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GRAVITATIONAL WAVE DISTURBANCES: HOW WILL INDIA CONTRIBUTE TO LIGO?

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An aerial view of the LIGO detector site near Livingston, Louisiana, U.S. that was released by Caltech/MIT/LIGO Laboratory in 2016. | Photo Credit: LIGO Laboratory

The story so far: On September 14, 2015, the two LIGO detectors in the U.S., at Livingston in Louisiana, and Hanford in Washington, registered a disturbance that was not unlike the chirp of a bird. It was due to gravitational waves travelling outwards from a point 1.3 billion light years away from the earth. At this point, two massive black holes with masses 29 and 36 times that of the sun had merged to give off gravitational wave disturbances. Black holes are exotic objects that we know little about, but their immense gravitational pull which traps even the fastest object in the world, which is light, is legendary. When objects with such an immense gravity merge, the disturbance is felt by the very fabric of space time and travels outward from the merger, not unlike ripples on a pond surface. Thus, gravitational waves have been described as “ripples in the fabric of space time”. Following the 2015 detection, which later won the Physics Nobel (2017), the two LIGO detectors detected seven such binary black hole merger events before they were joined by the European Virgo detector in 2017. The two facilities have now detected 10 events. The Japanese detector, KAGRA, or Kamioka Gravitational-wave Detector, is expected to join the international network soon. In the meantime, in a collaboration with LIGO, a gravitational wave detector is being set up in India. The LIGO India project is expected to join the international network in a first science run in 2025.

The acronym LIGO stands for Laser Interferometer Gravitational-Wave Observatory. LIGO consists of a pair of huge interferometers, each having two arms which are 4 km long. Remarkable precision is needed to detect a signal as faint as a gravitational wave, and the two LIGO detectors work as one unit to ensure this. Naturally, this requires weeding out noise very carefully, for when such a faint signal is being detected, even a slight human presence near the detector could derail the experiment by drowning out the signal.

LIGO, unlike usual telescopes, does not “see” the incoming ripples in spacetime. It does not even need to, because gravitational waves are not a part of electromagnetic spectrum or light. They are not light waves but a different phenomenon altogether — a stretching of spacetime due to immense gravity. A single LIGO detector cannot confidently detect this disturbance on its own. At least two detectors are needed. This is because the signal is so weak that even a random noise could give out a signal that can mislead one into thinking a genuine gravitational wave has been detected. It is because two detectors have detected the faint signal in coincidence that the observer is convinced it is a genuine reading and not noise.

Right now, with just three detectors, there is huge uncertainty in determining where in the sky the disturbance came from. Observations from a new detector in a far-off position will help locate the source of the gravitational waves more accurately.

Mergers of black holes or neutron stars, rapidly rotating neutron stars, supernova explosions and the remnants of the disturbance caused by the formation of the universe, the Big Bang itself, are the strongest sources. There can be many other sources, but these are likely to be too weak to detect.

As a largely unknown and fundamental phenomenon, gravitational waves are interesting to scientists. But once many more detectors are in place, the study also offers a new way to map out the universe, using gravitational-wave astronomy. Perhaps one day we will have such accurate detection facilities that signatures of gravitational waves bouncing off celestial objects can help us detect and map them.

LIGO India will come up in Maharashtra, near Aundha in Hingoli district. Most of the land has been acquired, and the small balance is going through a slightly longer acquisition procedure. The project is formally in the construction phase, with the building design conceptualised. Says Tarun Souradeep, spokesperson for LIGO India, “We are close to finalising the civil infrastructure drawings. The plans for immense vacuum infrastructure have been conceptualized, reviewed and are in an advanced stage.”

Like the LIGO detectors, the one at LIGO India will also have two arms of 4 km length. But while there are similarities there will be differences too. Being an ultra-high precision large-scale apparatus, LIGO India is expected to show a unique “temperament” determined by the local site characteristics. In an email to *The Hindu*, Dr. Souradeep, says, “LIGO India and its complex feedback control loops to high sensitivity will follow a fairly independent track and poses an exciting full-scale challenge. Under a memorandum of understanding, the National Geophysical Research Institute is carrying out a year-long, multiple-station seismic survey campaign at the LIGO India site to characterise the local properties. This is in addition to the elaborate geotechnical and geophysical survey completed earlier this year.”

Some of it includes design and fabrication of ultra stable laser, quantum measurement techniques, handling of complex control system for enforcing precision control, large-scale ultra-high vacuum technology, data analysis and machine learning. This is not a complete list and the development of such indigenous technology is likely to result in many spin-offs for industry and research.

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