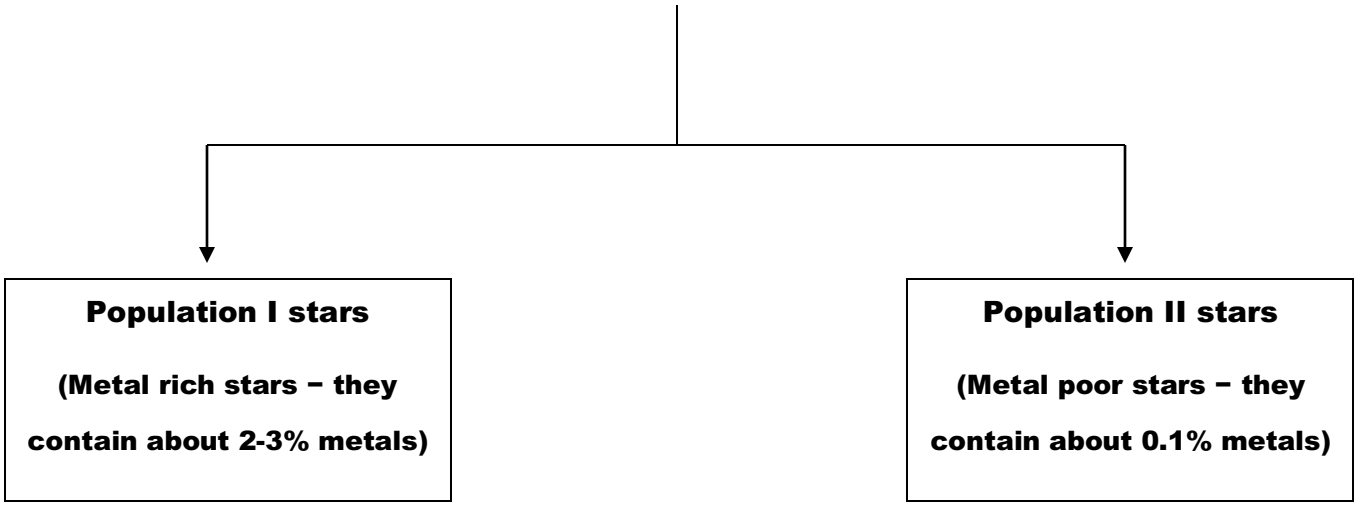
0.0 – 0.025 eV	**Cold neutrons**
0.025 eV	**Thermal neutrons**
0.025 – 0.4 eV	**Epithermal neutrons**
0.4 – 0.5 eV	**Cadmium neutrons**
0.5 – 1 eV	**EpiCadmium neutrons**
1 – 10 eV	**Slow neutrons**
10 – 300 eV	**Resonance neutrons**
300 eV – 1 MeV	**Intermediate neutrons**
1 – 20 MeV	**Fast neutrons**
> 20 MeV	**Ultrafast neutrons**

- Exosphere
- Thermosphere (**Aurora's occur**)
- Mesosphere (**Meteors burn**)
- Stratosphere (**Ozone layer is present**)
- Troposphere (**Weather occurs**)

5 Layers of Atmosphere

- Helps retain the **sun's heat** and prevents it from escaping back into space.
- Protects life from harmful radiation from the sun.

Stellar Populations



The pressure inside a star is the sum of the gas pressure and radiation pressure:

$$P = P_{radiation} + P_{gas} = \mathbf{P_{radiation} + P_{ion} + P_{electron}}$$

The **fraction of the pressure contributed by the gas** is customarily expressed as β, i.e.

$$P_{gas} = \beta P$$

$$P_{radiation} = (1 - \beta) P$$

- A photon may turn into an electron-positron pair if its energy hυ exceeds the rest-mass energy of the pair ($h\upsilon > 2m_e c^2$).

core contraction ⇒ envelope expansion **(star expands)**

core expansion ⇒ envelope contraction **(star shrinks)**

Mirror principle

$$\textbf{Force of gravity} \propto \frac{1}{(\text{distance between the centers of the particles})^2}$$

If we double the distance between two particles, the gravitational force between them drops to one-quarter of its previous strength

- Our Sun has a mass of approximately 2,000,000,000,000,000,000,000,000,000,000 kilograms, there are about 300,000,000,000 stars in our Milky Way galaxy, and there are between 50,000,000,000 and 1,000,000,000,000 galaxies in the observable Universe.

- The projectile fired with speed $< \sqrt{\frac{GM}{R}}$ (**circular-orbit speed**) is pulled to the Earth's surface after some distance by Earth's gravity.
- The projectile fired with speed $= \sqrt{\frac{GM}{R}}$ (**circular-orbit speed**) makes a perfect circle around the center of the Earth.
- The projectile fired with speed $\geq \sqrt{\frac{2GM}{R}}$ (**escape speed)** will still follow the curved path – but that curved path will be a parabola (**meaning that a projectile on a parabolic trajectory never returns to its starting point**).

$$v_{escape} = \sqrt{\frac{2GM}{R}}$$

Even if two different spheres have the **same mass**, the escape speed from their surfaces will be different if the two spheres have different radii.

The atmosphere in Titan, Saturn's Moon, is so thick and the gravity so low, that humans could fly through it by flapping "wings" attached to their arms.

Speed of light

If less than its actual value − stars would not be luminous enough

If higher than its actual value − stars would be too luminous

If the Earth's crust were significantly thicker, plate tectonic recycling could not take place.

Earth mass and size

If smaller than its actual value − its magnetic field would be weaker, allowing the solar wind to strip away our atmosphere held in place by the earth's gravity, slowly transforming our planet into a dead, barren world much like planet Mars.

- The sky always appears dark on the moon because it doesn't have an atmosphere. On Earth, the sky is blue because molecules in the air scatter blue light from the sun.
- In some cases lightning can go upward into space. It was spotted near the island of **Naru in the Pacific Ocean**.
- The number of exoplanets identified today soared past 1,000. Of these, 12 could be habitable to life as we know it.
- The octopus is **incredibly intelligent life form**. It is the only invertebrate that is capable of **emotion**, empathy, **cognitive function**, self-awareness, **personality**, and even relationships with humans. Some speculate that, without humans, octopi would eventually take our place as the dominate life form on Earth.

- Mars atmosphere is filled with 96% of CO_2 and just 2% O_2
- Satellites can travel at **18000 miles per hour** that means that in a day a satellite can go around the earth 14 times. There are over 2500 satellites orbiting earth at this moment.
- When we see a halo around the sun, or moon, it means that rain or storm is coming.
- When **magnetic ferrofluid** comes in contact with a magnetic object, it becomes a moving sculpture that reflects the shape of the object's magnetic field.

For massive stars:

$$\text{Luminosity} \propto (\text{mass})^4$$

$$\text{Luminosity} = \text{solar luminosity} \times \frac{(\text{mass})^4}{(\text{solar mass})^4}$$

while for less massive stars:

$$\text{Luminosity} \propto (\text{mass})^3$$

$$\text{Luminosity} = \text{solar luminosity} \times \frac{(\text{mass})^3}{(\text{solar mass})^3}$$

The wavelength corresponding to the value of λ_{max} decides the color of the star and one can calculate effective surface temperature $T_{surface}$ using **Wien's displacement law**: $\lambda_{max} \times T_{surface} = 2.897 \times 10^{-3}$ mK. For example: effective surface temperature of the sun is 5800K, this corresponds to $\lambda_{max} \approx 5500$ Angstrom. Hence, the sun appears **yellow** in color.

In comparison to our oceans, we know more about Mars and our Moon.

There are at least 2,000 thunderstorms occurring on Earth at any given time.

Saturn's rings could be circled in 258 days if you were moving at a speed of 75 mph.

- **In 1885, the first Supernovae was discovered outside of our galaxy.**
- **The first commercial soft drink ever consumed in space was Coca-Cola.**
- **The first woman to travel into space was a Soviet cosmonaut named Valentina Vladimirovna Tereshkova.**
- **In the past, Uranus was referred to as "George's Star" in tribute to King George III.**
- **The first living mammal to travel to space was a Russian dog named "Laika."**

Low mass red dwarf stars can keep burning for up to 10 trillion years!

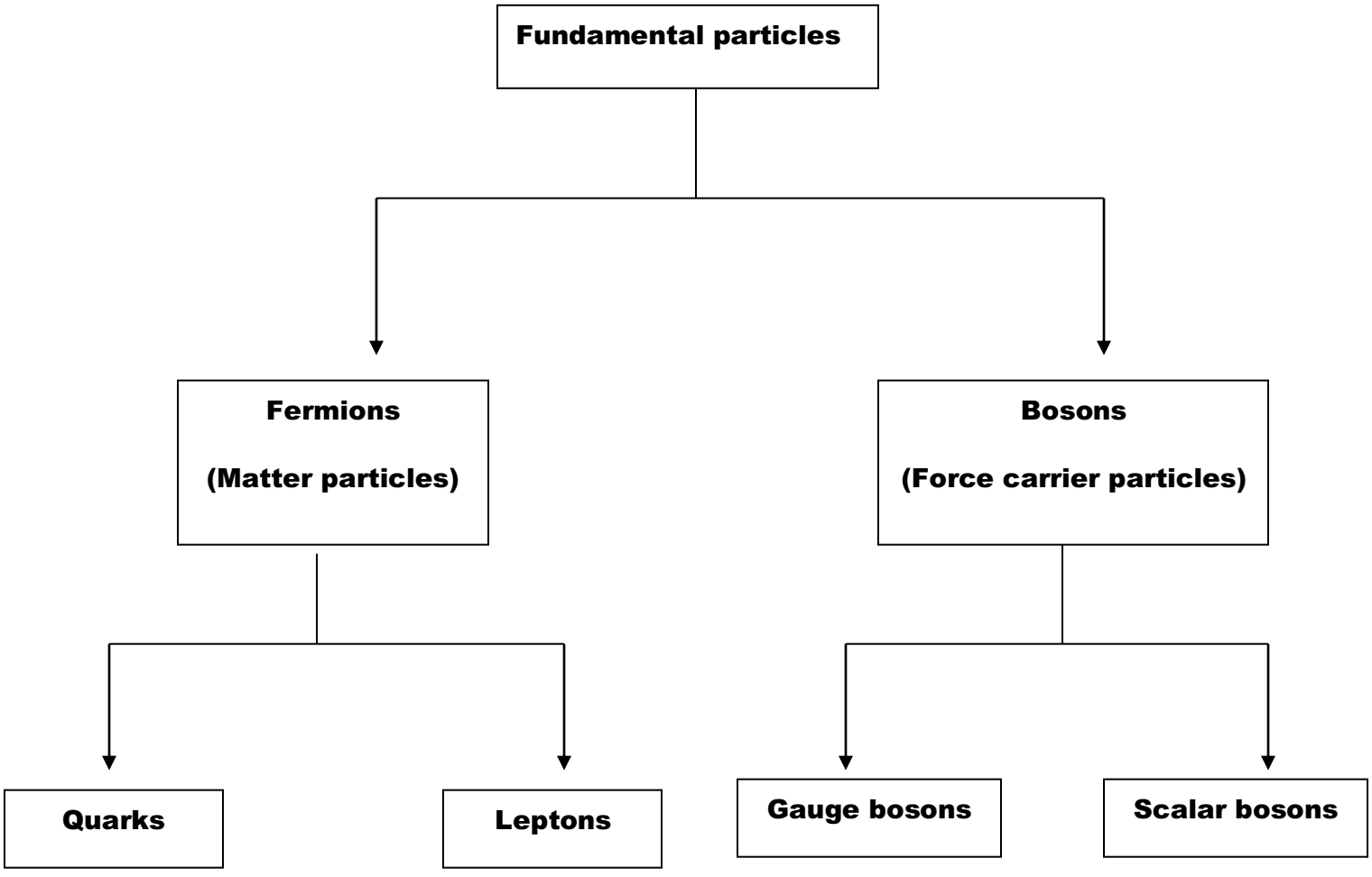
On July 26, 2061, Halley's Comet will again fly by Earth.

No other human has spent as much time in space as Gennady Padalka.

When we hold a normal pen in our hand with the nib facing downward, gravity draws the ink towards the nib. The ink is not drawn to the nib since there is no gravity in space. However, special pens that function in zero gravity have been developed.

In our solar system, Mars is the planet that has the highest likelihood of supporting life besides Earth.

- On average, gravity on a neutron star is 2 billion times stronger than gravity on Earth. In fact, it's strong enough to significantly bend radiation from the star in a process known as **gravitational lensing**, allowing astronomers to see some of the back side of the star.
- The word atom means undivided.
- According to **linear density model**, age of our sun is around 10 million years. But geologists have the proof that age of some of the rocks on the earth is greater than above mentioned value. Hence, our earth existed even before the birth of the sun – which is absolutely has no sense. Hence, **gravitational potential energy** cannot account for the age of stars.
- The **boiling point** is the temperature at which a substance changes from a liquid to gas.



Virial Theorem:

For any system of particles in equilibrium under the influence of a force,

$$\text{Thermal energy + gravitational potential energy} = \frac{1}{2}\text{ gravitational potential energy}$$

$$\textbf{Thermal energy} = -\frac{\mathbf{1}}{\mathbf{2}}\textbf{ gravitational potential energy}$$

Since **gravitational potential energy** is negative for any star. Thermal energy is always positive. This means that the **gravitational potential energy becomes more negative** – when a star of fixed mass contracts. In such a case only half of the energy released gravitationally would remain in the star and the other half would be released as radiation. It also suggests that the thermal energy increases if the gravitational potential energy becomes more negative. The gases become hotter when compressed.

- **Fusion reactions** can take place only at very high temperature of the order of 10^7 to 10^9 Kelvin. Hence, fusion reactions are termed **thermonuclear reactions**.
- If we were to fill a **bucket the size of the Sun** with water and pour it on the Sun, it wouldn't extinguish it. Instead, it will add to the Sun's mass and increase its Hydrogen and Oxygen reserves − creating a bigger blue-white star 13 times the original size, and would fry nearby planets.
- **Albert Einstein** presented his **theory of general relativity** in 1916, but for an entire century nobody could find physical proof of black holes. In 2016, scientists finally **detected gravitational waves** that emitted from two black holes colliding, proving that such things not only exists, but that **Albert Einstein** was right all along.
- An average human emits about 150 anti-electrons (**positrons**) per hour. These positrons come from the decay of **potassium-40 isotope** present in your body. At this rate, we need about 10^{21} years to produce just 1 gram of positrons.
- The **cornea** is the only organ in the **entire human body** that has no blood supply. It gets oxygen directly from the air.

Hydrogen is an explosive gas. Oxygen supports combustion. Still when these are combined it is water which is used to put out fires.

- **The number of moons in our solar system exceeds 200.**
- **Despite having a radius half that of the Earth and a diamond-covered surface, 55 Cancri e has an eight times greater mass than the Earth.**
- **The actual number of stars in the universe is unknown. There are 200 – 400 billion stars in the Milky Way alone, according to studies.**
- **Some American astronauts consume recycled urine, sweat, and bathwater in space because there isn't any water there.**

A Black Hole Is Not Visible Directly. We can observe the effects of a black hole on its environment by examining its surroundings.

German physicist and astronomer Karl Schwarzschild studied the mathematics of relativity that ultimately led to the prediction of the existence of black holes.

- A form of lasers called **'optical tweezers'** uses two **beams of light** to squeeze and manipulate objects as small as a single atom.

Big Bang

The singularity at the beginning of the universe. The **titanic explosion** that created the universe, sending the galaxies hurtling in all directions. When the universe was created, the temperature was extremely hot, and the density of material was enormous i.e., infinite. The big bang took place **13.7 billion years ago**, according to the **WMAP** satellite. The afterglow of the big bang is seen today as the cosmic background microwave radiation (of **temperature 2.7 degrees above absolute zero**). There are three experimental "**proofs**" of the big bang: the redshift of the galaxies, the cosmic background microwave radiation, and nucleosynethsis of the elements.

Big crunch

The singularity at the end of the universe i.e., The final collapse of the universe. If the density of matter is large enough (**Omega** – The parameter that measures the average density of matter in the universe – being larger than 1), then there is enough matter in the universe to reverse the original expansion and cause the universe to recollapse. Temperatures rise to infinity at the instant of the **big crunch**.

- The **proton-proton cycle** occurs in less massive stars with smaller central temperatures ($\approx 10^7$ Kelvin). In this cycle the total energy released is **26.7 MeV** − which maintains the luminosity of the star. In sun and other low mass stars, 90% of the energy produced is because of **proton-proton cycle.** In more massive stars in which temperature exceeds **15 $\times 10^6$ Kelvin**, hydrogen burning can occur with an entirely different sequence of reactions in which ${}_6C^{12}$ nucleus acts as a catalyst. In this process, reactions proceed with the formation of nitrogen and oxygen isotopes. This entire cycle is termed **CNO cycle**. The total energy produced in this cycle is **25.7 MeV** per fusion reaction.
- **Sir Issac Newton** stuck a sewing needle under his eyeball, pushed it all the way to the back of his eye socket, and wiggled it around to test his theory of optics.

Big freeze

The end of the universe when it reaches near absolute zero. The big freeze is probably the final state of our universe, because the sum of **Omega and Lambda** is believed to be 1.0, and hence the universe is in a state of inflation. There is not enough matter and energy to reverse the original expansion of the universe, so it will probably expand forever.

Big Bang nucleosynthesis

The production of deuterium, Helium-3 and Helium-4 (the latter to about 25% mass fraction) in the first 500 to 1000 sec of the early universe. These light isotopes, plus measurable amounts of lithium-7 and trace amounts of elements B, Be, are the result of non-equilibrium nuclear reactions as the universe cooled to about 10^8 K. Heavier isotopes were produced in **stellar nucleosynthesis**.

Black hole

A **region of space-time** from which nothing, not even light, can escape, because gravity is so strong and escape velocity equals the speed of light. Because the speed of light is the ultimate velocity in the universe, this means that nothing can escape a black hole, once an object has crossed the event horizon. **Black holes** can be of various sizes. **Galactic black holes**, lurking in the center of galaxies and quasars, can weight millions to billions of solar masses. Stellar black holes are the remnant of a dying star, perhaps originally up to forty times the mass of our Sun. Both of these black holes have been identified with our instruments. **Mini–black holes** may also exist, as predicted by theory, but they have not yet been seen in the laboratory conditions.

Zero point Energy

An intrinsic and unavoidable part of quantum physics. The ZPE has been studied, both theoretically and experimentally, since the discovery of quantum mechanics in the 1920s and there can be no doubt that the ZPE is a real physical effect.

There are 2,271 Satellites currently in orbit! Russia has the most satellites currently in orbit, with 1,324 followed by the U.S.A. with 658.

Casimir effect

The attractive pressure between two flat, parallel metal plates placed very near to each other in a vacuum. The pressure is due to a reduction in the usual number of virtual particles in the space between the plates. This tiny effect has been measured in the laboratory. The Casimir effect may be used as the energy to drive a time machine or wormhole, if its energy is large enough.

Cosmological constant

A mathematical parameter (**which measures the amount of dark energy in the universe**) introduced by Albert Einstein to give space-time an inbuilt tendency to expand. At present, the data supports **density parameter + cosmological constant = 1**, which fits the prediction of inflation for a flat universe. Cosmological constant, which was once thought to be zero, is now known to determine the ultimate destiny of the universe.

Dark matter

Invisible Matter usually found in a huge halo around galaxies, clusters, and possibly between clusters, that cannot be observed directly but can be detected by its **gravitational effect** and they does not interact with light. As much as 90 percent of the mass of the universe may be in the form of dark matter and they makes up 23 percent of the total matter/energy content of the universe. According to string theory, dark matter may be made of subatomic particles, such as the **neutralino**, which represent higher vibrations of the superstring.

Einstein's theory of gravity based on the idea that the laws of science should be the same for all observers, no matter how they are moving. It explains the force of gravity in terms of the curvature of a four dimensional space-time; so that the curvature of space-time gives the illusion that there is a force of attraction called gravity. It has been verified experimentally to better than 99.7 percent accuracy and predicts the existence of black holes and the expanding universe. The theory, however, break down at the center of a black hole or the instant of creation, where the theory predicts nonsense. To explain these phenomena, one must resort to a theory of subatomic physics.

Grand unified theory

A theory which unifies the electromagnetic, strong, and weak forces (**but not gravity**). The proton is not stable in these theories and can decay into positrons. GUT theories are inherently unstable (unless one adds super symmetry). GUT theories also lack gravity. Adding gravity to **GUT theories** makes them diverge with infinities.

Microwave background radiation

The remnant radiation (**with a temperature of about 2.7 degrees K) from the glowing of the hot early universe (big bang**), now so greatly red-shifted that it appears not as light but as microwaves (radio waves with a wavelength of a few centimeters). Tiny deviations in this background radiation give scientists valuable data that can verify or rule out many cosmological theories.

The total angular momentum = spin angular momentum + orbital angular momentum

$$\mathbf{I = S + L}$$

- For nuclei of odd mass number, I is an odd multiple of $\frac{\hbar}{2}$
- For nuclei of even mass number, I is an even multiple of $\frac{\hbar}{2}$

Neutron star

A cold collapsed star consisting of a solid mass of neutrons — which is usually about 10 to 15 miles across — supported by the exclusion principle repulsion between neutrons. If the mass of the neutron stars exceeds (3- 4 solar masses) i.e., if the number of neutrons becomes $\geq 5.9 \times 10^{57}$, then the degenerate neutron pressure will not be large enough to overcome the gravitational contraction and the star collapses into the next stage called **black holes**.

Quantum mechanics

The theory developed from wave equations, **Planck's quantum principle** and Heisenberg's uncertainty principle. No deviation from quantum mechanics has ever been found in the laboratory. Its most advanced version today is called quantum field theory, which combines special relativity and quantum mechanics. A fully quantum mechanical theory of gravity, however, is exceedingly difficult.

Special relativity

Einstein's 1905 theory based on the idea that the laws of science should be the same for all observers, no matter how they are moving, in the absence of gravitational phenomena. Consequences include: time slows down, mass increases, and distances shrink the faster you move. Also, matter and energy are related via $\mathbf{E = mc^2}$. One consequence of special relativity is the atomic bomb.

Virtual particle

In quantum mechanics, a particle that briefly dart in and out of the vacuum but can never be directly detected, but whose existence does have measurable effects. They violate known conservation laws but only for a short period of time, via the uncertainty principle.

Anthropic principle

We see the universe the way it is because if it were different we would not be here to observe it through a gigantic telescopes pointing deep into the immense sky – merely stating that the constants of nature must be tuned to allow for intelligence (otherwise we would not be here). Some believe that this is the sign of a cosmic creator. Others believe that this is a sign of the multiverse.

Black Hole Escape Velocity: It is widely held by astrophysicists and astronomers that a black hole has an escape velocity c (or c, the speed of light in Vacuum).

Antiparticle

Each type of matter particle has a corresponding antiparticle – first predicted to exist by **P. A. M. Dirac**. When a particle collides with its antiparticle, they annihilate, leaving only pure energy in the form of discrete bundle (or quantum) of electromagnetic (or light) energy called photons.

Electroweak unification energy

The energy (around 100 GeV) above which the distinction between the electromagnetic force and the weak force disappears.

Grand unification energy

The **energy above** which, it is believed, the electromagnetic force, weak force, and strong force become indistinguishable from each other.

1916

Black holes were predicted by **Albert Einstein's general theory of relativity**.

1967

American astronomer **John Wheeler** coined the term "black hole."

1971

The first black hole was discovered

The general relativity theory of Einstein suggests that time actually slows down near a black hole. The term "gravitational time dilation" refers to this phenomenon.

A black hole will pull matter toward it with its force of gravity if it travels through an interstellar matter cloud. This process is known as accretion.

Because it marks the point at which the black hole's gravitation overwhelms the momentum of the matter and spirals it around the accretion disc, the event horizon of a black hole is also referred to as the "point of no return." There is no known force that can bring something back once it has passed the event horizon.

Earth wouldn't fall in even if a black hole of equivalent mass is placed in instead of our Sun. The black hole's gravitational field would be identical to that of the sun. The Earth and other planets would continue to orbit the black hole in the same manner that they orbit the Sun right now.

Exogenesis

The idea that life came to Earth from another part of the universe

The Oscillating Universe Theory

The universe experiences expansion and contraction phases. The universe's matter would eventually get hotter and brighter, collapsing as a whole in a phenomenon known as the "Big Crunch." This would be followed by another Big Bang, creating a new universe.

Second Law of Thermodynamics

The idea that entropy of the universe can never decrease and will always tend to increase

- **When a light ray travels from a rarer medium to a denser medium, it gets slower and bends towards the normal.**
- **When a light ray travels from a denser medium to a rarer medium, it gets faster and bends away from the normal.**
- **The change in direction of a ray of light as it travels from one medium to another is termed refraction.**

Things may appear closer than they actually are due to refraction.

The law of reflection

↓

Angle of incidence = Angle of reflection

A light ray, for example, will be reflected at an angle of 45° if it strikes a surface at an angle of incidence of 45°.

A "**jiffy**" is a precise measure of time. It is equal to the 33.3564 picoseconds that light needs to travel one centimeter in a vacuum.

Remarkably, only 10% of the electrical energy consumed by a light bulb is converted to light when it is turned on; the remaining 90% is dissipated as heat.

- The sunset on Mars appears blue.
- The moon that orbits Earth is the solar system's fifth-largest moon.
- Comets, which are composed of sand, ice, and carbon dioxide, are remnants from the formation of our solar system 4.5 billion years ago.
- The characters of Alexander Pope and William Shakespeare were used to name the moons of Uranus.

A day on Earth only lasted 18 hours and 41 minutes 1.4 billion years ago.

It would take 42 minutes and 12 seconds to get to the other side if we dug a tunnel through the Earth and jumped in.

- Tens of thousands of black holes are at the center of the Milky Way galaxy.
- With a 940 kilometer width, Ceres is the biggest asteroid currently known.
- The Aquila constellation contains a gas cloud that contains enough alcohol to produce 400 trillion trillion pints of beer.

Because they don't have a solid surface, we couldn't walk on Jupiter, Saturn, Uranus, or Neptune.

- It would take more than 800 years to travel to Pluto in an aircraft.
- Every 90 minutes, the International Space Station orbits the planet **Earth**.
- Without a spacesuit, we could survive in space for roughly 15 seconds.
- The Milky Way and Andromeda galaxies will collide in 3.75 billion years.
- **Jupiter is referred to as a failed star because it contains the same elements as the Sun (hydrogen and helium), but it lacks the mass to have the internal pressure and temperature needed for hydrogen to fuse to helium, which is the source of energy for the sun and the majority of other stars.**

More than 600 people have now visited space.

Temperatures can drop as low as −454°F in the darkest regions of space. But space is a hot 250°F if we're orbiting close to Earth in the sunlight.

Shooting stars are pieces of cosmic junk that burn up as soon as they enter the atmosphere of Earth.

The gravity on Mars is around one-third that on Earth.

In the next ten years, there is a 10% risk that falling space trash will cause a fatality.

- The universe, which has been expanding since its creation in the Big Bang, is estimated to be 13.8 billion years old.
- Jupiter's magnetic field would be larger than the Moon if it could be observed.
- Since its discovery in 1846, Neptune has only completed one orbit around the Sun.

Asterism

A little cluster of stars that does not fully constitute one of the 88 constellations that the International Astronomical Union recognizes

The point of greatest separation for an object travelling in an elliptical orbit around another celestial object is known as the **Apoapsis**. According to Kepler's Second Law, the object moves at slowest speed at this point in the orbit.

Anomalous cosmic rays

Cosmic rays that are believed to have energy between 10^7 and 10^8 eV and originated from neutral interstellar atoms that have been ionized by solar UV radiation after entering the heliosphere.

Each star orbits the other in an elliptical orbit in a binary star system. The apastron is the point where the two stars are the furthest apart. The periastron is the point where the two stars are nearest to one another.

There is no proof that life exists on Mars. But, it is the planet with the finest circumstances for sustaining life, and because astronomers recently discovered water ice just beneath the surface of Mars, they feel there may be a chance for life there.

- Since many undersea organisms possess both female and male reproductive systems, the majority of marine creatures are hermaphrodites.
- **Bremsstrahlung radiation** is the radiation that an electron emits as a result of the acceleration brought on by another charged particle's electric field **(most often a proton or an atomic nucleus)**.

Core-collapse supernovae

Cataclysmic stellar explosions of massive stars at the end of their thermonuclear evolution creating neutron stars and black holes

- Only transverse waves can be polarized. Sound waves do not undergo polarization, since they are longitudinal waves.
- When a ray of light traverses an edge or a slit, it bends. **Diffraction** is the name given to this bending.
- The Earth could be powered for a year by 60 minutes of solar energy.
- The word **"energy"** comes from the Greek term **"energeia,"** which **Aristotle** coined

in 384 BC.

- The oldest artificial satellite still in orbit around Earth is **Vanguard 1**, which was the first spacecraft to use solar cells.
- In addition to speeding up particles, particle accelerators also increase their mass.
- The **British thermal unit** (BTU) is the metric unit of energy or work. It is the amount of energy required to warm one pound of water by one degree Fahrenheit.

The Large Hadron Collider (LHC)

The most effective particle accelerator ever constructed − that accelerates ions or protons close to the speed of light. It is made up of a 27 kilometer long ring of superconducting magnets and several accelerating components that increase the particle energy as they travel through them.

The **Standard Model of particle physics**, which was created in the early 1970s and defines the fundamental particles and their interactions, has so far been effective in explaining nearly all experimental findings in particle physics and has accurately predicted a wide range of phenomena. The Standard Model, however, is not complete. **Many questions** remain unanswered, which the **LHC** will assist in resolving.

- Will we find proof of Supersymmetry?
- What is the origin of mass?
- What exactly are dark energy and dark matter?
- Why does the cosmos have considerably more matter than antimatter?
- How does the quark-gluon plasma produce the particles that make up the universe's matter?

Conclusion

Why did the cosmos wait an endless amount of time to start if it had a beginning? But why did it take an unlimited amount of time to get to this point if the cosmos had existed forever? Was the universe created and started by divine intervention? What makes the universe what it is? To address these questions, which appear to be as old as human civilization itself, ancient civilisations all around the world recounted creation tales. The question is not just relevant to cosmology; in fact, it offers potential avenues for deciphering the underlying physics of our universe. Despite some significant achievements, not all problems have been resolved. The whole form of the laws of nature is not yet well understood. Without this knowledge, we are unsure of how far we can advance in our quest to comprehend the universe's future. Will it keep growing indefinitely? **Is inflation a natural law?** Or will the universe eventually collapse? Theoretical developments and new observational findings are pouring in quickly.

The lingering issue in theoretical physics over the past few years has been developing a quantum theory of gravity. Numerous theories of quantum gravity have been put forth. There is currently no full and consistent quantum theory of gravity that combines the concepts of quantum theory and general relativity, and the contender theories still have significant formal and conceptual issues to solve. The universe is a curious place, brimming with wonder and magnificence as well as a myriad of questions left unanswered and unexplained mysteries. **Cosmology** is a very dynamic and intriguing field that involves the scientific study of the big-scale characteristics of the universe as a whole. The microstructure of spacetime at the so-called **Planck scale**, where the units of mass, length, and time are formed by the combination of the speed of light in a vacuum, the Dirac constant, and Newton's gravitational constant, is adequately described by new theories of the vast universe that have emerged in recent decades. The answers to the ages-old queries are nearing completion through observations of outer space. What brings us here? **What is our origin?** Are space and time fundamental or emergent? Is there a beginning to the cosmos,

or is it eternal? Will the rules of nature ever be fully understood? Can we enter a black hole and emerge in a different universe?

It is the one true and perfect symbol of your existence. Without it, neither you nor I would exist. We would go zinging off into empty space. While there is gravity, there is life trying to understand what gives the universe its structure and make us exist as Human Beings. It is all close to Newton's gravity. What goes up must come down.

Something unknown is running behind every atom we don't know what… No one knows who tuned the music of dancing mysteries or what powered the Big Bang. It's completely a Baffling Mystery. The fact that we are only an advanced strain of talking monkeys purely concerned with survival have been able to get this close to an understanding of our universe is a big victory for our continuing quest. Thoughts are the Conceived Babies of the Human Mind. The usual approach of science of building a scientific model cannot answer the question why the thought goes on in our mind the way it is. In most of the organisms the conditions would not be right for the generation of thoughts to predict things more or less, even if not in a simple way, only in the few complex organisms like us spontaneous thoughts would generate and breathe fire into the question: **WHY DOES THE UNIVERSE APPEAR THE WAY IT IS?** The answer is then simple. If it had been little different it would not have rushed out too fast for the stars to form and for life to begin.

Religion has certain ideas at the heart of it which forces us to imagine a personal God to light the blue touch paper and set the universe going, it serves to stand in wonder at the structure of the world, and in so far it allows our imperfect senses to acknowledge it.

How did the universe begin?

Religion answers God created the universe.

Science questions who created the God.

Every fact begins as philosophy and ends as theory which is just a set of rules and equations. What is it that breathed fire into the time and prepared a cosmos for it to describe. The astounding thing is that the calcium in our bones, the phosphorous in our teeth, and the iron in our hemoglobin came from a cosmic dust. So, forget biblical God. The massive stars exploded so that we could be here today to justify something, why the universe exists, why we exist.

The faster you move, the heavier you are. That's Relativity. For those who yearn to learn what it is so that they can hope to understand what prevents them from flying at the speed of light, that is all there to the Einsteinian special theory of relativity. It's just the change of Newtonian laws by introducing a correction factor to the mass. Is our universe the only one giant hologram? No, says M theory. Great many Holograms were created not by the grace of biblical God, but simply because of spontaneous creation. Our universe was one among a vast ensemble of Holograms created with particular values of the physical constants so that we could be here today to make sense of what we see and ask the question: **How old is the Universe?**

In the beginning few seconds of the Big Bang, huge amounts of both matter and antimatter were created, and then they combined and annihilated disappearing in a flare of energy. But for some reason, there was an extremely small amount more matter than its antimatter. Everything that we observe today was that tiny fraction of matter that survived. **Why was there more matter than antimatter right after the Big Bang? Why?**

Merely to produce life permitting universe?

In the long history of human evolution those who learned to adopt and survive most effectively have prevailed. Because there is a law such as evolution, life could start and new life forms could emerge on their own (abiogenetically) sustaining themselves by reproducing in the environment fitted for the functional roles they perform. There would be no stars. No galaxies either. Our life

permitting universe would have ceased to exist, long before any planets suitable for supporting life could have formed. The physical constants are fixed so that we could be here today to take part in the discussion of the question of why it is that we and the universe exist at all. In a bewildering world, the problem of whether the time never begin and has always been ticking, or whether it had a beginning at the Big Bang, is really a concern for physicists: either science could account for such an inquiry. If one believes that the time had a beginning, the obvious question was how it had begun? Personally, I'm sure that the time began with a hot Big Bang. But will it go on ticking forever? If not, when it will wind up its clockwork of ticking? I'm much less sure about that. Although singularity theorems predicted that the time, the space, and the matter or energy itself had a beginning, they didn't convey how they had a beginning. It would clearly be nice for singularity theorems if they had a beginning, but how can we distinguish whether they had a beginning? In much as the time, the space, and the matter or energy had a beginning at the Big Bang it would deepen implication for the role of a mysterious creator in the affairs of creation. But if they stick on the boundary of reason in that they have neither origin nor end: it would exactly be what place then for a human shaped creator?

Its gravity is so immense that nothing even light can slip out of its influence. No matter, how strong a light we shine on it, no light ever reverts back. Consideration of black holes suggests, not only does science God throw dice, but sometimes throws them ineffably. Before the Big Bang there was nothing, and then suddenly we got a huge amount of energy. Where did it come from? Is the energy so compelling that it brings about its own existence? Or does it need a creator? All our life, we have been captivated by the big questions that face us, and have tried to find answers to them on the day we begin to make sense of what we see. Up until recently, we have tended to refrain from such questions, feeling that they belonged to traditional philosophy or theology, and not to science. How the energy came about without a Creator? Biblical God did not create the energy, the laws of physics is the reason there is energy rather than nothing. To one bent on darkness, ignorance will come as a release. It is not a lack of wisdom that scares us away again and again from our childhood, but fear of darkness, ignorance, and stupidity that we burden ourselves with or even the fear of becoming a ridiculous being.

The inaccessibility of its data for conversion into words, often interpreted as the puzzle of understanding it. Unrevealed questions about the universe remain unrevealed; the approach that all is uncertain; to express it − the touch of the genius. When science doesn't comprehend the weirdness of nature, it is in the heart of darkness. When it has an intuitive guess as to what the outcome is; it stands convicted of the offense of making unverifiable supernatural claims as adherents of certain religion do. And, when it is fairly damn sure of what the final result is going to be, it is still in some uncertainty. But its history —by far the most favorable claim to wisdom —teaches that the most it can hope for is a consecutive improvement in its approach, learning from its falsity, an asymptotic way or means of reaching something rather than nothing. The science has a lot of exposure with darkness and disbelief and a state of not having an immediate conclusion, and this exposure is of great significance, I think. Science generally insists that all irregularities can be confined, in a postulate, in terms of physical laws which can be philosophized using mathematical statements, thus reducing the gigantic universe into a simple structure and humans to complex substructures whose goal correspond to nothing more than a complete understanding of **why it is that we and the universe exist.**

The galaxies are flying away from each other at extremely impressive speeds as the fabric of space the y occupy stretches such that greater the relative distance between them the greater their speed of recession. Thus, our world is not static and unchanging with time as had been previously thought

It's evolving with time.

Personally, I'm sure that the accelerated expansion began with a hot Big Bang. But will it expand forever is still in question. **c** is not just the physical constant or the most freaking thing that will prevent anything from flying faster than light, but rather a fundamental feature of the way space and time are woven into a four dimensional malleable fabric that is no longer detached into three spatial dimensions and one dimensional time. A remarkable consequence of this is that photon is always restricted to travel at the speed of light.

Can We Travel Through Time? Time travel is conceivable, according to science. All we need is a starship that can travel faster than light to go through time. Unfortunately, Albert Einstein's

Special theory of relativity demonstrated that the more closer a starship was to the speed of light, the more fuel energy was required to accelerate it. Therefore, exceeding the speed of light would require a limitless supply of energy. **General Theory of Relativity**, proposed by **Albert Einstein** in 1915, was a game-changer. Space and time were no longer distinct, independent concepts in this. They were combined into a single continuum called **"spacetime"** instead. The matter and energy present in this spacetime caused it to be distorted and curled rather than flat. However, it might be conceivable to foretell how the cosmos would begin if general relativity and quantum theory are coupled. **Quantum Mechanics** and **General Relativity** do not work together. What about: **Before the Big Bang?** Neither theory can predict what happened. The unification of so called **weak nuclear forces** with the **Maxwell equations** is what known as the **Electroweak theory**. And the **electroweak theory** and **quantum chromodynamics** together constitutes the so called **Standard Model of particle physics**, which describes everything except gravity. Even hundreds of years later, the desire to comprehend the interconnected nature of the universe and how we fit within it is still intense. In some ways, the universe does prove to be much bigger and more magnificent than our progenitors could have ever imagined, which makes puzzles about its beginnings and design much more appealing to research.

Is everything understood in strings? The best choice we have at the moment is superstrings, but there is no direct evidence that it is the correct description of what the universe is. Are there only 11 dimensions or could there be more? Ever since we launched the war on the darkness, we are on our own way attacking the dark world as a whole instead of one planet at a time, raising the prospect of novel theories that stick on. Wars longer than World Wars has been fought and won. With such victories, we cannot be certain of the complete description of the universe we live in. From the Big Bang to Black Holes, the universe is full of dancing mysteries that may never be revealed. What is it breathes fire into the discussion? And, our discussion is nothing less than questioning why our understanding is slow in its progress that it can't step in once from artificial to superficial thinking? Huge questions remain to be answered, but the answers have always seemed well beyond our reach until now. The universe did not come of a sudden. It was simply an evolution and in the whole process universe has undergone drastic changes before it became what it is today. An advanced breed of talking monkey can glorify orderly pleasing sound of

what exists, but he cannot make a brilliant move: for that he would have to explore every possibility of its grand design.

If the gravitational binding pressure one second before the Big Bang had been greater than the internal pressure, the universe which we observe today could have existed in the hot fireball called singularity. The singularity exploded so that we could be here today to question: **Are we alone in this astounding Universe?** It's not likely to be true for life not to exist somewhere other than earth. Two possibilities exist: either we're alone in this astounding universe or we are not. Both are equally worrying us. If we're not alone, why should we Fear Aliens? Predacious Humanoid Extraterrestrial Species may destroy Humanity to protect their civilizations.

Everything happens simultaneously. It appears as though everything has designed to make the universe appear as it appears the way it is. The apparent grand design that shaped our vision of understanding is overwhelming. Science makes belief in God impossible… No time existed before the Big Bang. How could Biblical God create the universe as there was no time for him to do so? We can govern the cosmos if we comprehend it. All of the existing models are obviously inadequate in this regard. Trying to understand what is visible to us while pondering the nature of the cosmos. We are interested in discovering a **comprehensive theory of everything** that encompasses gravity, quantum mechanics, and all other physical interactions. If we succeed in this, we will truly comprehend the universe and our place in it. If the rules of physics had been a little distinct, life as know it would not have been evolved into literally something.

Cosmologists who have made considerable breakthroughs in the last century are very concerned with the issue of whether or not the universe had a beginning. The past creation myths reveals who we are to us. Without it, we become unidentified. **Questions abound in cosmology.** There is always something new to learn in cosmology, even if it's just answering a question we've never thought to ask before. This is what keeps cosmology so exciting and intriguing.

Best Cosmology Books of All Time:

- **A Brief History of Time**

  Book by Stephen Hawking

- **Cosmos**

  Book by Carl Sagan

- **The Fabric of the Cosmos**

  Book by Brian Greene

- **The Elegant Universe**

  Book by Brian Greene

- **The Big Picture: On the Origins of Life, Meaning, and the Universe Itself**

  Book by Sean Carroll

- **A Universe from Nothing: Why There Is Something Rather Than Nothing?**

  Book by Lawrence M. Krauss

- **The First Three Minutes: A Modern View of the Origin of the Universe**

  Book by Steven Weinberg

- **A Short History of Nearly Everything**

Book by Bill Bryson

- **The Grand Design**

  Book by Stephen Hawking

- **Death by Black Hole: And Other Cosmic Quandaries**

  Book by Neil deGrasse Tyson

- **Pale Blue Dot: A Vision of the Human Future in Space**

  Book by Carl Sagan

- **The Hidden Reality: Parallel Universes and the Deep Laws of the Cosmos**

  Book by Brian Greene

- **The Universe in a Nutshell**

  Book by Stephen Hawking

- **Astrophysics for People in a Hurry**

  Book by Neil deGrasse Tyson

- **Parallel Worlds: A Journey through Creation, Higher Dimensions, and the Future of the Cosmos**

  Book by Michio Kaku

- **Big Bang: The Origin of the Universe**

  Book by Simon Singh

- **Our Mathematical Universe: My Quest for the Ultimate Nature of Reality**

  Book by Max Tegmark

- **A Briefer History of Time**

Book by Stephen Hawking, Leonard Mlodinow

- **Reality Is Not What It Seems: The Journey to Quantum Gravity**

  Book by Carlo Rovelli, Simon Carnell, Erica Segre

- **Einstein: His Life and Universe**

  Book by Walter Isaacson

- **Black Holes and Time Warps: Einstein's Outrageous Legacy**

  Book by Kip S. Thorne, Stephen Hawking

- **The Demon-haunted World: Science As a Candle in the Dark**

  Book by Carl Sagan

- **Origins: Fourteen Billion Years of Cosmic Evolution**

  Book by Neil deGrasse Tyson, Vikas Adam, et al

- **The Theory of Everything: The Origin and Fate of the Universe**

  Book by Stephen Hawking

- **Brief Answers to the Big Questions**

  Book by Stephen Hawking

- **Black Holes and Baby Universes**

  Book by Stephen Hawking

- **The Black Hole War: My Battle with Stephen Hawking to Make the World Safe for Quantum Mechanics**

  Book by Leonard Susskind

- **The Varieties of Scientific Experience: A Personal View of the Search for God**

Book by Carl Sagan, Ann Druyan

- **Hyperspace: A Scientific Odyssey Through Parallel Universes, Time Warps, and the Tenth Dimension**

  Book by Michio Kaku

- **Just Six Numbers: The Deep Forces That Shape the Universe**

  Book by Martin Rees

- **The Inflationary Universe: The Quest for a New Theory of Cosmic Origins**

  Book by Alan Guth

- **Coming of Age in the Milky Way**

  Book by Timothy Ferris

- **From Eternity to Here: The Quest for the Ultimate Theory of Time**

  Book by Sean Carroll

- **Seven Brief Lessons on Physics**

  Book by Carlo Rovelli

- **Billions and Billions: Thoughts on Life and Death at the Brink of the Millennium**

  Book by Carl Sagan

- **The Life of the Cosmos**

  Book by Lee Smolin

- **The 4% Universe: Dark Matter, Dark Energy, and the Race to Discover the Rest of Reality**

  Book by Richard Panek

- **Welcome to the Universe: An Astrophysical Tour**

  Book by Neil deGrasse Tyson

- **The Holographic Universe: The Revolutionary Theory of Reality**

  Book by Michael Talbot

- **The Road to Reality: A Complete Guide to the Laws of the Universe**

  Book by Roger Penrose

- **The Structure of Scientific Revolutions**

  Book by Thomas S. Kuhn and Ian Hacking

- **Contact**

  Book by Carl Sagan

- **Three Roads To Quantum Gravity**

  Book by Lee Smolin

- **The Illustrated A Brief History of Time and The Universe in a Nutshell**

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- **The Fabric of Reality: The Science of Parallel Universes--and Its Implications**

  Book by David Deutsch

- **Relativity: The Special and the General Theory**

  Book by Albert Einstein, Nigel Calder

- **The Goldilocks Enigma: Why Is the Universe Just Right for Life?**

  Book by Paul Davies

- **The Whole Shebang: A State-of-the-Universe[s] Report**

  Book by Timothy Ferris

- **The Cosmic Landscape: String Theory and the Illusion of Intelligent Design**

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  Book by Lisa Randall

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- **Why Does $E=mc^2$? (And Why Should We Care?)**

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- **How the Universe Got Its Spots: Diary of a Finite Time in a Finite Space**

  Book by Janna Levin

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If you feel that this information has been useful to you, please take a moment to share it with your friends on LinkedIn, Facebook and Twitter. Think about leaving a quick review on **Google Play Books** if you think this book has given you insight into the grand narrative of the cosmos from a fresh, inspired perspective and you have learnt something valuable.

Cosmology is a study area that combines the astronomy and physics in an endeavour to comprehend the physical universe as a cohesive whole. It is both incredibly fun and fascinating. I want to spread my passion to as many individuals as I can. I also hope that this isn't the end of your quest for solutions to the mysteries that have plagued mankind since its beginning. What role does humanity have in the universe's 14 billion year history? What role does humanity play in the history of this planet? How does humanity participate in the complex chain of life here on Earth?

Thank you!

After sleeping through a hundred million years in wisps, ashes and smoking gun, we – the rational beings developed from the Darwin's principle of natural selection – still don't fully understand space, our solar system, and the galaxy. The entire cosmos, of which the planet Earth and the human species are a part, is made up of space, time, matter, and energy. Astronomers' understanding of the cosmos is always changing since there are billions of stars and galaxies, as well as stormy planets, exploding stars and weird black holes in our own galaxy that have not yet been thoroughly examined or defined. But we – a hoard of talking monkeys whose consciousness is from a collection of connected neurons – do currently know some extremely interesting things about the universe.

How did the Universe begin? What elements make up stars? What is the true nature of the universe? Have there ever been inhabitants of Mars? How many moons could fit inside earth? From its accelerated expansion to dark matter and energy, the universe continues to amaze and perplex us. The size of the cosmos is unknown, but one thing is for certain: it is vast. The concept of something so enormous can make our existence on the planet Earth feel insignificant because there is obviously a lot of exciting stuff going on in there. This book takes us on a voyage across the galaxy, visiting all the planets, the Moon, the Sun, stars, black holes, comets, asteroids, and more. This is a great addition to your bookshelf whether you are working on an astronomical assignment or you simply want to learn more about our amazing universe.