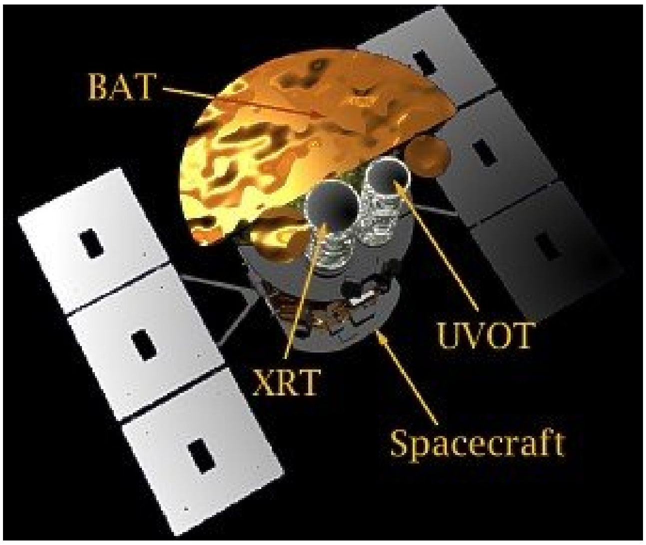
# Seeing the light of neutron star collisions

16 October 2017



The Swift satellite with instruments. Credit: NASA

When two neutron stars collided on Aug. 17, a widespread search for electromagnetic radiation from the event led to observations of light from the afterglow of the explosion, finally connecting a gravitational-wave-producing event with conventional astronomy using light, according to an international team of astronomers.

Previous gravitational-wave detections by LIGO (Laser Interferometer Gravitational-Wave Observatory) and Virgo, a European observatory based in Pisa, Italy, were caused by collisions of two black holes. Black hole collisions generally are not expected to result in electromagnetic emissions and none were detected.

"A complete picture of compact object mergers, however, requires the detection of an electromagnetic counterpart," the researchers report online today (Oct. 16) in *Science*.

The August 17 detection of a gravitational wave from the collision of two neutron stars by gravitational wave observatories in the U.S. and Europe initiated a rapid cascade of observations by a variety of orbiting and ground-based telescopes in search of an electromagnetic counterpart.

Two seconds after detection of the gravitational wave, the Gamma Ray Burst monitor on NASA's Fermi spacecraft detected a short gamma ray burst in the area of the gravitational wave's origin.

While the Swift Gamma Ray Burst Explorer—a NASA satellite in low Earth orbit containing three instruments—the Burst Alert Telescope, the X-ray Telescope and the Ultraviolet/Optical Telescope—can view one-sixth of the sky at a time, it did not see the gamma ray burst because that portion of the sky was not then visible to Swift. Penn State is in charge of the Mission Operations Center for Swift orbits the Earth every 96 minutes and can maneuver to observe a target in as little as 90 seconds.

Once the Swift team knew the appropriate area to search, it put the satellite's instruments into action. Swift is especially valuable in this type of event because it can reposition to a target very quickly. In this case, the telescope was retargeted approximately 16 minutes after being notified by LIGO/Virgo, and began to search for an electromagnetic counterpart.

Initially, because of the predictions of theoretical models, the researchers thought that the electromagnetic radiation they would see would be X-rays. This is why NASA's NuSTAR, (Nuclear Spectroscopic Telescope Array), which looks at X-rays, also searched the sky for electromagnetic signals. Neither Swift nor NuSTAR detected any X-rays.

"For gamma ray bursts, models predict that an early X-ray emission would be seen," said Aaron Tohuvavohu, Swift science operations and research assistant, Penn State. "But there were none detectable from this event until 9 days post-merger."

Instead, Swift identified a rapidly fading ultraviolet afterglow.

"The early UV emission was unexpected and very exciting," Tohuvavohu added.

Gamma ray bursts appear as a directional burst of energy from collapsed massive stars. Any type of detector must be within a certain arc of the burst to see it. The afterglow of the explosion, is however, more omnidirectional.

"Whatever we thought was going to happen, wasn't what actually happened," said Jamie A Kennea, head, Swift Science Operations team and associate research professor of astronomy and astrophysics, Penn State. "The next neutron star-neutron star merger event could look very different."

The combination of location data from the various observations of the event presented a good estimate of where the two stars were in the universe.

"Swift tiled the entire field in the area identified and did not find anything else that could have caused the emission," said Michael H. Siegel, associate research professor and head of the Ultraviolet Optical Telescope team, Penn State. "We are confident that this is the counterpart to the detected gravitational wave that LIGO saw."

The Swift discovery is spectacular because it is associated with a gravitational wave event which makes this a bona-fide double neutron star merger, said Peter Mészáros, Eberly Chair of Astronomy and Astrophysics and professor of physics, Penn State, who has studied gamma ray bursts and gravitational waves extensively.

"The thing that is surprising is that we now have only optical but not X-ray emissions," said Mészáros. "Typically, a neutron star-neutron star merger should have X-rays for a long time with optical emissions fading relatively faster. The only thing one can infer from this, based on the models that I and others have developed, is that the X-ray beam is narrower and not directed straight at us."

In this case, the merger would have produced X-rays, but they would have been pointed in a direction away from the Earth, preventing Swift and NuSTAR from detecting the initial X-ray emissions.

Mészáros notes that the gravitational waves looked like they came from objects smaller in mass than black holes, which pointed to neutron stars, and that the electromagnetic emissions separately correlated to the event provide two ways to show proof-positive that this is a neutron star merger.

The neutron star-neutron star collision occurred 130 million light years away in another galaxy. A light year is the distance light can travel in one year, which is almost 6 trillion miles.

According to the researchers, this event was close to our solar system by astronomical standards. The black hole-black hole collisions originally detected by LIGO, in contrast, were billions of light years away.

"A neutron star-neutron star collision was our best hope for an electromagnetic signature," said Kennea. "But it is still surprising that we got one on our first neutron star-neutron star collision."

Provided by Pennsylvania State University

APA citation: Seeing the light of neutron star collisions (2017, October 16) retrieved 17 June 2019 from https://phys.org/news/2017-10-neutron-star-collisions.html