LIGO Detects Gravitational Waves Once Again

Binary black hole mergers emerging as a new tool for probing the universe and understanding strong gravity

The two detectors of the Laser Interferometer Gravitational-wave Observatory (LIGO), in Hanford (WA) and Livingston (LA), have once again detected gravitational waves from the merger of two stellar mass black holes. The merger happened three billion light-years away but its waves reached Earth on January 4, 2017. GW170104 is the farthest event LIGO has observed ever since it began operations in its advanced configuration in September 2015.

The new detection occurred during LIGO's ongoing second observing run, which began on November 30, 2016. The first two direct observations of gravitational waves were made, respectively, in September and December of 2015, during LIGO's first observing run. The third detection is described in a recent paper in the journal, Physical Review Letters. These detections were made by scientists and engineers of the LIGO Scientific Collaboration and Virgo Collaboration. Washington State University professor Sukanta Bose, graduate student Bernard Hall, and adjunct faculty member Nairwita Mazumder contributed to this finding.

The three WSU scientists collaborated with other members of the LIGO Scientific Collaboration in characterizing the detectors, thereby, improving their sensitivity to these weak signals. Specifically, they did analyses on the data that helped to identify artifacts so that their noise sources could be understood, and then either eliminated, or otherwise mitigated in their effect. Because such artifacts can obscure the signals in the detectors, it is important that every effort be made to remove this type of background, so that true signals are not lost in noise, and so that phenomena of a non-astrophysical origin are not mistaken for true signals. This, in turn, helped in extending the depth to which LIGO can search for these cosmic events.

The two black holes that merged to produce the GW170104 signal were 31 and 19 times as massive as our Sun, respectively. Their merger produced a larger black hole of about 49 solar masses as a remnant. Unlike the last two events, here the observation indicates that at least one of the two black holes that merged might have been spinning about an axis not completely aligned with the orbital rotation of the binary. This suggests that there is more than one way these binaries are formed. Along with the first two detections, GW170104 is subjecting Einstein's theory of gravity, General Relativity, to increasingly stringent observational tests. So far, however, there is no indication that these events deviate from Einstein's predictions.

Like the last two events, in this case as well, multiple telescopes were used by astronomers to search for electromagnetic counterparts. In some of these sky pointings, a technique developed by Bose and his collaborators was used to enhance the chances of finding an afterglow, in case the merger emitted such radiation. "The fact that no counterpart has been found is consistent with what we expect from the merger of two black holes," said Bose. "But we should still search for it since we have not exhaustively explored all possible fates of these mergers." He further hopes that future LIGO observations will find binaries of neutron stars. A neutron star is about fifty percent heavier than the Sun, and is formed from the core of a massive star at the end of its life when the star itself is about ten to thirty times as massive as the Sun. The merger of a neutron star with another one of its kind will produce gravitational waves that will have an imprint of its composition, which is only partially understood and is an area of intense research that Bose has contributed to.

The LIGO Laboratory is funded by the NSF, and operated by Caltech and MIT, which conceived and built the Observatory. The NSF led in financial support for the Advanced LIGO project with funding organizations in Germany (MPG), the U.K. (STFC) and Australia (ARC) making significant commitments to the project. More than 1,000 scientists from around the world participate in the effort through the LIGO Scientific Collaboration, which includes the GEO Collaboration. LIGO partners with the Virgo Collaboration, which is supported by Centre National de la Recherche Scientifique (CNRS), Istituto Nazionale di Fisica Nucleare (INFN) and Nikhef, as well as Virgo's host institution, the European Gravitational Observatory, a consortium that includes 280 additional scientists throughout Europe. Additional partners are listed at: http://ligo.org/partners.php.