

Short Thermonuclear Bursts at High Accretion Rates: Curious Case of Cygnus X-2

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Abstract

Cygnus X-2 is a persistently bright neutron-star low-mass X-ray binary and a prototypical Z source, accreting at a rate close to the Eddington limit. At such high accretion rates, thermonuclear burning on the neutron-star surface is expected to become stable, making Type I X-ray bursts rare or absent. We present a systematic analysis of all available AstroSat observations of Cygnus X-2, revealing a population of unusually short-duration thermonuclear bursts, with durations ranging from only 2–6 s. We investigate the temporal and spectral properties of these bursts, including their rise and decay times, peak intensities, burst fluences, and time-resolved blackbody parameters. We further examine the location of the bursts along the characteristic Z track to investigate their connection with the accretion state. The short durations and thermonuclear spectral evolution provide evidence that these events originate from unstable nuclear burning despite the high persistent luminosity of the source. We discuss possible physical scenarios, including localized ignition, incomplete surface coverage, and marginally stable burning, which could allow thermonuclear instabilities to persist locally even when the global accretion flow is close to the stable-burning regime. Our results provide a new opportunity to investigate the combined picture of accretion geometry, nuclear burning, and burst ignition in luminous neutron-star systems.

Keywords: X-ray binaries – neutron stars – thermonuclear bursts – accretion