



Black Hole Merger

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Why in News?

An international team of scientists has detected the most **massive black hole merger** ever observed. The event, named **GW231123**, was observed by the **LIGO-Virgo-KAGRA (LVK) collaboration**, which forms the **Gravitational Wave Network**.

What is a Black Hole Merger?

- **About:** A black hole merger occurs when **two black holes orbit each other** and gradually move closer by emitting [gravitational waves](#) (ripples in space-time caused by some of the most violent and energetic processes in the universe).
 - As they spiral inward, they eventually **collide and merge into a single, larger black hole**.
 - These gravitational waves are detected on Earth by observatories like the LVK network of gravitational wave observatories.
- **Significance of GW231123:** It involved two black holes, approximately **100 and 140 times** the mass of the Sun, colliding to form a single, massive black hole about **225 times the Sun's mass**.
 - The waves from GW231123 actually **originated billions of years ago**, but only reached Earth in 2025.
 - This black hole merger, unlike **typical stellar black holes under 60 solar masses**, GW231123 is much bigger and **spinning unusually fast**, making the discovery even more intriguing.
- **Implications:** Black holes this big are typically thought to come from the collapse of huge stars. This event suggests that some may instead **form through mergers** of smaller black holes.

Gravitational Wave Network

- The gravitational wave network, often referred to as the LVK collaboration, is a global alliance of observatories that work together to detect gravitational waves.
- LVK:
 - **LIGO (Laser Interferometer Gravitational-Wave Observatory):** The first to detect gravitational waves in 2015, LIGO has two detectors located in the US.
 - That historic gravitational wave detection confirmed a prediction made by Einstein (predicted their existence in his general theory of Relativity in 1916) and earned the **2017 Nobel Prize in Physics**.
 - **Virgo:** Located in Italy, Virgo joined the network to increase detection accuracy and help pinpoint the location of events.
 - **KAGRA (Kamioka Gravitational Wave Detector):** A newer detector in Japan, KAGRA adds sensitivity and a broader geographic spread.

Note: India in collaboration with the US is building the third detector of LIGO, which will be known as **LIGO-India**.

BLACK HOLES

ABOUT

- A place in space with **extremely high gravity pull**; even light can't escape (hence, **invisible**)
- The strong gravity is due to matter being squeezed into a tiny space

The term 'black hole' was coined in the mid-1960s by American physicist John Archibald Wheeler

Albert Einstein and Black Hole

- First predicted their existences in **Theory of General Relativity**
- It showed that when a massive star dies, it leaves behind a small, dense remnant core

India's first dedicated satellite, AstroSat observed for the very first-time rapid variability of high energy X-ray emission from a black hole system

DETECTION

- By seeing how stars very close to black holes act differently than other stars
- In April 2019, scientists at the **Event Horizon Telescope Project** released the first-ever image of a Black Hole (shadow, more precisely)

TYPES

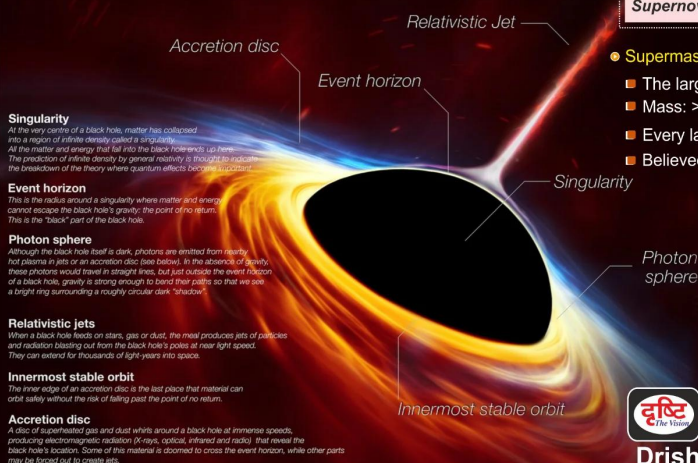
- **Miniature (Hypothetical):**
 - The smallest; size of just 1 atom
 - Mass: varies from 1/100th of a milligram to the mass of a large mountain
 - Believed to be formed when universe began
- **Stellar:**
 - Mass: 20x the mass of sun
 - Believed to be formed due to Supernovae explosion

Supernova is an exploding star that has reached the end of its life

- **Supermassive**
 - The largest
 - Mass: >1 million suns together
 - Every large galaxy has a supermassive black hole at its centre
 - Believed to be made at the same time as their home galaxy

Sagittarius A is the supermassive black hole at the centre of Milky Way (mass: ~about 4 mn suns)

The Sun will never turn into a black hole as it is not big enough to make a black hole



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UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims

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)

Q. What is the purpose of 'evolved Laser Interferometer Space Antenna (eLISA)' project? (2017)

- (a) To detect neutrinos

- (b) To detect gravitational waves
- (c) To detect the effectiveness of missile defence system
- (d) To study the effect of solar flares on our communication systems

Ans: (b)

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