SPACE

Contents

1. Basic Physics

Fundamental Particles

- Atom - Electrons and nucleus
- Nucleus - Protons and Neutrons
- Matter particles, force particles
- Fermions,
- Bosons – gluon: bind proton and neutron; Higgs boson – mass; photon – EM energy;

Forces of interaction

'Four fundamental interactions' which are

- Gravity
- Electromagnetism
- Weak Nuclear force
- Strong Nuclear force

Standard Model predicts the presence of a particle called Higgs Boson.

GOD PARTICLE

- An invisible force field which formed after the big bang; responsible for giving mass to particles- Higgs Field.

CERN - LARGE HADRON COLLIDOR

- LHC is a giant particle accelerator, on the border of France and Switzerland.
- LHC accelerates protons to speed of light. They collide resulting in emergence of many particles one of which is Higgs boson.
- India an associate member; Validated standard model of physics;

NEUTRINOS

- Subatomic particles - mass less charge less; released while decaying of nucleus(beta decay); do not interact with matter;
- Observatories: IceCube observatory detected neutrons from distant galley for first time;
- Indian Neutrino observatory - at Bodi Hills, Theni District of Tamil Nadu; opposition – Periyar tiger reserve,

GRAVITATIONAL WAVES

- Ripples in the geometry of space and time.

LIGO

- The Gravitational-Wave Observatory (LIGO) - detect gravitational waves.
- Uses laser interferometry to measure the minute ripples in space-time.

LIGO-INDIA

- IndIGO (Indian Initiative in Gravitational-wave Observations)
- A site near Aundha Nagnath in the Hingoli District, Maharashtra has been selected.

LISA PATHFINDER

- Laser Interferometer Space Antenna
- ESA - build a space-based observatory for detecting gravitational waves.

2. Big bang theory

Star formation

Nebulae or molecular cloud – gravitational collapse; protostars – encompassed in dirt, more visible in Infrared;
Brown dwarf – not massive enough to fuse hydrogen (13 Jupiters);
Main sequence star – temperature 10 Mn kelvin; proton-proton chain reaction;
Red giant – exhaustion of hydrogen; fusion of Helium; expansion of outer atmosphere;
Chandrashekhar limit: object massive than this limit should collapse into neutron star;
Neutron star – more massive than 1.44 / 1.53 sun; protons and electrons combine to form neutrons;
Black hole – more than 3 solar masses; gravitational collapse;

BLACK HOLE

- Strong gravity - matter pressed into tiny space; event horizon – boundary marking outer edge of black hole; supermassive black holes – center of all galaxies; Schwarzchild radius – gravitational radius defining event horizon of black hole; Gravitational lensing: massive cosmic objects distort and magnify light from objects behind it; Einstein ring;
- Pulling force of gravity is so strong that light is not able to escape.

Dark matter/Dark energy

- Dark – do not emit light, charge; matter – have mass, interact through gravity;
- Universe: 5% visible matter; 95% dark matter and energy; dark matter – 27%;
- Dark energy: negative, repulsive, opposite to gravity; slows down expansion of universe; 68% of universe;

3. Engines – Rocket

- Ramjet
- Scramjet
- Rocket
- Cryogenic
- Semi-cryogenic

4. LAUNCH VEHICLES - INDIA

PSLV

- Polar Satellite Launch Vehicle - since 1994 - primarily developed to launch remote sensing satellites into sun synchronous orbits.
- PSLV is a 4-stage launch vehicle:
    - 1st & 3rd stages - solid.
    - 2nd & 4th stages - liquid.
    - Liquid engine: Vikas

PSLV can deliver payloads of up to:

- 3,250 kg to LEO (Low Earth Orbit)
- 1600 kg to SSO (Sun Synchronous orbit)
- 1400 kg to GTO (Geosynchronous Transfer Orbit)

GSLV

Geosynchronous Satellite Launch Vehicle -

- Payload: 2.5 tonne class in Geostationary Transfer Orbit; 4.5 tonne class in Low Earth Orbit.

3-stage Launch vehicle with

- 1st stage - solid fuel; 2nd stage – liquid; cryogenic in the 3rd stage.

Cryogenic engine

- Cryogenic means low temperature - highly efficient liquid propellant engines.
- It uses liquid oxygen and liquid hydrogen as the propellant.
- Highly efficient rocket stage that provides more thrust for every kg of propellant
- Technological challenges:
    - Ensure that both come in contact only in the combustion chamber.
    - Two different states of temperature are required to be maintained. To keep propellant in liquid state, low temperature is to be maintained while in the combustion chamber very high temperature and pressure are created by combustion to create a greater thrust.
- Semi cryogenic engine: heavy lift rockets; Liquid oxygen + RP-1 (rocket propellant 1) Kerosene;

GSLV MK-III / LVM 3

- Most powerful rocket of India - called ISRO's 'Fatboy',
- 3-stage heavy-lift rocket - indigenous cryogenic engine in the 3rd stage.
- Can carry more than 4 tonnes to GTO or about 10,000 kg to a LEO.
- Designated launch vehicle for Chandrayaan 2 and Gaganyaan.

Agniban

- semi-cryogenic 3D printed rocket engine – by Agnikul;
- India's 1st private space launchpad

Skyroot

- Prarambh mission:
- Vikram-S

5. Satellites

Hysis: Hyperspectral Imaging Satellite

- India's first hyperspectral imaging satellite - LEO - Sun-synchronous polar orbit
- Observes earth's surface in in 55 spectral or colour bands - spread across 3 different ranges including visible, near infrared and shortwave infrared.

IRNSS

- INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM - NavIC
- IRNSS is a 7-satellites constellation (GPS - 24)
- Position accuracy of 20 metres in its primary coverage area.
- Can service regions extending up to 1500 km around India's boundary.

It provides two types of services

- **Standard positioning service**- meant for all users.
- **Restricted service** - Encrypted service provided only to authorised users like military and security agencies.

4 satellites are placed in a geosynchronous orbit & 3 in geostationary orbit.

6. Space Missions

GAGANYAAN

- Will carry 3 astronauts to LEO (300 to 400 KM) for at least 7 days.
- Rocket: GSLV Mk-III
  - CREW MODULE ATMOSPHERIC RE-ENTRY TECHNOLOGY - CARE
  - CREW ESCAPE SYSTEM - for emergency or accidents
  - ENVIRONMENTAL CONTROL & LIFE SUPPORT SYSTEM - ECLSS
  - VYOMMITRA: ISRO's humanoid robot that will test-flight Gangayaan.

Other missions

- Aditya L1 : Solar
- Parker Probe: NASA, Solar
- Artemis: NASA, Moon
- Artemis accord: NASA -2000, peaceful use of outer space;
- Shukrayaan: Venus
- DART: Kinetic impactor, Didymos;
- Messenger: Mars
- Discovery, InSights, Spirit, opportunity: Mars lander and rover;
- New frontiers: NASA. – exploring solar system; New Horizon – Pluto;
- Lucy – Jupiter Trojan asteroids;

7. Space Bodies

NewSpace India Limited (NSIL)

- ISRO has formed the NewSpace India Limited (NSIL), a public sector undertaking (PSU) under the

administrative control of the Department of Space that will

- commercially exploit the research and development work of the space agency,
- Co-produce PSLV and launch satellites through Small Satellite Launch Vehicles (SSLVs).

IN-SPACe:

- It will act as a single-point interface between Indian Space Research Organisation (ISRO), and everyone who wants to participate in space-related activities, or use India's space resources.
- It will also hand-hold, promote and guide the private industries in space activities through encouraging policies and a friendly regulatory environment.

Antrix Ltd

- Itis another PSU under the Department of Space that acts as a commercial arm of ISRO and markets the products and services of the Indian Space Research Organisation (ISRO).

8. Solar system

Asteroid Belt

Torus-shaped region in the Solar System, located roughly between the orbits of the planets Jupiter and Mars;

Kupier Belt

- Disk-shaped region found in the outer solar system, past the orbit of Neptune;
- At least three dwarf planets are located in the Kuiper belt: Pluto, Haumea and Makemake;

Van Allen radiation belt

- Zone of energetic charged particles-originate from the solar wind, captured by and held around a planet by that planet's magnetosphere.
- Earth has two such belts, and sometimes others may be temporarily created.

Goldilocks Zone

It is the area around a star where it is not too hot and not too cold for liquid water to exist on the surface of surrounding planets.

Exoplanet

An exoplanet or extrasolar planet is a planet outside the Solar System.