Merger Of Two Black Holes with Unequal Masses Detected

Why in News

The gravitational wave observatories at **Laser Interferometer Gravitational-Wave Observatory (LIGO)** have detected a merger of **two unequal-mass black holes for the first time.**

Key Points

- The event, dubbed **GW190412,** was observed on 12th April, 2019. The event came almost **five years after the first ever detection of gravitational wave signals** by LIGO detectors.
    - On 14th September, 2015 the LIGO Observatories detected a signal from GW150914.
- **GW190412:** It involved the merger of two black holes weighing approximately **8 and 30 Solar masses,** respectively. The merger took place at a distance of **2.5 billion light years away.**
    - A solar mass is the mass of the sun equal to **approximately 2×10^{30} kg.**
    - It is a **standard unit of mass in astronomy.**
- The new unequal mass system is a **unique discovery** since all binaries observed previously by the LIGO and Virgo (Italy) detectors consisted of two roughly similar masses. This will make it possible to infer many more things such as:
    - a more **accurate determination of the distance** from the event.
    - the **spin or angular momentum** of the black hole with more mass.
    - the **orientation of the whole event** with respect to viewers on Earth.

- **Difference between binary blckholes of equal masses and unequal masses:**
    - Dominant emission of gravitational waves happens at **twice the orbital frequency** of the binary blackholes of **equal masses** and is negligible.
    - In binary blackholes with unequal masses, the emission happens at a **frequency that is three times the orbital frequency.**
        Orbital frequency is a scalar **measure of rotation rate.**
    - Also, in the merger of unequal black holes, the **spin of the more massive black hole** can be determined from the **extra features in the signal waveform.**
        The spin of the heavier black hole plays a more prominent role in the dynamics of the binary.
- **Verification with the prediction of General Relativity:**
    This observation once again confirms Einstein's theory of general relativity, which predicts the existence of higher harmonics, i.e. gravitational waves at two or three times the fundamental frequency.
    - General relativity, also known as the general theory of relativity, is the geometric theory of gravitation **published by Albert Einstein in 1915.**
    - **The key predictions of Einstein's theory:** the first direct **detection of gravitational waves** and the first **observation of the collision and merger of a pair of black holes.**

Black hole

- A black hole is a place in space where **gravity pulls so much that even light can not get out.** The gravity is so strong because **matter has been squeezed into a tiny space.**
- Gravitational waves are created when two black holes orbit each other and merge.

Laser Interferometer Gravitational Wave Observatory:

- LIGO is the **world's largest gravitational wave observatory.**
- LIGO consists of two widely separated interferometers within the United States - one in Hanford, Washington and the other in Livingston, Louisiana - operated in unison to detect gravitational waves.
- Though its mission is to detect gravitational waves from some of the most violent and energetic processes in the Universe, the data LIGO collects may have effects on many areas of physics including **gravitation, relativity, astrophysics, cosmology, particle physics, and nuclear physics.**

<u>Source : TH</u>