India Approves Construction of LIGO

For Prelims: Gravitational Waves, LIGO-India Project

For Mains: Significance and benefit of LIGO-India Project.

Why in News?

Recently, the government approved the construction of the **Laser Interferometer Gravitational-Wave Observatory (LIGO) project** after seven years of in-principle approval.

- It will be built by the Department of Atomic Energy **and the Department of Science and Technology with the U.S. National Science Foundation** and several national and international research institutions.

What is LIGO-India Project?

- **About:**
  - The project **aims to detect** gravitational waves from the universe.
  - The Indian LIGO would have **two perpendicularly placed 4-km long vacuum chambers,** that constitute the most sensitive interferometers in the world.
  - It is expected to begin scientific runs **from 2030.**
- **Location:**
  - It will be located in the **Hingoli district of Maharashtra**, about 450 km east of Mumbai.
- **Purpose and Significance:**
  - It **will be the fifth node** of the planned network and will bring India into a **prestigious international scientific experiment.**
  - It will make India a unique platform that brings together the frontiers of science and technology of the **quantum and the cosmos.**
- **Benefits of LIGO-India:**
  - The LIGO-India project would have **several spin-off benefits** to Indian science, apart from making India an **integral part of** one of the **most prestigious international scientific experiments.**
  - The observatory is expected to enable dramatic returns in astronomy and **astrophysics,** as well as leapfrog Indian science and **technology in cutting-edge** frontiers of great national relevance.

What are Gravitational Waves?

- Gravitational waves were first postulated (1916) in **Albert Einstein's General Theory of Relativity,** which explains how gravity works.
- These waves are produced by the movement of massive celestial bodies, such as black holes or neutron stars, and are the ripples in spacetime that propagate outward.

What is LIGO?

- **About:** LIGO is an **international network of laboratories** that **detect gravitational waves.**
  - LIGOs are designed **to measure changes in distance that are several orders of magnitude smaller than the length of the proton.** Such high precision Instruments are needed because of the extremely low strength of gravitational waves that make their detection very difficult.

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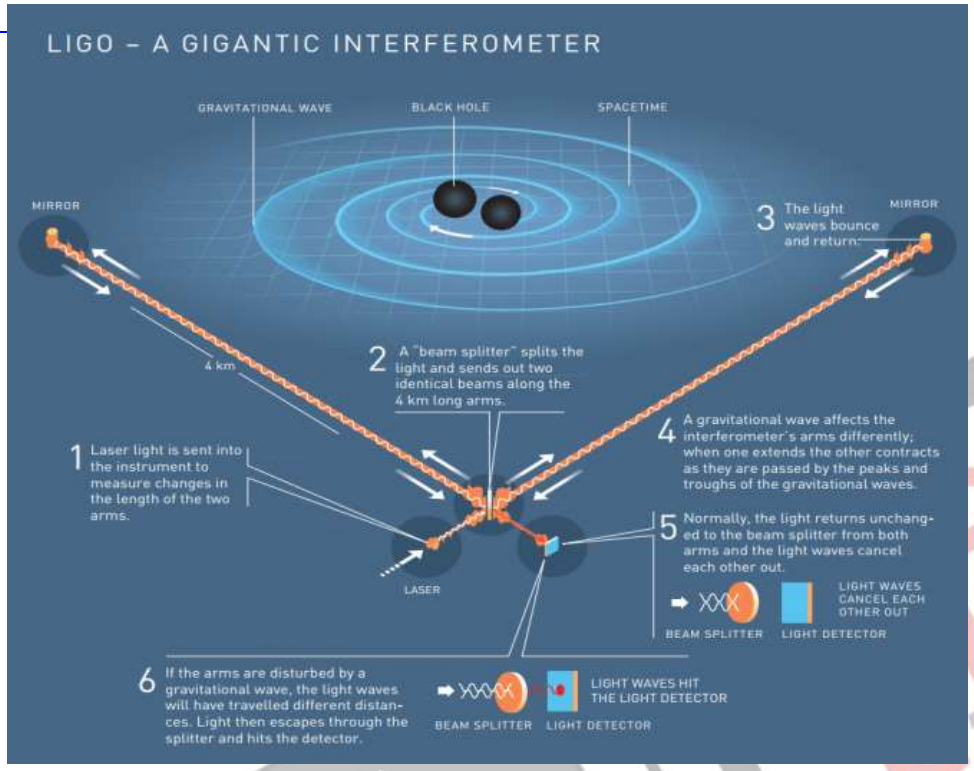

- **First Detection of Gravitational Waves:**
  - The LIGO in the US first detected **gravitational waves in 2015,** which led to a **Nobel Prize in Physics in 2017.**
    - These gravitational waves were produced **by the merger of two black holes, which were about 29 and 36 times the mass of the Sun,** 1.3 billion years ago.
    - Black hole mergers are **the source of some of the strongest gravitational waves.**
- **Operational LIGO:**
  - Besides **the United States (in Hanford and Livingston)**, such gravitational wave observatories are currently **operational in Italy (Virgo) and Japan (Kagra).**
    - **To detect gravitational waves,** four comparable detectors need to be operating simultaneously around the globe.
- **Working Mechanism:**
  - LIGO consists of two 4-km-long vacuum chambers, set up at **right angles to each other, with mirrors at the end.**
  - When light rays are released simultaneously in both chambers, they should return at the same time.
  - However, **if a gravitational wave arrives, one chamber gets elongated while the other gets squished, causing a phase difference in the returning light rays.**
    - Detecting this phase difference confirms the presence of a gravitational wave.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Q. Recently, scientists observed the merger of giant 'blackholes' billions of light-years away from the Earth. What is the significance of this observation? (2019)

(a) ‘Higgs boson particles’ were detected.
(b) ‘Gravitational waves’ were detected.
(c) Possibility of intergalactic space travel through ‘wormhole’ was confirmed.
(d) It enabled the scientists to understand ‘singularity’

Ans: (b)

Exp:

- Every few minutes a pair of black holes smash into each other. These cataclysms release ripples in the fabric of space time known as gravitational waves.
- Gravitational waves are ‘ripples’ in space-time caused by some of the most violent and energetic processes in the Universe.
- Albert Einstein predicted the existence of gravitational waves in 1916 in his General Theory of Relativity.
- The strongest gravitational waves are produced by catastrophic events such as colliding black holes, the collapse of supernovae, coalescing neutron stars or white dwarf stars, etc.
- Scientists have yet again detected gravitational waves produced by the merger of two light black holes about a billion light-years away from the Earth.
- It was recorded by Laser Interferometer Gravitational-Wave Observatory (LIGO).
- **Therefore, option (b) is the correct answer.**

Source: IE