PRESS RELEASE

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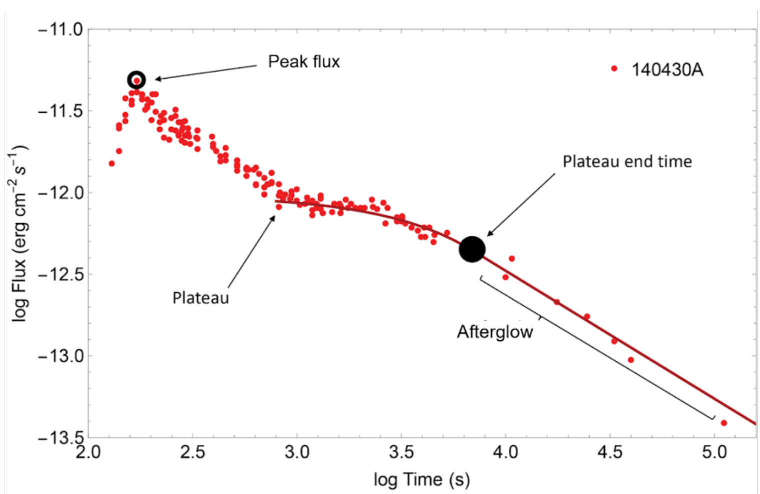
SUBARU AND SWIFT GAMMA-RAY BURSTS:

A New Optical 3D Leap Across Wavelengths

Boulder, Co, **July 22nd, 2022**

A new method to exploit Gamma-Ray Bursts (GRBs), the most energetic explosions in the universe, as independent measurements of the Universe's expansion rate has been discovered in optical wavelength by an international team of 23 researchers led by Maria Dainotti, NAOJ Assistant Professor. The team analyzed 500 optical GRBs – the largest known sample of its kind comprising data from the Subaru and RATIR Telescopes, among other ground-based facilities, and the *Swift* satellite – and showed that a specific population of GRBs (179 GRBs) can be used as independent probes of cosmological distances.



The example of GRB 140430A is a typical long (>2 sec) duration GRB that shows the peak flux, end time of the plateau, and the flux at the end time of the plateau.

Since GRBs are much brighter than the Supernovae (SNe) seen up to 11 billion light-years, they can be seen from much farther distances (13.2 billion light-years). This allows a glimpse at distant GRBs, which paint an extraordinary picture of the "infancy" of our 13.8-billion-year-old Universe. Studying the very early Universe is critical to understanding how the first stars were born and how they evolved over time (cosmological evolution). However, one continuing problem is that GRBs are difficult to standardize due to the variety of their features, which vary over several orders of magnitude even when GRBs are observed with a single instrument. This makes it difficult to define GRBs as standard candles, or benchmarks used to measure cosmological distances.

In this work with optical GRB light curves, the combination of three parameters (the peak luminosity of the prompt emission, the luminosity at the end of the plateau and its duration in optical wavelength, see Figure 2) identify a plane that works as the best distance indicator. The novel finding is that for the first time, this correlation still works as the best distance indicator even after correction for selection biases. This relation is an extension of the same 3D correlation in X-rays also found by the same lead author in 2016 (see previous NASA press release Swift: News (nasa.gov)).

The Fundamental Plane revealed in the work

Another key discovery is that the plateau is chromatic, or dependent on the wavelength. To reach this conclusion, the team compared X-rays and optical data for 89 GRBs with both X-rays and optical observations. They find that for the majority of cases, the plateau is not due to a geometric effect because the plateau is chromatic. They therefore rule out the explanation that the end of the plateau could coincide with the jet break, as this would depend on the geometric effect of the observer's viewing angle. This instead suggests the physical nature of the plateau emission most likely originates from a fast-rotating neutron star.

The paper has been accepted in Astrophysical Journal Supplement, 261, 25.

A video showing the key features of this research is shown below. https://youtu.be/3ER_Xm6Y2dQ. This work has also been shared in a press release by NAOJ and the Subaru Telescope.

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SSI scientists work on many prestigious space missions, including but not limited to the Mars Exploration Rovers, Rosetta, Mars and Lunar Reconnaissance Orbiters, Mars Science Lander, Juno, ExoMars, OSIRIS-REx, and Mars 2020. Areas of research also include heliophysics, observational astronomy (with such facilities as Hubble Space Telescope, SOFIA), and exoplanets (Kepler). SSI's National Center for Interactive Learning (NCIL) fosters collaboration between scientists and educators to create nationally touring exhibits for museums and libraries, provide professional development and webinar training for science educators, and build popular digital games and apps with over a million hits.

The paper "On the Hubble constant tension in the SNe Ia Pantheon sample" is based upon work supported in part by the National Astronomical Observatory of Japan (NAOJ), from Interdisciplinary Theoretical and Mathematical Sciences Program (iTHEMS) of RIKEN. The authors acknowledge financial support from University of Salerno.