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FIRST MERGER OF TWO BLACK HOLES WITH UNEQUAL MASSES DETECTED

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Gravity: The black hole’s spin drags along the nearby space-time.

For the first time since it started functioning, the gravitational wave observatories at LIGO scientific collaboration have detected a merger of two unequal-mass black holes. The event, dubbed GW190412, was detected nearly a year ago, and this is almost five years after the first ever detection of gravitational wave signals by these powerful detectors. Subsequent analysis of the signal coming from the violent merger showed that it involved two black holes of unequal masses coalescing, one of which was some 30 times the mass of the Sun and the other which had a mass nearly 8 times the solar mass. The actual merger took place at a distance of 2.5 billion light years away. This study has been published in preprint server *ArXiv,* and is pending peer review.

The detected signal’s waveform has special extra features in it when it corresponds to the merger of two unequal-sized black holes as compared with a merger of equal-sized black holes. These features make it possible to infer many more things about the characters in this celestial drama, namely, a more accurate determination of the distance from the event, the spin or angular momentum of the more massive black hole and the orientation of the whole event with respect to viewers on Earth.

While the mass of the black hole bends the space-time close to it, the spin or angular momentum of this inscrutable object drags the nearby space-time, causing it to swirl around, along with it. Hence both these properties are important to estimate.

Pointing out the difference between binary black holes with equal masses and those with different masses, K.G. Arun of Chennai Mathematical Institute (CMI), says, ”Dominant emission of gravitational waves happens at twice the orbital frequency of the binary… In this case, we find, for the first time, emission at a frequency that is three times the orbital frequency. This emission is negligible when binaries contain equal masses and when the orbit is face-on. GR has a unique prediction for the details of this emission which is verified by this observation.”

Anand Sengupta of IIT Gandhinagar, along with Prof. Arun and Phd scholar Soumen Roy from IIT Gandhinagar made important contributions to this analysis. The trio worked on the contribution to the signal from higher harmonics which form a fainter component to the signal. “Following this a sophisticated statistical analysis was performed to measure the strength of the sub-dominant component and its statistical significance, by calculating the odds that it was not a false positive. For instance, that it was not some instrumental noise mimicking this effect,” says Prof. Sengupta. “The asymmetry in the masses made the feeble higher harmonic component better ‘heard’, leading to its unambiguous detection,” he adds.

Also, in the case of 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. Hence, it leaves a stronger imprint on the waveform, making it easy to measure,” says Prof. Arun.

A second Indian team consisting of researchers from ICTS-TIFR, Bengaluru, verified the consistency of the signal with the prediction of General Relativity.

The existence of higher harmonics was itself a prediction of General Relativity.

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