The Joint Institute for Nuclear Astrophysics

# Superburst Precursor Observations Show Carbon Detonation in Neutron Stars


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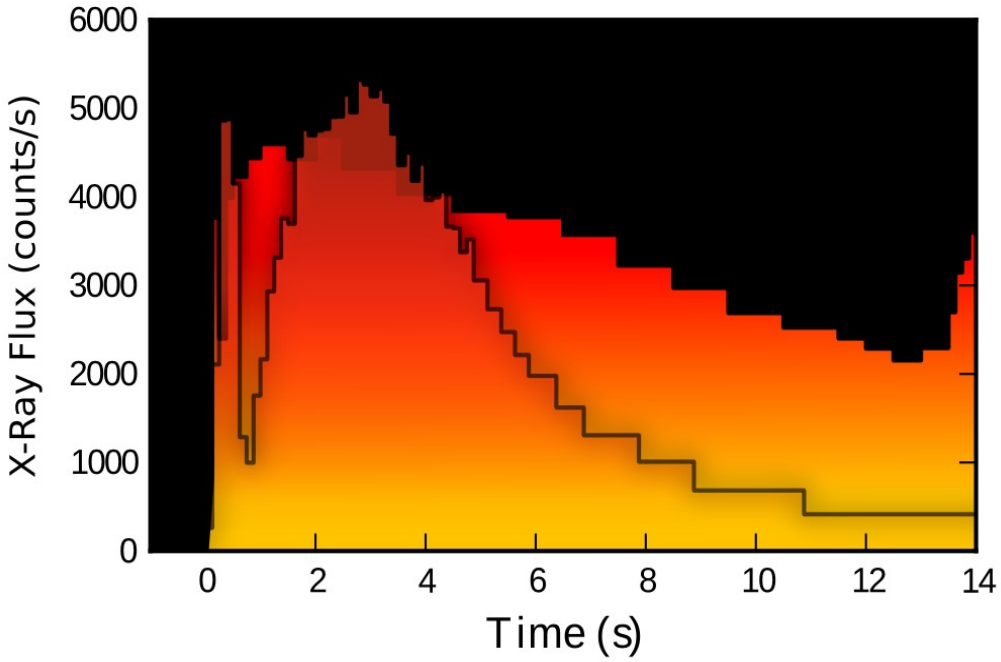


*Figure: the light curve of accreting neutron star 4U 1820-30 frequently exhibits brief bursts from helium burning (foreground). Compared to the precursor at the start of a rare superburst (background), the precursor is much more energetic.*

Superbursts are day-long flares observed from neutron stars. In a thick carbon-rich layer thermonuclear burning ignites deep below the star's surface. This makes superbursts probes of the properties of neutron-rich isotopes and their nuclear reactions in the crust. They are detected with X-ray telescopes, but unfortunately observations are very rare.

We developed a new spectral analysis technique to study the start of the superburst from 4U 1820-30 in detail. At the start of the observation there was a short precursor before the superburst. The precursor looks similar to the short helium flashes that are frequently observed from the same star. The figure compares a helium flash (foreground) to the precursor (background). All helium bursts have a similar duration, but the precursor is significantly longer and emits 150% to 200% more energy!

Our recent models (Keek & Heger 2011) predict that the most powerful superbursts start as a detonation, driving a shock that heats the stellar surface (see also Weinberg & Bildsten 2007). As the precursor is too energetic for a normal helium burst, this makes a strong case for observational evidence of a carbon-detonation and subsequent shock. The brief precursor, therefore, contains important information about the nature of carbon burning deep inside the neutron star.