Astronomers detect kilonova associated with a nearby gamma-ray burst

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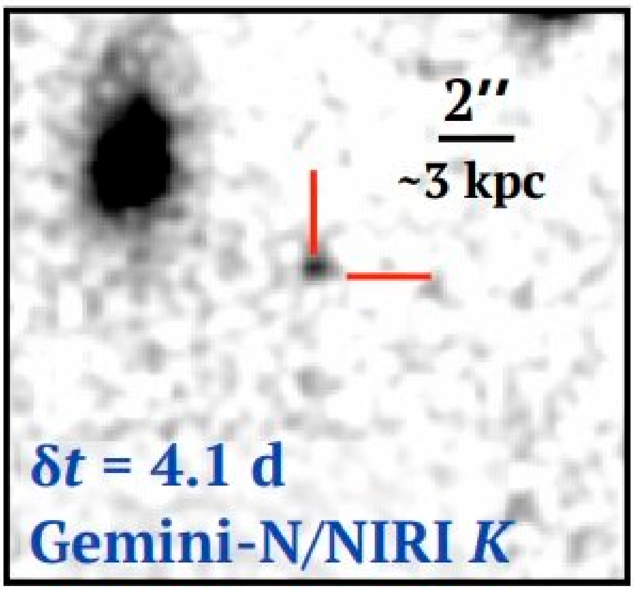

Smoothed Gemini/NIRI Kband image of GRB 211211A at 4.1 days post-burst. The astronomers detected a K ≈ 22.4 mag point source at the position of GRB 211211A's optical afterglow. Credit: Rastinejad et al, 2022

An international team of astronomers has detected a new kilonova associated with a nearby gamma-ray burst (GRB) known as GRB 211211A. The finding, reported in a paper published April 22 on arXiv.org, could improve our understanding about the origin and nature of the still mysterious GRBs.

Kilonovae (also known as r-process supernovae) are transient events occurring when two compact objects, like neutron stars, merge. They are assumed to emit short gamma-ray bursts and strong electromagnetic radiation due to the radioactive decay of heavy r-process nuclei. To date, kilonovae are the only observed source of r-process nucleosynthesis in the universe, and may be responsible for creating the majority of elements heavier than iron.

GRB 211211A was identified on December 21, 2021, by the Burst Alert Telescope (BAT) onboard NASA's Swift spacecraft, at a distance of about 1.14 billion light years. It lasted approximately 51.37 seconds and its spectral hardness turned out to be close to the mean of the long-RGB population. The light curve of this burst consists of several overlapping pulses exhibiting little spectral evolution.

A group of researchers led by Jillian Rastinejad of Northwestern University in Evanston, Illinois, conducted a multi-wavelength follow-up observational campaign of GRB 211211A in order to shed more light on its nature. For this purpose they employed such instruments as the Nordic Optical Telescope (NOT), Calar Alto Observatory, or Karl Jansky Very Large Array (VLA).

Optical imaging of this GRB has revealed an uncatalogued source fading rapidly over the first three days post-burst. Further observations in K-band with the Gemini-North telescope, detected source with a K-band luminosity of 22.4 mag, indicative of a strong infrared excess compared to the optical afterglow light curve. Afterward, NOT imaging conducted 17 days after the burst identified an associated supernova (SN).

The results suggest that this SN is indeed a kilonova. The researchers found that the assumed merger ejected about 0.04 solar masses of r-process-rich material. This is consistent with the merger of two neutron stars with masses close to 1.4 solar masses.

"If we assume that the progenitor binary consists of two neutron stars and use predictions from merger simulations to constrain the relative component masses and velocities, we obtain a good fit with a 1.4+1.3 solar masses binary producing ≈ 0.02 solar masses of ejecta, though matching the luminosity in the first day may require additional heating by the GRB jet over the minute-long timescale of the burst," the astronomers explained.

According to the authors of the paper, their detection of a kilonova following a long GRB implies that the current neutron star merger rates calculated from short GRBs may under-estimate the true population. They suppose that mergers related to long duration GRBs may contribute significantly, both to the compact object merger rate and to r-process enrichment.

More information: J. C. Rastinejad et al, A Kilonova Following a Long-Duration Gamma-Ray Burst at 350 Mpc. arXiv:2204.10864v1 [astro-ph.HE], arxiv.org/abs/2204.10864