Weak Hydrogen Flash as the Precursor of X-ray Bursts?

In an X-ray binary star system, a neutron star accretes hydrogen-rich gas from a sun-like companion star. When the mass transfer is fast, the accreted gas is heavily compressed and heated to high temperature so that the hydrogen burning is limited by beta-decay processes, i.e., the conversion of a proton to a neutron. These weak nuclear reactions slowly and stably fuse hydrogen to helium. Hence, a helium layer is formed under the hydrogen burning layer. If the mass transfer speed is maintained, enough helium fuel will be piled up and can trigger an explosion known as normal X-ray Burst. However, when the mass transfer is somehow slowed down, to the point where hydrogen burning is governed by the proton capture process, then hydrogen can burn explosively. The heat from the explosive hydrogen burning transports both up to the surface and down to the helium layer. If the helium layer is sufficiently heated, it can ignite and trigger a violent explosion. Since the helium layer is usually $\sim 10$ times more massive than the hydrogen layer, it takes $\sim 10$ times longer for the heat from helium burning to transport to the surface. From the observational point of view, the X-ray burst is composed of a weak burst first (due to hydrogen explosive burning) and then a strong burst (due to helium explosive burning). Such kind of burst was discovered by Bhattacharyya and Strohmayer (2007), who found that, when the accretion rate drops to around 0.01 Eddington rate, an unusual burst with a weaker precursor occurs (shown in the bottom-right figure).

To test this argument, a multi-zone model with varying mass accretion rate is needed. We are using a 1-D Lagrangian hydrodynamical scheme (the KEPLER code) to simulate the burst and to understand the mechanism of the unusual burst with a precursor.

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References:


Researchers:

Peng, F.¹
Brown, E.F.²
Heger, A.³

¹ Caltech, ² MSU, ³ LANL