CENTER FOR GRAVITATIONAL WAVE ASTRONOMY
Press release

LIGO and Virgo make first detection of gravitational waves produced by colliding neutron stars.
Several astronomers, UTRGV CGWA, among them participated in the discovery which marks first cosmic event observed in both gravitational waves and light.

For the first time, scientists have directly detected gravitational waves — ripples in space and time — in addition to light from the spectacular collision of two neutron stars. This marks the first time that a cosmic event has been viewed in both gravitational waves and light.
The discovery was made using the U.S.-based Laser Interferometer Gravitational-Wave Observatory (LIGO); the Europe-based Virgo detector; and some 60 ground- and space- based telescopes. Among these 60, the TOROS (Transient Optical Robotic Observatory of the South), an international collaboration with more than 50 scientists, and lead by CGWA faculty and students, operated two telescopes: one in Co. Tololo, Chile and the other one in Bosque Alegre, Argentina.

Neutron stars are the smallest, densest stars known to exist and are formed when massive stars explode in supernovas. As these neutron stars spiraled together, they emitted gravitational waves that were detectable for about 100 seconds; when they collided, a flash of light in the form of gamma rays was emitted and seen on Earth about two seconds after the gravitational waves. In the days and weeks following the smashup, other forms of light, or electromagnetic radiation — including ultraviolet, optical, infrared, and radio waves — were detected.

The observations have given astronomers an unprecedented opportunity to probe a collision of two neutron stars. For example, observations made by the U.S. Gemini Observatory, the European Very Large Telescope, and NASA's Hubble Space Telescope reveal signatures of recently synthesized material, including gold and platinum, solving a decades-long mystery of where about half of all elements heavier than iron are produced.

The LIGO-Virgo results are published today in the journal Physical Review Letters; additional papers from the LIGO and Virgo collaborations and the astronomical community have been either submitted or accepted for publication in various journals.

CGWA TOROS group also publishes today an article in the Astrophysical Journal Letters that summarizes its observations.

A stellar sign

The gravitational signal, named GW170817, was first detected on Aug. 17 at 8:41 a.m. Eastern Daylight Time; the detection was made by the two identical LIGO detectors, located in Hanford, Washington, and Livingston, Louisiana. A third detector, Virgo, situated near Pisa, Italy, recovered only a small signal but provided crucial information for localizing the cosmic event.

Around the same time, the Gamma-ray Burst Monitor on NASA's Fermi space telescope had detected a burst of gamma rays.

The data indicated that two astrophysical objects located at the relatively close distance of 130 million light-years from Earth had been spiraling in toward each other. The inspiraling objects were estimated to be in a range from around 1.1 to 1.6 times the mass of the sun, in the mass range of neutron stars. A neutron star is about 20 kilometers, or 12 miles, in diameter and is so dense that a teaspoon of neutron star material has a mass of about a billion tons.

While binary black holes produce "chirps" lasting a fraction of a second in the LIGO detector's sensitive band, the Aug. 17 chirp lasted approximately 100 seconds and was seen through the entire frequency range of LIGO — about the same range as common musical instruments. Scientists could identify the chirp source as objects that were much less massive than the black holes seen to date.

Dr. Mario Díaz says that "this detection nicely confirms a long expected astrophysical event and ties many loose ends. It confirms that the source of short duration Gamma Ray Bursts are these collisions, and confirms that an optical event had to be associated with it".

Theorists have predicted that when neutron stars collide, they should give off gravitational waves and gamma rays, along with powerful jets that emit light across the electromagnetic spectrum. The gamma-ray burst detected by Fermi is what's called a short gamma-ray burst; the new observations confirm that at least some short gamma-ray bursts are generated by the merging of neutron stars — something that was only theorized before.

But while one mystery appears to be solved, new mysteries have emerged. The observed short gamma-ray burst was one of the closest to Earth seen so far, yet it was surprisingly weak for its distance. Scientists are beginning to propose models for why this might be, McEnery says, adding that new insights are likely to arise for years to come.

A patch in the sky

Though the LIGO detectors first picked up the gravitational wave in the United States, Virgo, in Italy, played a key role in the story. Virgo recovered a small signal; combined with the signal sizes and timing in the LIGO detectors, this allowed scientists to triangulate the position in the sky. Scientists concluded that a gravitational wave came from a relatively small patch in the southern sky. This event has the most precise sky localization of all detected gravitational waves so far.

This much better localization allow a handful of observatories around the world, hours later, to start searching the region of the sky where the signal was thought to originate. A new point of light, resembling a new star, was first found by optical telescopes. Ultimately, about 60 observatories on the ground and in space observed the event at their representative wavelengths.

At the moment of collision, the bulk of the two neutron stars merged into one ultradense object, emitting a “fireball” of gamma rays. The initial gamma-ray measurements, combined with the gravitational-wave detection, also provide confirmation for Einstein’s general theory of relativity, which predicts that gravitational waves should travel at the speed of light.

Theorists have predicted that what follows the initial fireball is a “kilonova” — a phenomenon by which the material that is left over from the neutron star collision, which glows with light, is blown out of the immediate region and far out into space. The new light- based observations show that heavy elements, such as lead and gold, are created in these collisions and subsequently distributed throughout the universe.

CGWA TOROS optical observations confirm this, having detected, like other groups, that the kilonova observed was brighter in the blue region of the spectrum than some theoretical models had predicted.

The **Center for Gravitational Wave Astronomy** was founded in 2003 with grants from the National Aeronautic Space Administration and the National Science Foundation. Its founding scientists UTRGV Profs. Mario Diaz and Joseph Romano are members of the LIGO Scientific Collaboration since 1998, The CGWA has the largest group of gravitational- wave researchers in Texas and one of the largest in the USA involved in the LIGO Scientific Collaboration global research effort. The TOROS collaboration is led by Principal Investigator Prof. Diaz with coPIs TAMU Prof. Lucas Macri and University of Cordoba (Argentina) Prof. Diego Garcia Lambas,

---

LIGO is funded by the NSF, and operated by Caltech and MIT, which conceived of LIGO and led the Initial and Advanced LIGO projects. Financial support for the Advanced LIGO project was led by the NSF with Germany (Max Planck Society), the U.K. (Science and Technology Facilities Council) and Australia (Australian Research Council) making significant commitments and contributions to the project.
More than 1,200 scientists from around the world participate in the effort through the LIGO Scientific Collaboration, which includes the GEO Collaboration. Additional partners are listed at http://ligo.org/partners.php.

The Virgo collaboration consists of more than 280 physicists and engineers belonging to 20 different European research groups: six from Centre National de la Recherche Scientifique (CNRS) in France; eight from the Istituto Nazionale di Fisica Nucleare (INFN) in Italy; two in the Netherlands with Nikhef; the MTA Wigner RCP in Hungary; the POLGRAW group in Poland; Spain with the University of Valencia; and the European Gravitational Observatory, EGO, the laboratory hosting the Virgo detector near Pisa in Italy, funded by CNRS, INFN, and Nikhef.