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DETECTING THE UNIFIED CALL OF BLACK HOLES AND STARS

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Reaching out: Detections till now have been of events that were relatively close to us. | Photo Credit: Pitris

Since the first detection of the merger of black holes dated September 14, 2014, by the two gravitational wave detectors at LIGO in the U.S., the field has witnessed important developments. The LIGO detectors have been joined in their search for gravitational waves from various sources by the VIRGO detector in Italy and the KAGRA detector in Japan. The Indian detector LIGO India is being developed and is expected to join these in their search. In the meantime, Indian scientists have been involved in many aspects of the research and data analysis, especially in gravitational wave radiometry, which is a way to measure gravitational waves from hitherto unknown sources and detect their presence in the sky.

Until now, the number of mergers detected by LIGO, VIRGO and KAGRA detectors is minuscule compared with the number of mergers actually taking place in the sky. The idea that the gravitational waves arising from the collection of all these mergers should be present like a background signal has been around for some time. As suggested by Sanjit Mitra of IUCAA Pune, who has worked in this area, take the analogy of people watching a football game: When you observe individual members among the spectators, you can see their actions, hear their comments etc. But when you look at the crowd as a whole, you may observe the roaring sound of the applause and the cheering which is quite different from observing individuals. The background gravitational waves are like watching the stadium from far, while detections made by the detectors so far has been like observing individuals. Dr. Mitra and a team of researchers have contributed significantly to building up an algorithm that is geared to detect such a so called stochastic gravitational wave background. Their recent work has been published in *Physical Review D.*

Just as studying the cosmic microwave background tells us about the early universe, its formation, the stochastic gravitational wave background would reveal the structure of the universe around us. Detections till now have been of events that were relatively close to us. Distant binary coalescences, milli-second pulsars, etc are expected to produce a background, and detecting any of this would be a great breakthrough.

The radiometer algorithm which Indian researchers played a key role in developing, comes in useful as a tool for detecting hitherto unknown sources: “So far what we have detected gravitational waves from binary mergers, which are well-modelled sources. If we have to detect an unknown source which is persistent, such as the stars which are unlike supernovae which are momentary, it is like scanning every direction of the sky and making a map,” says Dr Mitra. With recent algorithms developed in India, the radiometer analysis has been made hundreds of times faster and they are now being used by the international collaboration for the official analysis.

The gravitational wave background consists of an isotropic component and an anisotropic component. The isotropic component is constant when you look in different directions and the anisotropic component depends on the direction. In the football field analogy, suppose the home team scores, there is a uniform applause and cheering emanating from all over. This is what the isotropic component is like. On the other hand when a player whose fans are gathered in a small corner of the stadium make noise to support him or her, or a wavelike disturbance is set up in the crowd, this is like the anisotropic component.

The present results are not that the isotropic component has been detected, we are still far from that, but that the group has successfully shown that it must be below a certain level as otherwise it would have been detected. Future improved versions of the detectors will have to work below this level to detect the background.

“If the gravitational wave background is discovered, it will be a major discovery in astronomy, probably one of the most celebrated ones,” says Dr.Mitra. “It will primarily tell us about the distant astrophysical sources and the early universe. Disentangling these pieces of information and extracting scientific inferences from those measurements will become a very hot topic.”

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