Thermonuclear bursts on neutron stars: News from Terzan 5

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D. Chakrabarty, M. van der Klis, D. Altamirano, A. Cumming, et al.

X-ray Universe, Berlin, June 2011
- Thermonuclear bursts without cooling tail.
- Additional heating in the neutron star envelope.
Thermonuclear bursts on neutron stars

Type I X-ray burst ↔ thermonuclear burst

Defining property:
thermal (~0.5-3 keV) spectrum
+ cooling along the decay: “cooling tail”

Cooling of the neutron star photosphere after the fast injection of heat during thermonuclear runaway

Terzan 5: smooth burst evolution

11 Hz pulsar in a ~21hr orbit (Strohmayer et al. 2010; Papitto et al. 2011) showing MANY X-ray bursts (~400 between Oct. 13 – Nov. 19, 2010) Interesting burst properties, mHz QPOs…
Terzan 5: smooth burst evolution

Energetics: thermonuclear
\( (\alpha \equiv \frac{E_{\text{accretion}}}{E_{\text{burst}}} \sim 100) \)

Smooth evolution from type I to 'non-cooling' X-ray bursts, and vice versa.

→ First X-ray bursts without cooling tail identified as thermonuclear!

M. Linares. X-Universe 2011
$\beta \equiv \frac{\text{Peak burst luminosity}}{\text{Persistent luminosity}}$

- $\beta > 0.7$: type I X-ray bursts.
- $0.2 < \beta < 0.7$: single bursts DON’T but daily averages DO show cooling.
- $\beta < 0.2$: no cooling.

→ A hot NS between bursts can hide cooling during faint bursts.

(Supported by spectral simulations; M. Zamfir priv. comm.)
Terzan 5: bursting regimes

The highest burst rates, in a regime (persistent luminosity $> 0.2 \ L_{\text{Edd}}$) where bursts were extremely rare!

$t_{\text{rec}} \sim L_{\text{pers}}^{-3.2 +/- 0.5}$

In this regime ‘hot CNO’ should give constant heating rate: (Cumming & Bildsten 2000)

Need extra heating, from triple alpha? or previous bursts?

Linares et al. in prep

M. Linares. X-Universe 2011
New transient in Terzan 5, unprecedented behavior: X-ray bursts smoothly evolve from type I to non-cooling. First non-cooling bursts identified as thermonuclear!

Systematics of standard burst spectroscopy can hide cooling in thermonuclear bursts.

Threshold: $\beta = \frac{L_{\text{peak}}}{L_{\text{persistent}}} = 0.2$

Cooling (type I) vs. thermonuclear X-ray bursts: Sufficient but not necessary!


Extremely high burst rate, $t_{\text{rec}} \sim L_{\text{pers}}^{-3}$

Extra heating by He burning or ‘hot ashes’?