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SPACE TECHNOLOGY

THUSHAR ASOK

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SPACE TECHNOLOGY

- Basics
- Current Developments

UNIVERSE

- All existing matter & space
- It consists of both physical (subatomic particles like electrons, protons to galactic super-clusters) and non-physical (light, gravitation, space etc.) components
- The universe, at present, is said to possess about **100 billion galaxies**, each comprising an average of **100 billion stars**.

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BIG BANG THEORY

- Prevailing cosmological model for the birth of Universe

- It states that **13.8 billion years ago**, all of space was contained in a **single point** of very **high-density** and **high-temperature** state from which the universe has been **expanding in all directions** ever since

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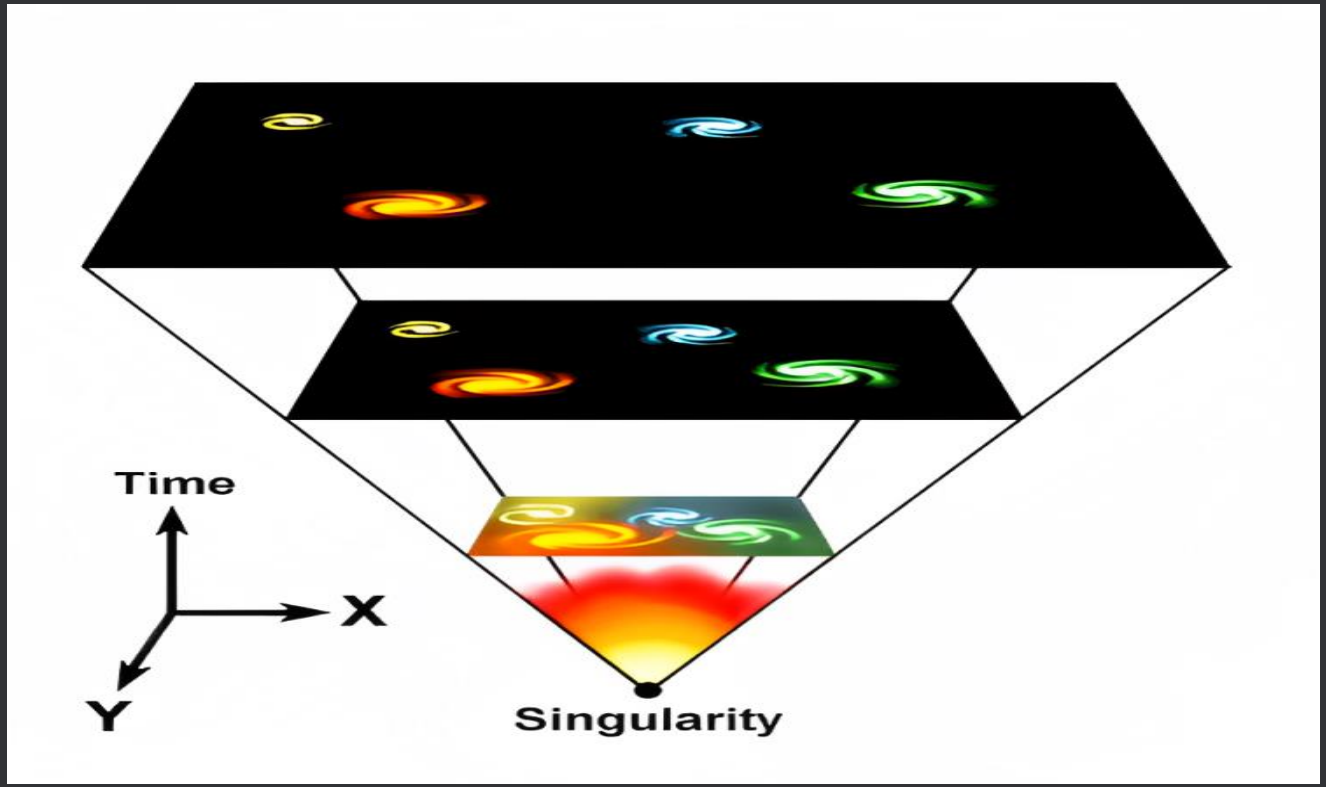

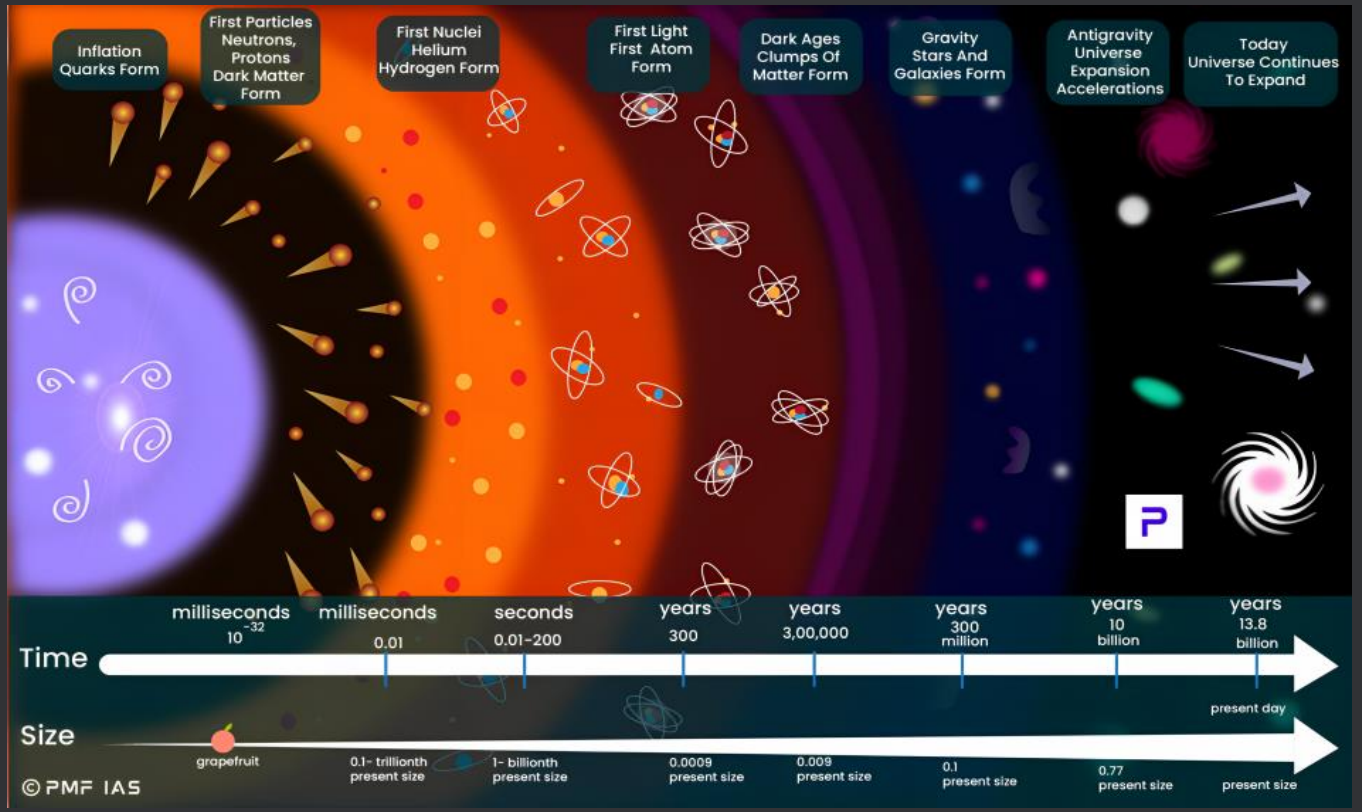

Big Crunch (Death of Universe)

At some point, the universe would reach a maximum size & begin collapsing. The universe would become denser & hotter again, ending in a state like that in which it started — a single point of very high density

DOPPLER – SHIFT OR REDSHIFT

- Phenomenon that occurs when light waves are stretched, causing them to appear redder in color. This happens when an object emitting light is moving away from the observer

- **Hubble's Law** states that the farther a galaxy is from us, the faster it appears to be moving away from us

CMD

- Cosmic Microwave Background
- Relic radiation (thermal radiation left over from the “Big Bang”)
- Oldest light in the Universe and can be found in all directions
- Its discovery is considered a landmark **proof for the concept of “accelerating expansion of the universe”** and **the Big Bang Theory**

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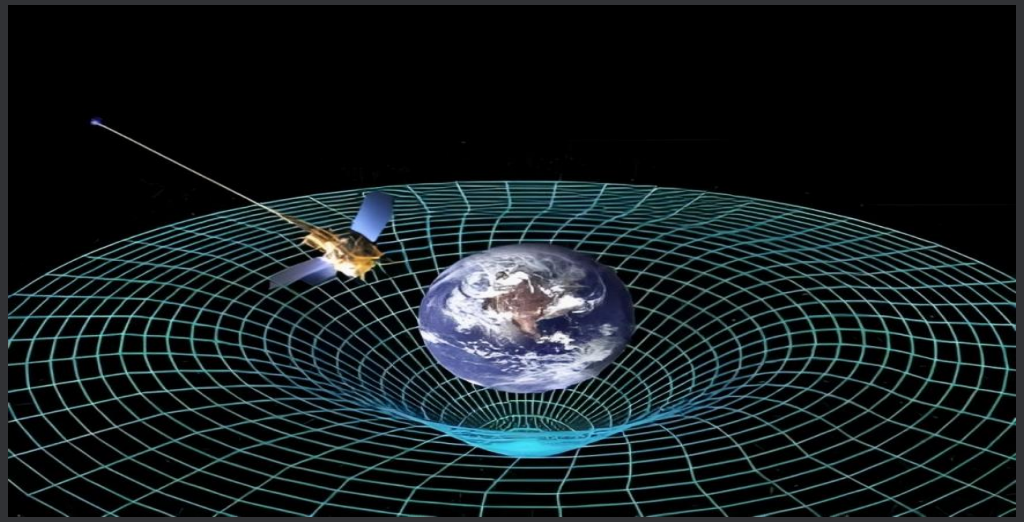
GRAVITATIONAL WAVES

- Gravitational waves are ripples in the fabric of spacetime caused by the movement of massive objects, such as black holes or neutron stars



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- Albert Einstein predicted the existence of gravitational waves in 1916

- In the universe, massive objects like planets, stars, and galaxies warp the fabric of space-time around them, creating what we experience as gravity

- This warping of space-time fabric affects the behavior of objects in the universe, causing them to move in curved paths around massive objects

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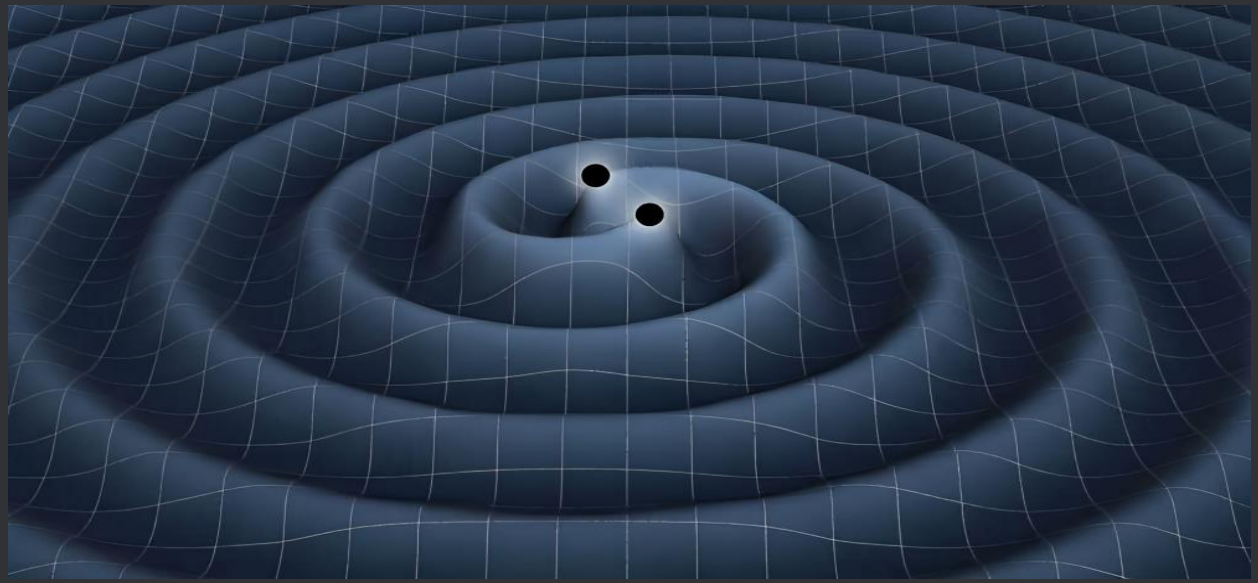
When massive objects move or collide in space, they cause ripples or waves in the fabric of spacetime, which we call gravitational waves



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LIGO

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- Laser Interferometer Gravitational-Wave Observatory
- Scientific experiment designed to detect and study gravitational waves
- LIGO consists of two identical observatories, located in Livingston, Louisiana and Hanford, Washington. Each observatory contains a pair of long, L-shaped tunnels

IndIGO

- Indian Initiative in Gravitational-wave Observations, is an initiative to set up advanced experimental facilities for a multi-institutional Indian national project in gravitational-wave astronomy

- LIGO-India is envisaged as a collaborative project between a consortium of Indian research institutions and the LIGO Laboratory in USA, along with its international partners

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GRAVITATIONAL LENSING

- Gravitational lensing is a phenomenon that occurs when the light from a distant object, such as a star or a galaxy, is bent and distorted by the gravitational pull of a massive object, such as a black hole or a galaxy cluster

- Gravitational lensing is a powerful tool for astronomers to study the distribution of matter in the universe, including the dark matter that cannot be directly observed

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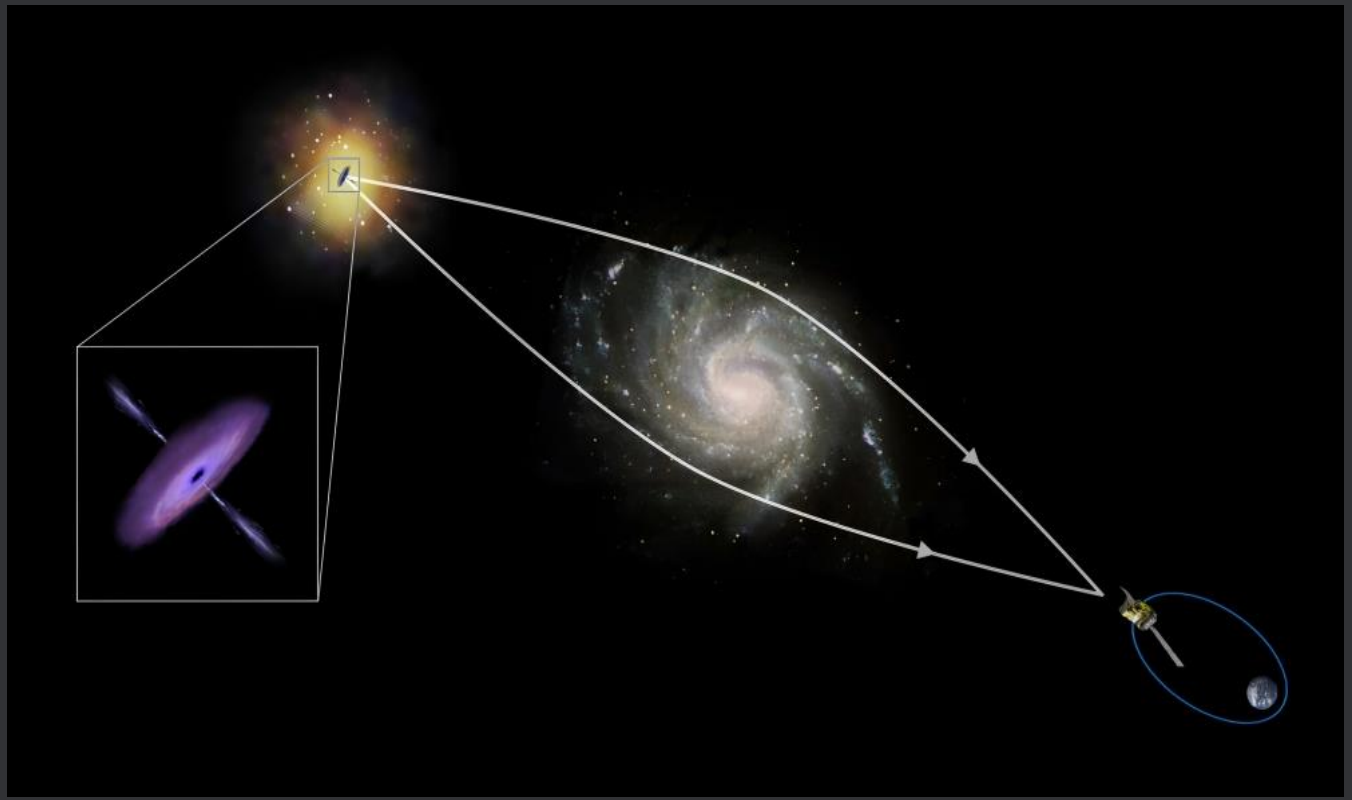

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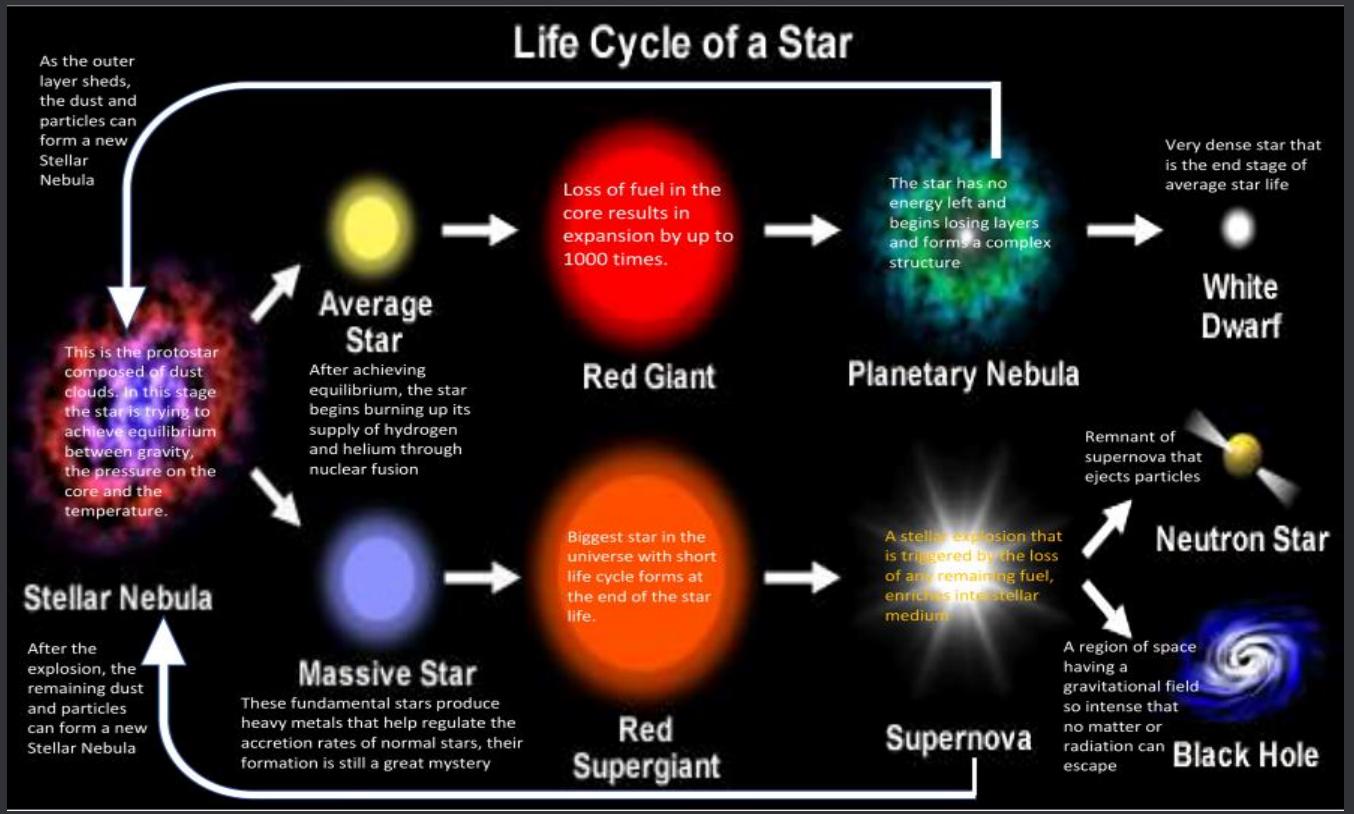
STARS – LIFE CYCLE



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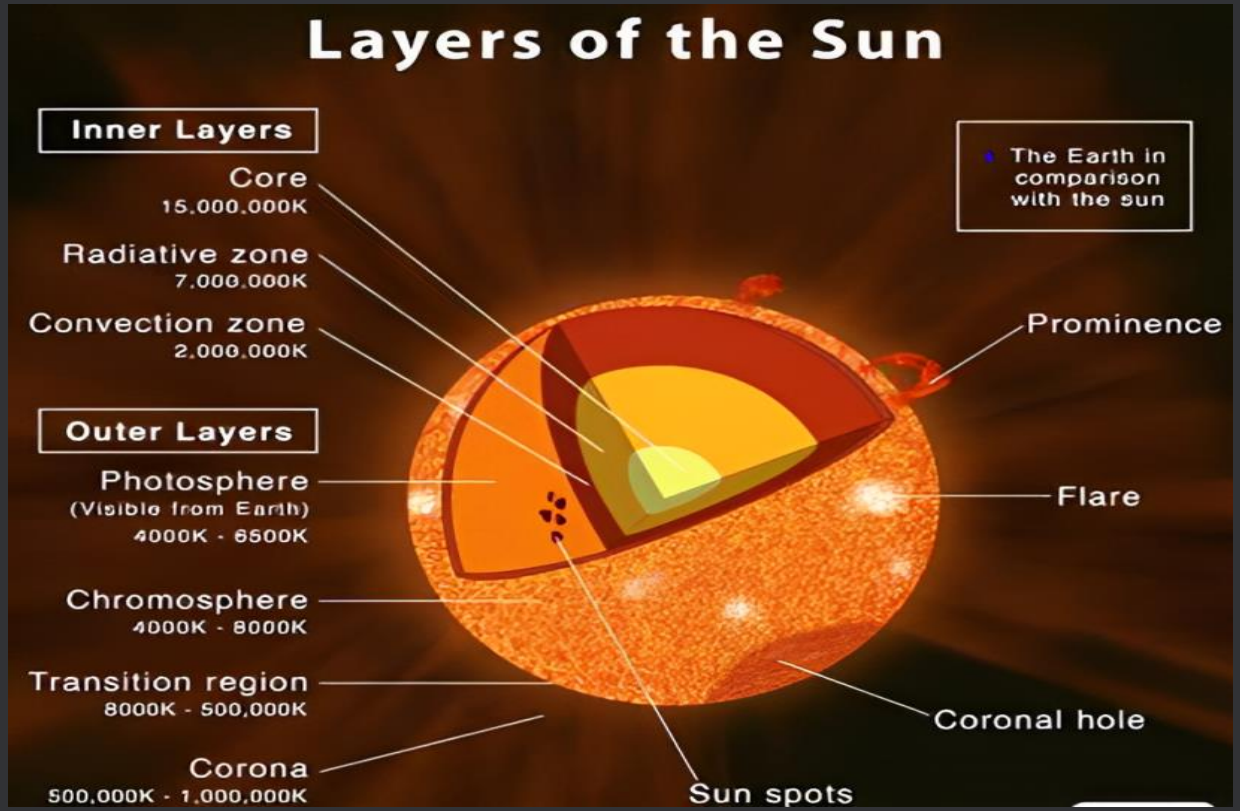
SUN



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- Coronal Paradox – Corona , outermost layer of the Sun's atmosphere, is much hotter than its surface
- Coronal Mass Ejections - Powerful eruptions of plasma and magnetic field from the Sun's corona
- When a CME is directed towards the Earth, it can have significant impacts on our planet's environment and technological infrastructure.

- The ejected plasma and magnetic field can interact with the Earth's magnetic field, causing geomagnetic storms that can disrupt satellite and power grid operations, radio communications

- Sunspots - dark regions that appear on the surface of the Sun. They are caused by strong magnetic fields that suppress the flow of heat from the Sun's interior to its surface, resulting in cooler and darker areas on the Sun's surface.

GOLDILOCKS ZONE

- Habitable zone, around a star where conditions are just right for liquid water to exist on the surface of a planet

- Area around a star where the temperature is just right for liquid water to exist on a planet's surface.

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PARTICLE PHYSICS

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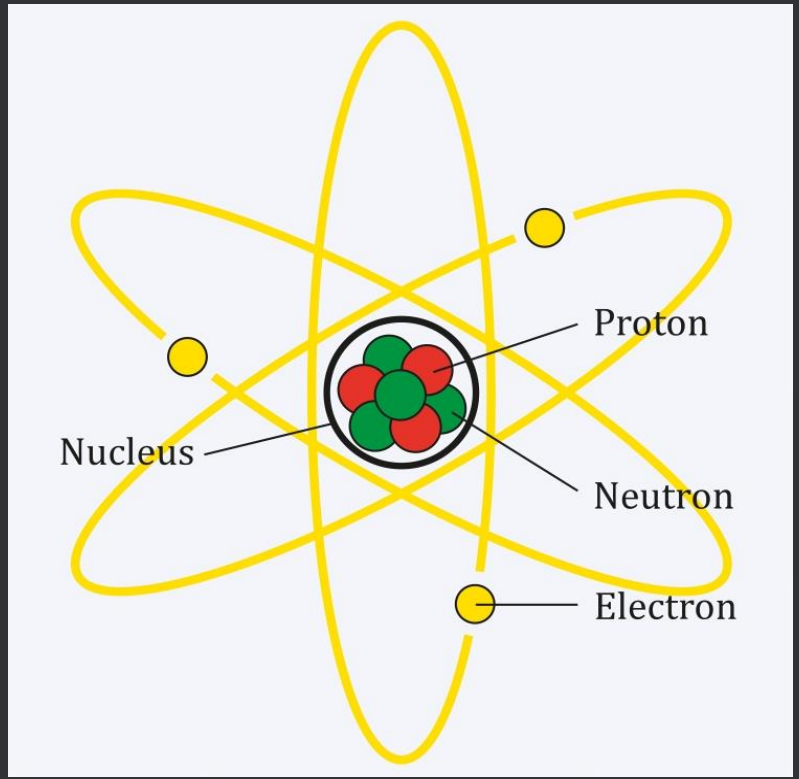

FUNDAMENTAL PARTICLES

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NEUTRINO

- Neutrinos are tiny subatomic particles that are similar to electrons, but they have no electric charge and very little mass
- They are second most abundant particle in the universe, emitted by stars, nuclear reactors or anything having radio isotopes
- They are also called as ghost particle

Neutrino Research Projects

- Indian Neutrino observatory: Theni, Tamil Nadu
- DUNE - USA
- Sudbury neutrino observatory: Canada
- Jiangmen underground neutrino observatory: China

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SIGNIFICANCE OF NEUTRINO RESEARCH

- Quantum encryption technology & data security
- Faster, global communication
- Mineral deposit in earth crust can be located
- Prediction of earthquakes and tsunami
- The characteristics of neutrino matches with dark matter particles. Any confirmation or negation will answer fundamental question in space exploration

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HIGGS BOSON

- Elementary particle associated with Higgs Field
- Interaction with Higgs field gives mass to other fundamental particles such as electrons
- Higgs boson was discovered at Large Hadron Collider (LHC) in Switzerland
- Photon is a fundamental particle without mass

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LARGE HADRON COLLIDER

- (LHC) is the world's largest and most powerful particle collider and the largest machine in the world operated by **CERN** (European Organisation for Nuclear Research)
- It collides two beams of particles to study physics at very high energies
- Subatomic particles are made to collide together at close to the speed of the light
- It provides insights into fundamental laws of nature
- ATLAS , CMS – Particle accelerators at LHC

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DARK MATTER

- Dark matter is a mysterious form of matter that does not emit, absorb, or reflect light or any other form of electromagnetic radiation
- It interacts with normal matter through gravity, which means that it can influence the motion of visible matter such as stars and galaxies
- It can only be detected indirectly through its gravitational effects on visible matter like Gravitational lensing
- Dark matter is around 27% of the universe

Projects for Dark Matter

LUX-ZEPLIN: USA

LUX: Australia

XENON 1T-GRAM SASSO: Italy

EUCLID: Europe

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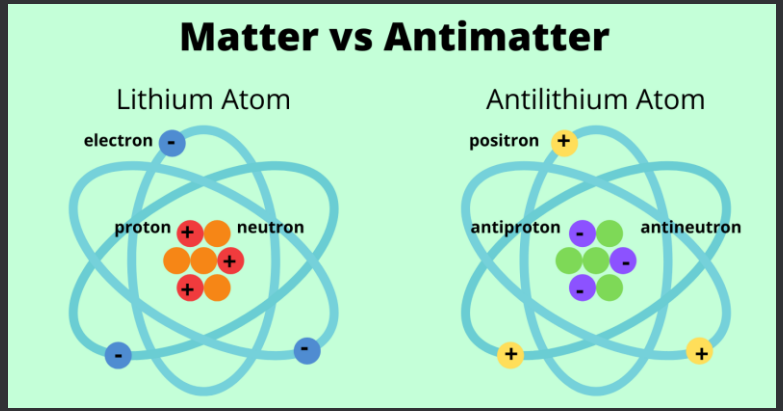
ANTI MATTER

- Antimatter is a term used in particle physics
- It is a material composed of antiparticles
- These have the same mass as particles of ordinary matter but have opposite charge and properties, such as lepton and baryon number



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SATELLITE & ORBIT

- A satellite is any object that orbits another object in space. Satellites can be natural, like the moon orbiting Earth, or artificial, like man-made satellites
- An orbit is the path that a satellite takes around the object it is orbiting
- Objects stay in orbit due to the balance of gravitational forces between two objects
- Orbital velocity is the speed needed to stay in orbit. Satellites that have higher orbits have slower orbital velocity

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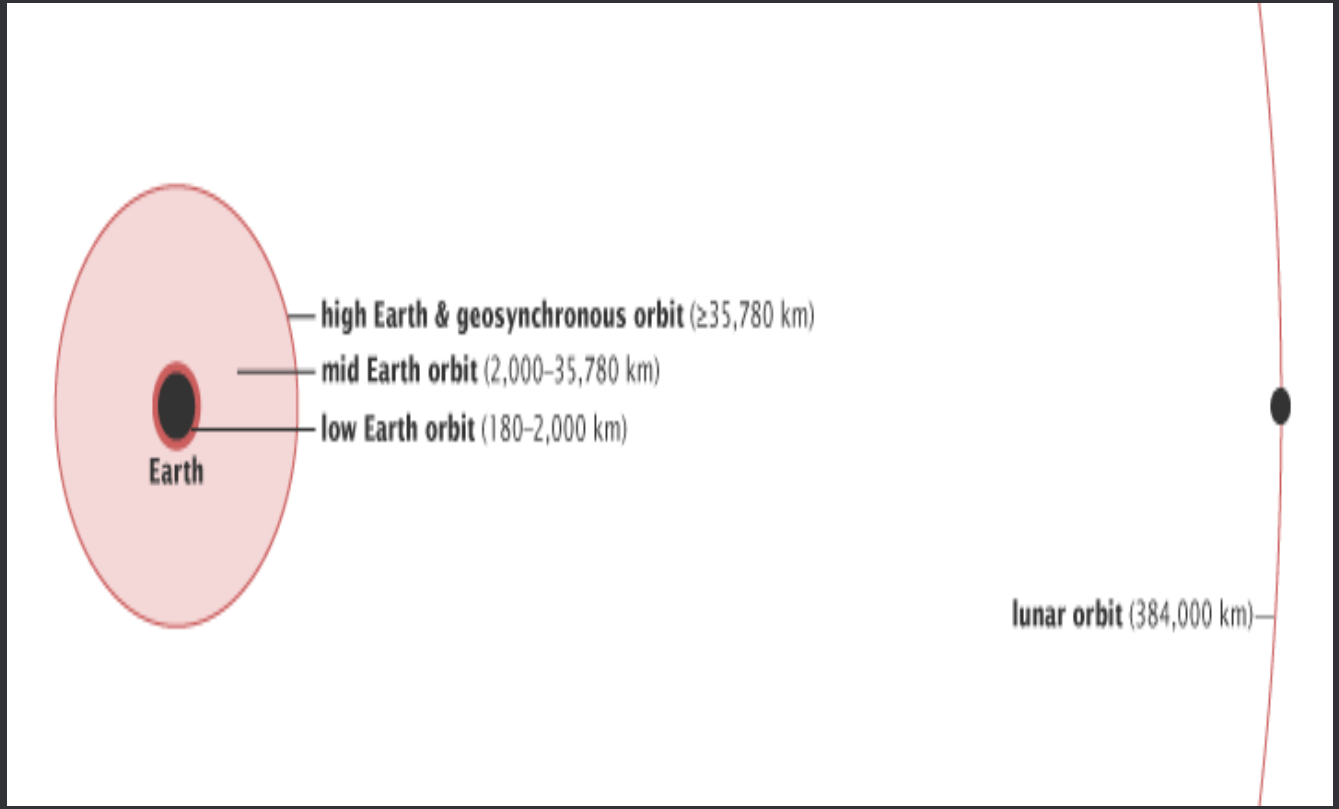
TYPES OF ORBIT



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LAUNCHERS

PSLV

- PSLV is an indigenously-developed expendable launch system
- It has 4 stages in its Operation. PSLV's first stage and third stage are solid-fuelled stages.
- PSLV's second stage and fourth stage are liquid-fuelled stages.
- The second stage engine, Vikas, is a derivative of France's Viking engine

- Developed by ISRO to place satellites mostly remote sensing satellites in polar and near polar Lower Earth Orbits
- Several PSLV missions were successful in sending satellites towards geosynchronous transfer orbit
- Chandrayaan-1 – 2008 and Mars Orbiter Mission were launched using PSLV

GSLV

- GSLV project was initiated to launch satellites to geosynchronous orbit (most of them are heavy for PSLV)
- 3 stages - GSLV has solid-fuelled first stage, liquid-fuelled second stage (vikas engine) and a cryogenic third stage
- Cryogenic rocket stage is more efficient and provides more thrust

SSLV

- Small Satellite Launch Vehicle (SSLV) is a 3 stage Launch Vehicle configured with three Solid Propulsion Stages (production – NSIL)
- Aim – to launch small payloads
- SSLV is capable of launching ~500kg satellite in 500km planar orbit
- The key features of SSLV are Low cost, with low turn-around time, flexibility in accommodating multiple satellites, Launch on demand feasibility, minimal launch infrastructure requirements, etc.

NEXT GEN LAUNCH VEHICLE

- In NGLV, ISRO is looking at a cost-efficient, three-stage to orbit, reusable heavy-lift vehicle with a payload capability of ten tonnes to **Geostationary Transfer Orbit (GTO)**
- It will feature **semi-cryogenic propulsion** (refined kerosene as fuel with liquid oxygen (LOX) as oxidiser) for the booster stages
- Use - launching **communication satellites, deep space missions, future human spaceflight and cargo missions**

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SCRAMJET ENGINE

- Scramjet and ramjet are both types of air-breathing jet engines that can operate at hypersonic speeds, which means they travel at speeds greater than Mach 5
- Ramjets are typically used for supersonic flight, which means they are most effective at speeds above Mach 2
- Scramjet is more advanced type of ramjet that can operate at even higher speeds

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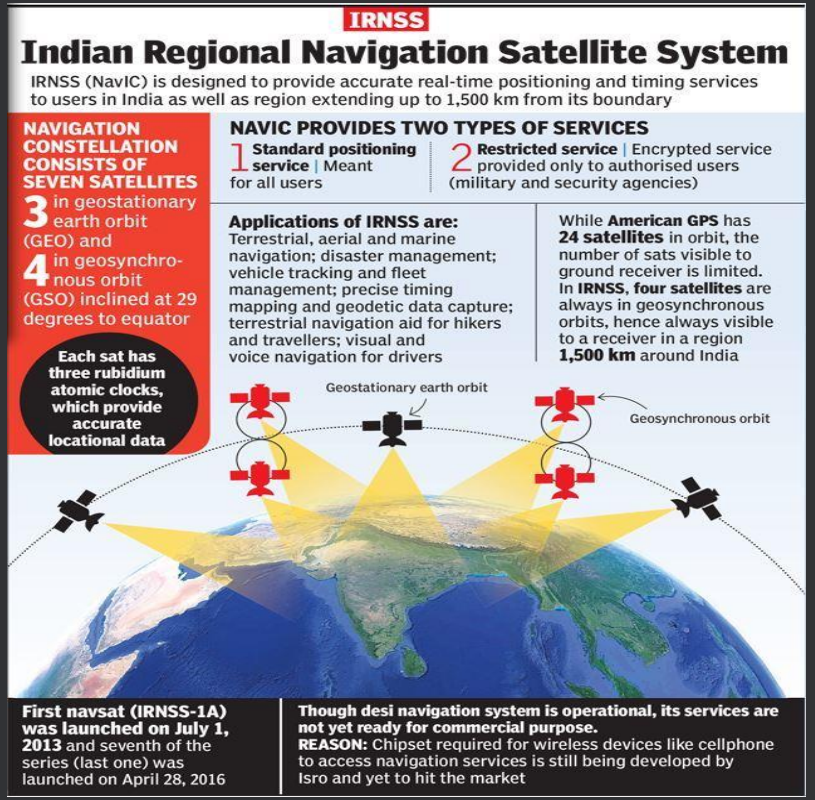
NAVIC



GAGAN

- GPS Aided GEO Augmented Navigation
- It is an Indian Satellite Based Augmentation System jointly developed by the **AAI** and the **ISRO** to provide the best available navigational services across the Indian FIR (Flight Information Region)
- GAGAN enhances the precision and reliability of location estimations by providing enhanced information to GPS receiving modules
- Applications – Railways , Traffic management

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GAGANYAAN

- Human spaceflight to LEO
- Program envisages two unmanned missions and one manned mission
- Objective is to demonstrate the indigenous capability to undertake a human space flight mission to LEO
- Launch Vehicle – LVM3
- Human Rated LVM3 - LVM3 is re-configured to meet human rating requirements with Crew Escape System (CES) & CARE module
- It has Environment Control & Life Support System

ASTROSAT

- It is a mission to observe the celestial sources simultaneously in X-Ray, Optical and UV Spectral bands simultaneously (First multi wavelength astronomy mission of ISRO)
- Launch vehicle – PSLV C30
- Satellite was placed into an orbit of 650 Km
- This has put India in an exclusive club of countries which have multi wavelength space observatories

NISAR

- NASA – ISRO – Synthetic Aperture Radar
- SAR measure changes in the surface of the Earth. It refers to a technique for producing high-resolution images
- NISAR can detect movements on the planet's surface as small as 0.4 inches
- It will scan the globe every 12 days over the course of its three-year mission of imaging the Earth's land, ice sheets and sea ice to give an unprecedented view of the planet

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MANGALYAAN

- India's first interplanetary mission
- Launch vehicle - PSLV-C25
- Primary objectives of the mission was to develop technologies required for designing and operating interplanetary missions
- Study the topography of Mars & Phobos
- Mission made India the first Asian country, and the fourth in the world after ROSCOSMOS, NASA & ESA
- Other missions - Tianwen – 1 , Hope Mission , Perseverance

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ADITYA – L1

- First space-based Indian mission to study the Sun
- Spacecraft shall be placed in a halo orbit around the Lagrange point 1 (L1)
- A satellite placed in L1 point has the major advantage of continuously viewing the Sun
- Launch Vehicle – PSLV XL
- The main objective is that it will help in tracking Earth-directed storms and predict its impact through solar observations
- Other Missions – Parker Solar Probe , Solar orbiter

IN – SPACe - Facilitator and regulator for the Private Space agencies to access Indian Space Infrastructure

NSIL - To commercially exploit the emerging global space market. It carries out Production of SSLV . Launch services to global satellite customers on board SSLV, PSLV, GSLV

Antrix Corporation Limited – Commercial & marketing arm of ISRO . Wholly owned GOI company

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MISSION PRARAMBH

- Launch of Vikram–S , India’s first privately launched rocket
- Vikram-S rocket is a single-stage sub-orbital launch vehicle developed by Skyroot Aerospace which would carry three customer payloads
- India’s first private launch pad- Sriharikota

SSA

- Space Situational Awareness (SSA) refers to keeping track of objects in orbit and predicting where they will be at any given time.
- It involves monitoring the movement of all objects, natural (meteors) ,man-made (satellites) and tracking space weather.
- SSA observatory – Digantara (space based startup) in Garhwal region , Uttarakhand
- **Project NETRA:** Early warning system in space to detect space debris and other hazards to Indian satellites

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KESSLER SYNDROME

- The Kessler Syndrome is a theoretical scenario in which the density of objects in low Earth orbit is so high that collisions between space debris and satellites or spacecraft would create a cascade of collisions, generating even more debris and making it increasingly difficult and risky to operate in space

POEM

- The Polar Orbital Experimental Module (POEM) is a platform that will assist in carrying out in-orbit experiments using the final and otherwise discarded 4th stage of ISRO's PSLV rocket

- Second dedicated commercial mission of NSIL

SARAS 3 TELESCOPE

- SARAS aims to design, build and deploy in India a precision radio telescope to detect extremely faint radio wave signals from the depths of time, from our “Cosmic Dawn” when the first stars and galaxies formed in the early Universe

- Cosmic Dawn is the period from about 50 million years to one billion years after the Big Bang

- It is an experimental effort of Raman Research Institute

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JAMES WEBB TELESCOPE

- It is the most powerful infrared telescope of NASA
- NASA + ESA + Canadian Space Agency
- The telescope will study the atmospheres of a wide variety of Exoplanets
- It will also search for atmospheres similar to Earth's, and for the signatures of key substances such as methane, water, oxygen
- Launched on an Ariane 5 ECA rocket to L2 region

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SOFIA MISSION

- It is a joint program between NASA and the German Aerospace Centre (DLR)
- Largest Air – borne observatory
- Stratospheric Observatory for IR astronomy
- It is a 2.7-meter infrared telescope designed to observe cosmic objects in far-infrared wavelengths
- In 2020, SOFIA discovered water molecules (H2O) on the sun-facing side **of the Moon**

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ARTEMIS MISSION

- NASA’s next-generation lunar exploration mission
- To land humans on the moon by **2024** and explore more of the lunar surface
- Artemis will be launched on the Space Launch System (SLS), which is the most powerful rocket in the world
- Astronauts will be sent aboard the Orion spacecraft from the Earth to lunar orbit

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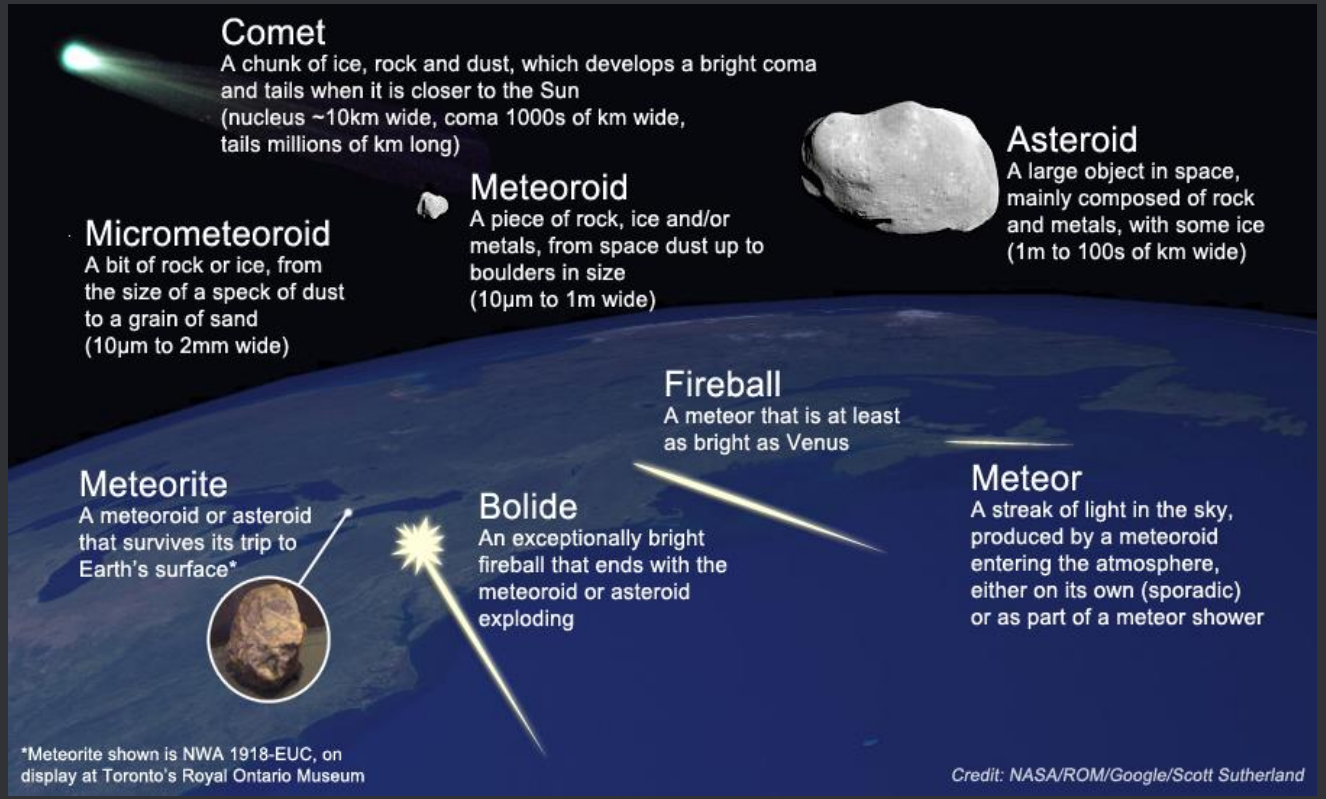

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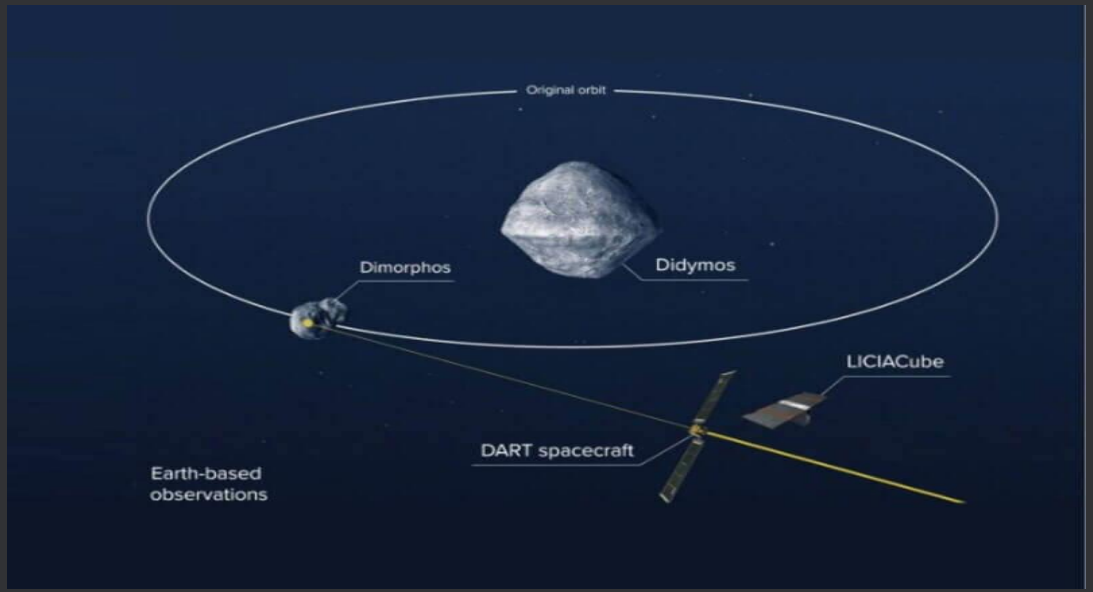
ASTEROID MISSIONS

- NASA mission of asteroid deflection by changing an asteroid's motion in space through kinetic impact



OSIRIS – Rex

- United States' first asteroid sample return mission
- It collected sample from Asteroid Bennu

Hayabusa Mission

- Japanese mission
- Asteroid Ryugu

STARLINK PROJECT

- Starlink is a SpaceX project to build a broadband network to provide space internet
- The goal of the project is to create a low-cost, satellite-based broadband network that can provide global internet access
- In Low Earth Orbit, the Starlink satellites will be placed in an altitude range between 350 km and 1,200 km

ARTEMIS ACCORD

- Artemis Accords ensures that space exploration is conducted in a safe, sustainable and transparent manner and in full compliance with international law
- The founding members of the Artemis Accords are Australia, Canada, Italy, Japan, Luxembourg, United Arab Emirates, United Kingdom, and the US
- India is not a member

ITER

- International Thermonuclear Experimental Reactor (ITER) is a **nuclear fusion power plant**
- ITER is a unique partnership of nations jointly responsible for the construction, operation, and decommissioning of an experimental fusion facility
- 35 nations are part of this project
- India joined in 2005
- EAST – Artificial sun of China

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THANK YOU