Source : www.thehindu.com Date : 2019-11-17

WEEDING OUT BLACK HOLE MIMICKERS BY LOOKING AT GRAVITATIONAL WAVES

Relevant for: Geography | Topic: The Earth and the Solar System

Remote objects: The properties of merging black holes can be calculated from the initial part of the signal waveform. | Photo Credit: LIGO

In September 2015, the LIGO detectors in the US made history by directly detecting for the first time the merging of two black holes. Since then, LIGO, joined by other detectors around the world, has gone on to detect eleven events of which one is the merger of two neutron stars and the remaining ten, of pairs of black holes (binary black holes).

As they spiralled in towards each other and merged, the binary black holes let off characteristic gravitational wave signals. The properties of the merging black holes, namely the masses and spins could be arrived at by looking at the initial part of the signal waveform. Similarly, by carefully looking at the tail end – also known as the ring down part of the signal, the mass and spin of the final merged state (black hole) can be inferred.

The question emerges – whether other exotic objects exist that may act as black hole mimickers and give off similar signals. And if so, how is one to distinguish between such spinning black holes and exotic objects?

Theoretically, there are possibilities such as the so-called gravastars and boson stars which are black hole mimickers. For instance, a gravastar is a strange object that would have a core of exotic matter resembling dark energy with an external shell of normal star-like matter. “There are no observational evidences for their existence till date, but then, there were not too many ways in which one could look for them. Gravitational waves could be one…” says K. G. Arun, Chennai Mathematical Institute, Chennai, who led the study.

The spinning of the compact object has a different effect on it whether it is a black hole or, for instance, a gravastar. Since the gravastar is filled with dark energy, it exerts a negative pressure on the outside. So when it spins it behaves differently from normal stars and black holes. When a normal star spins about an axis, it tends to bulge about the equator and get compressed at the poles. However, for a gravastar this effect is just reversed – It gets compressed near the equator and bulges out at the poles. Thus their shapes change differently when spinning.

“Any compact object, in general, can undergo deformations due to its spinning motion and these deformations are expressed in terms of what is called spin-induced multipole moments,” says M. Saleem an author of the paper published in *Physical Review D,* who is a post-doctoral fellow at CMI.

“For black holes, due to the existence of event horizon, any property we measure from outside will depend on only its mass and spin, unlike other compact objects. This is the fact which we make use in our proposed test,” he explains.

One property that can distinguish between a black hole and exotic object is known as spin-induced quadrupole moment. This parameter takes the value 1 for a black hole. “For other compact objects, the value ... of this parameter is different from 1 and will vary depending on the internal structure,” says N. V. Krishnendu, the first author, formerly a PhD student at CMI, and now a post-doctoral researcher at Albert Einstein University, Hannover.

The researchers, including C.K. Mishra of IIT Madras, tested out their ideas on the events detected so far and found that the events of 2015, December and 2017, June were indeed just binary black hole mergers. These were the “low-mass” events for which their method is applicable. Further development of the idea can be used as a tool to discover exotic objects.

END