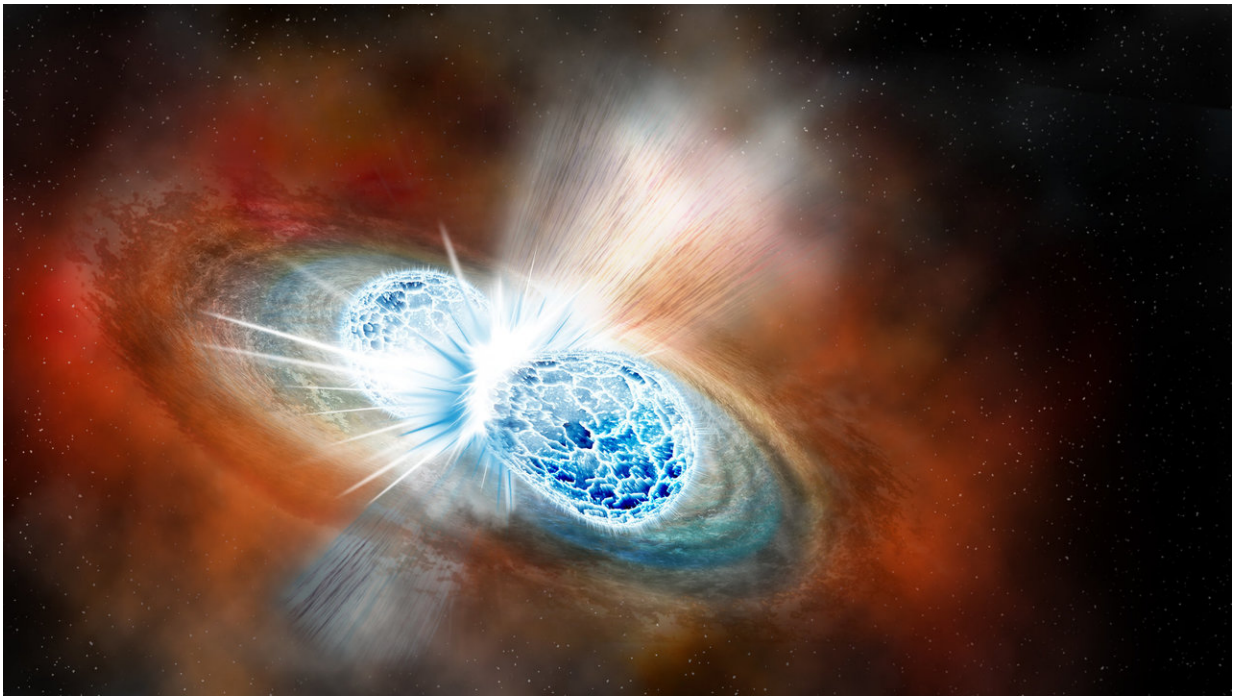
Astronomers first to see source of gravitational waves in visible light

October 16 2017



An artists rendition of merging neutron stars. Credit: Robin Dienel; Carnegie Institution for Science

For the first time, astronomers have observed in visible light a cataclysmic cosmic event that generated gravitational waves detected on Earth.

The event was the merger of two neutron stars in a galaxy 130 million

light-years away. The merger resulted in a supernova-like explosion, the light of which was first observed by a team of astronomers at the Carnegie Institution for Science's Las Campanas Observatory in northern Chile.

The breakthrough discovery of the visible counterpart of a gravitational-wave-triggering event marks the start of a new era in which astronomers can study cosmic phenomena using both gravitational wave experiments and traditional telescopes.

The discovery also sheds light on the nature of neutron star mergers, and provides insight into the origin of heavy elements such as gold and platinum—insight which has long remained elusive.

The team includes Carnegie-Dunlap Fellow Maria Drout, along with astronomers from the Carnegie; the University of California, Santa Cruz; and other institutions.

Gravitational wave detection triggers search for visible counterpart

Scientists from the Laser Interferometer Gravitational Observatory (LIGO) and Virgo experiment detected the gravitational waves on August 17, 2017. They determined that the signal was the result of a binary neutron star merger—a first, as all previous detections were of binary black hole mergers.

While astronomers don't expect to see a visible counterpart to a binary black hole merger, they do when two neutron stars come together. So, when LIGO/Virgo scientists narrowed down the location of the event to a patch of the southern sky the size of over a hundred full moons, they notified the team of astronomers—and the search was on.

But, it was still daytime in Chile which, for Drout and her colleagues, meant a ten hour wait until sunset. Plus, when the sun finally set, the search area was nearing the horizon.

According to Drout, "We knew we only had about an hour at the beginning of the night to find the source before it set, so we had to act fast."

The astronomers began recording images of galaxies within the target area according to a careful search strategy they had prepared during the day. They brought to bear three telescopes at Las Campanas: the Swope and two Magellan telescopes. As they obtained images, the collaborators compared them with archival images of the same galaxies.

After examining galaxies in nine images, members of the team exchanged a short series of messages:

"found something

sending you a screenshot."

"wow!"

"!"

The astronomers had found what they were looking for: a bright, star-like object, designated SSS17a. It was located in a galaxy identified as NGC 4993 and had not been visible in archival images.

Further confirmation came from analysis led by Drout. It showed that aspects of the brightness of SSS17a were unlike any explosion that had been previously observed by astronomers. SSS17a was about as bright as a faint supernova, but its brightness decreased faster than a typical

supernova, and it became redder and cooler at a faster rate than a typical supernova.

Follow-up analysis also supported the theory that most of the heavy elements in the Universe, like gold and platinum, were created in neutron star mergers and not in supernovae.

"As we followed the glow of the explosion over the few weeks when it was visible for a short time each night," says Drout, "it showed some key characteristics of being powered by the radioactive decay of these heavy elements."

This strongly suggests that these heavy elements were synthesized following the merger, solving a decades-old astrophysics question about how all the heavy elements in the Universe were forged.

"And this is just the beginning," says Drout. "We expect LIGO and Virgo to detect dozen of neutron star mergers in the coming decade. We are entering a new era of astrophysics."

The gravitational wave event detected on August 17, 2017, is identified as GW170817, and is different from the black hole merger event detected on August 14, 2017, announced in September, and identified as GW170814.

Provided by University of Toronto