News

Rare cosmic explosion blasts hole in established science

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On Dec. 11, 2021, the NASA's **Neil Gehrels Swift Observatory**, which has its Mission Operations Center at Penn State, detected a blast of high-energy light from a galaxy roughly 1 billion light-years away. The event, which was simultaneously detected by **Fermi Gamma-ray Space Telescope**, brings into question what was thought to be settled science concerning gamma-ray bursts (GRBs), the most energetic explosions in the universe.

"It was something we had never seen before," said Simone Dichiara, assistant research professor of astronomy and astrophysics at Penn State and member of the Swift team. "We knew it wasn't associated with a supernova, the death of a massive star, because it was too close. It was a completely different kind of optical signal, one that we associate with a kilonova, the explosion triggered by colliding neutron stars."

The Swift team was able to rapidly identify the explosion's location, in the constellation Boötes, enabling other facilities to quickly respond with follow-

While studying the aftermath of a long gamma-ray burst (GRB), two independent teams of astronomers using a host of telescopes in space and on Earth, including the Gemini North telescope on Hawai'i and the Gemini South telescope in Chile, have uncovered the unexpected hallmarks of a kilonova, the colossal explosion triggered by colliding neutron stars. Credit: NOIRLab/NSF/AURA/J. da Silva/Spaceengine

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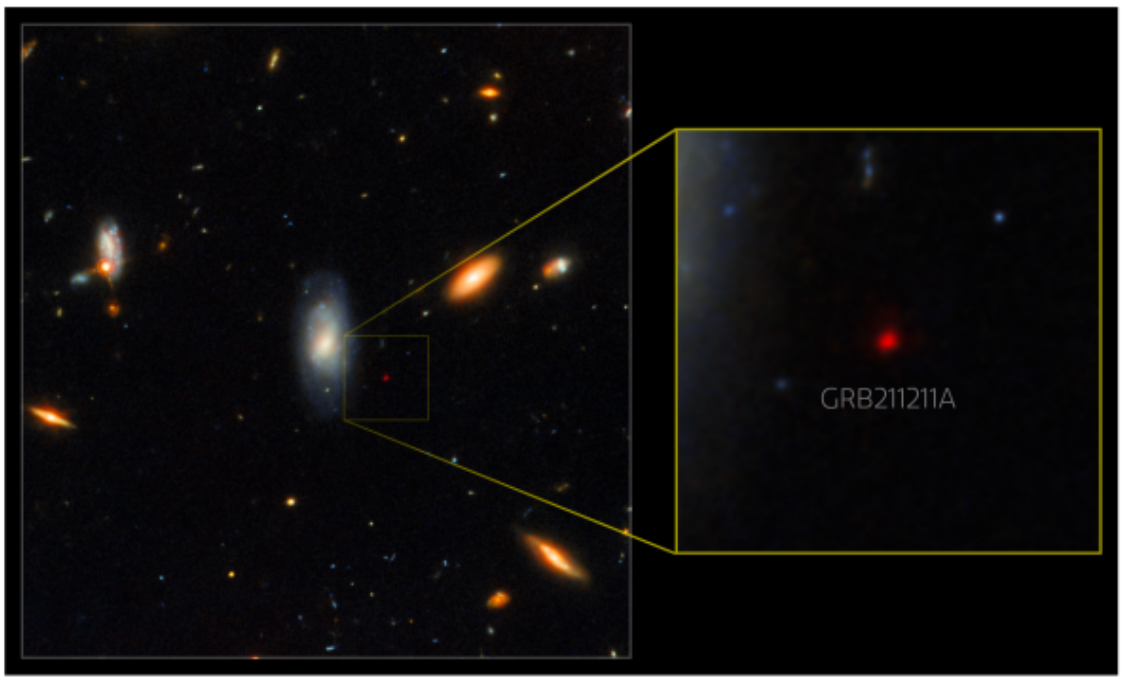
Gamma-ray bursts come in two varieties: long and short. Scientists previously understood long GRBs, which last a couple of seconds to one minute, as forming when a super massive star explodes as a supernova. Short GRBs, which last less than two seconds, were previously thought to only occur when two compact objects — like two neutron stars or a neutron star and a black hole — collide to form a kilonova.

The revelation that a kilonova could trigger a long gamma-ray burst rewrites the decades-long paradigm of cosmic explosions: that long GRBs are strictly the signature of the death of massive stars, Dichiara explained. The discovery means not all long GRBs are made by supernovae, some are produced by the merger of neutron stars.



This composite Gemini North and Hubble shows the telltale near-infrared afterglow of a kilonova produced by a long GRB. This discovery challenges the prevailing theory that long GRBs exclusively come from supernovae, the end-of-life explosions of massive stars. Credit: International Gemini Observatory/NOIRLab/NSF/AURA/M. Zamani; NASA/ESA.

“This event was a game-changer that showed to us how our well-established knowledge of the universe was in fact only a partial and incomplete view,” said Eleonora Troja, an astronomer at the University of Rome Tor Vergata and lead author on the paper. “This result was hard to digest at first and we spent months trying to figure out alternative explanations, but in the end this is the only one that works well. Although we have been studying GRBs for decades, it is awesome to see how the universe can surprise us in the most unexpected ways.”

The work was supported by the European Research Council through the Consolidator grant BHianca and by the National Science Foundation.

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