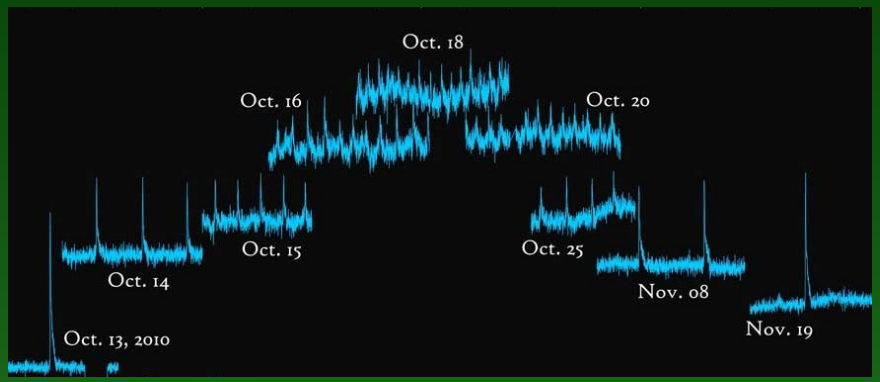
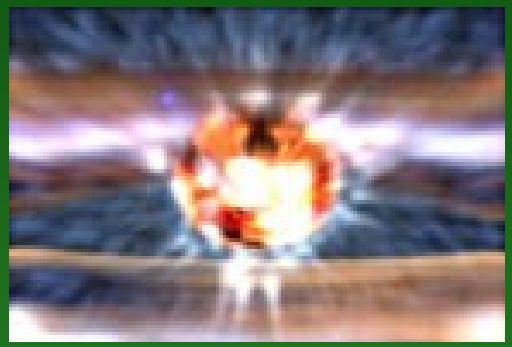
Thermonuclear burning on rapidly accreting neutron stars



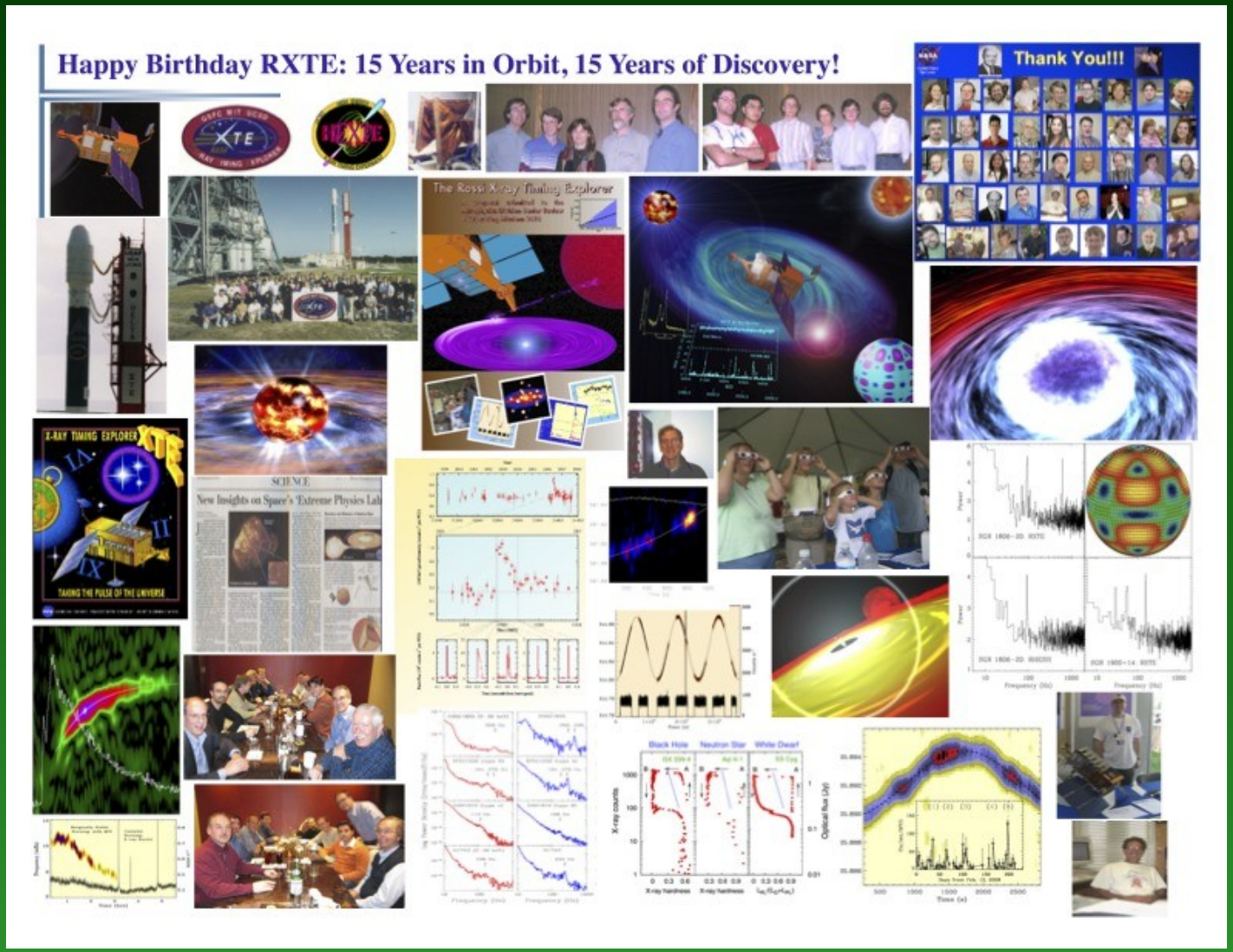


Manu Linares (MIT)
Chakrabarty, Altamirano, Cumming, Keek, et al.

"16 years of discovery with RXTE", GSFC, 2012/03/30

Massachusetts Institute of Technology
Kavli Institute for Astrophysics and Space Research

RXTE has revolutionized our understanding of thermonuclear bursts on neutron stars

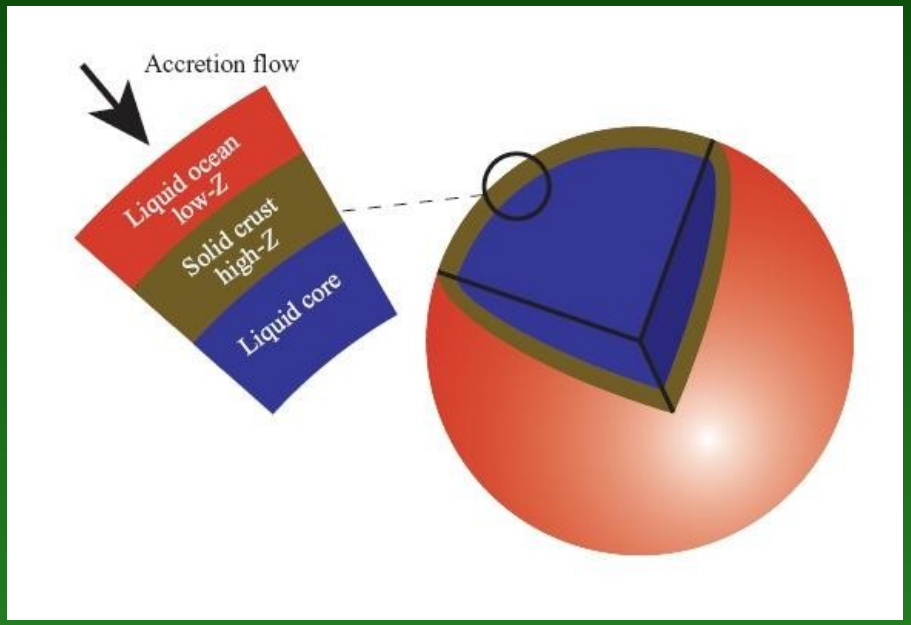


and when you think you've seen it all…

Burning regimes *(a shell flash in a nutshell)*

mdot=accreted mass/time/area

(Eddington-normalized: mdot/m_{Edd})



→ Burst rate should increase with increasing mdot up to stable burning at ~100%Edd

Increasing mdot

- **Unstable H burning:**

  mdot/m_{Edd}<0.01

  Thermally unstable H burning.

- **Pure He ignition:**

  0.01<mdot/m_{Edd}<0.04

  He ignites in the absence of H.

- **Mixed H/He ignition:**

  0.04<mdot/m_{Edd}<1

  He ignites in a mix of H&He.

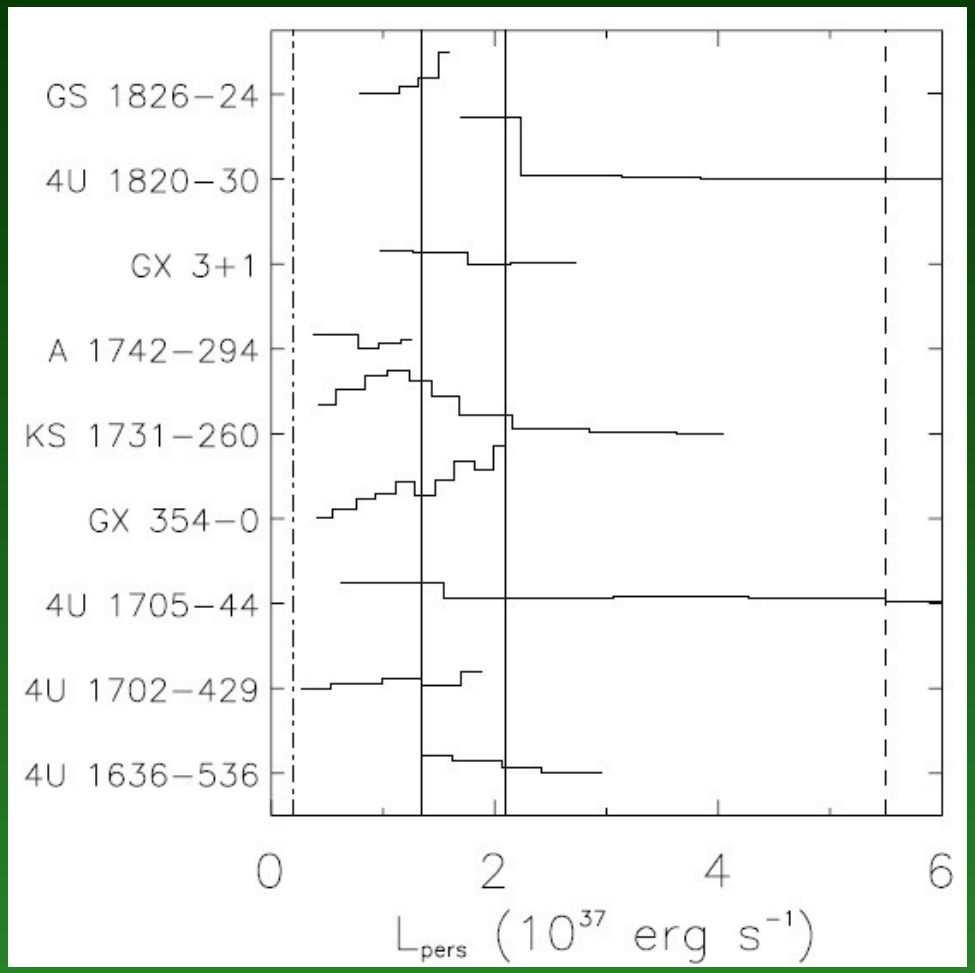
- **Stable H&He burning:**

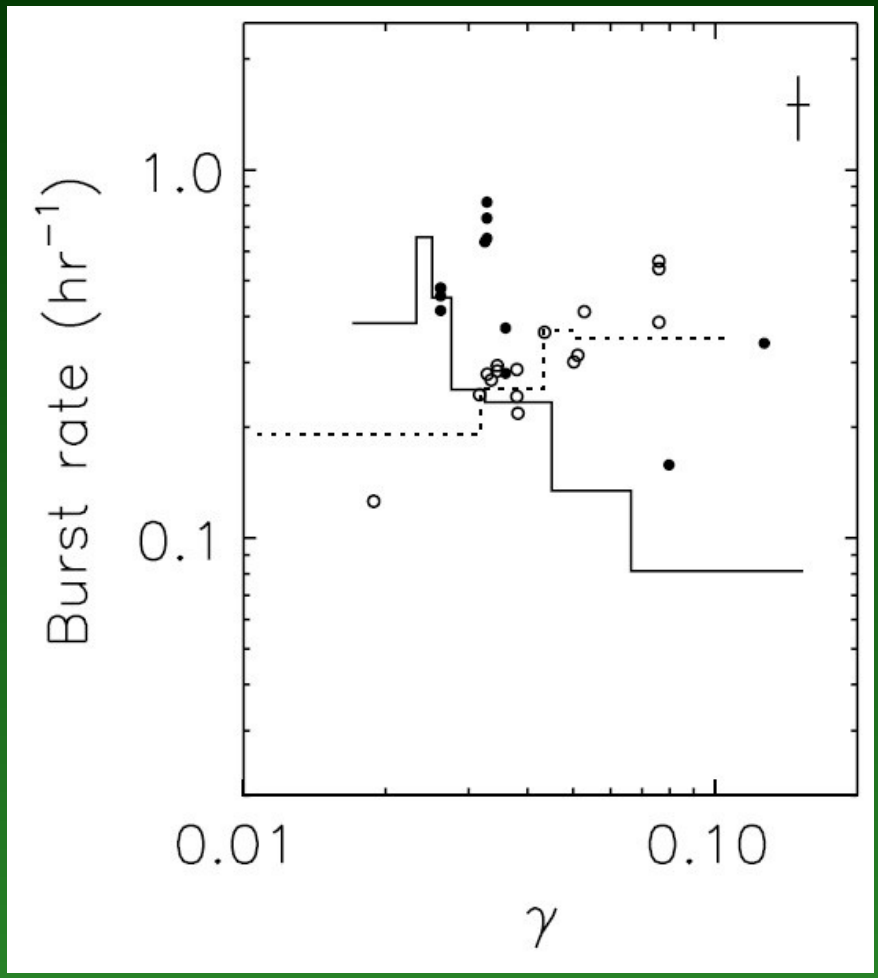
  mdot/m_{Edd}>1

  Both H and He burn stably. No bursts.

Pic: Horowitz; Refs: Woosley & Taam (1976); Fujimoto ea (1981); Taam (1981); Bildsten (1998); Cumming & Bildsten (2000); Woosley ea (2004)

Bursting regimes *(observational status until 2010)*

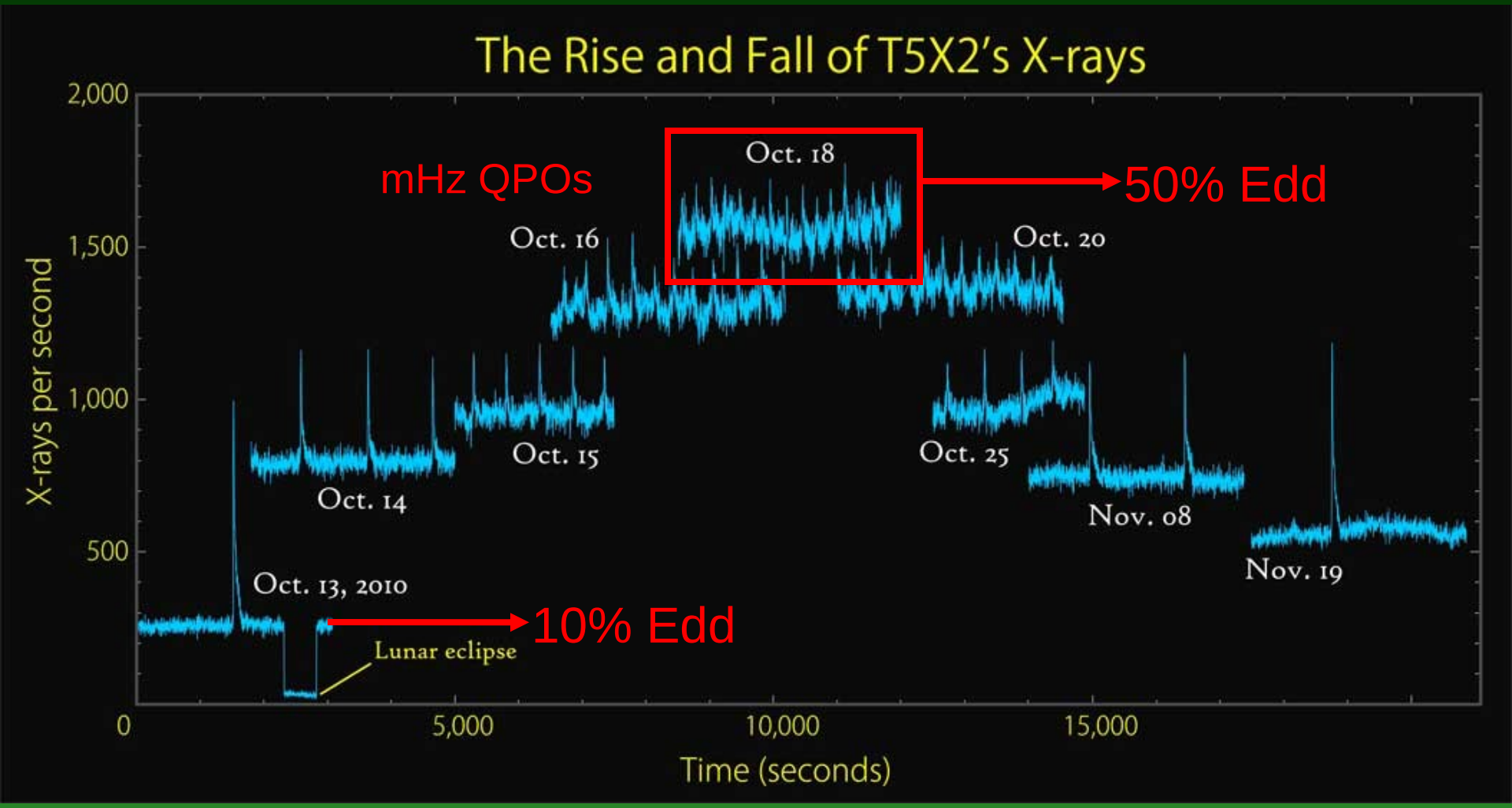




Cornelisse ea (2003); Galloway ea (2008)

Where are the bursts at mdot > 10%Edd??

T5X2: smooth burst evolution



New burster in Terzan 5: T5X2 = IGR J17480-2446

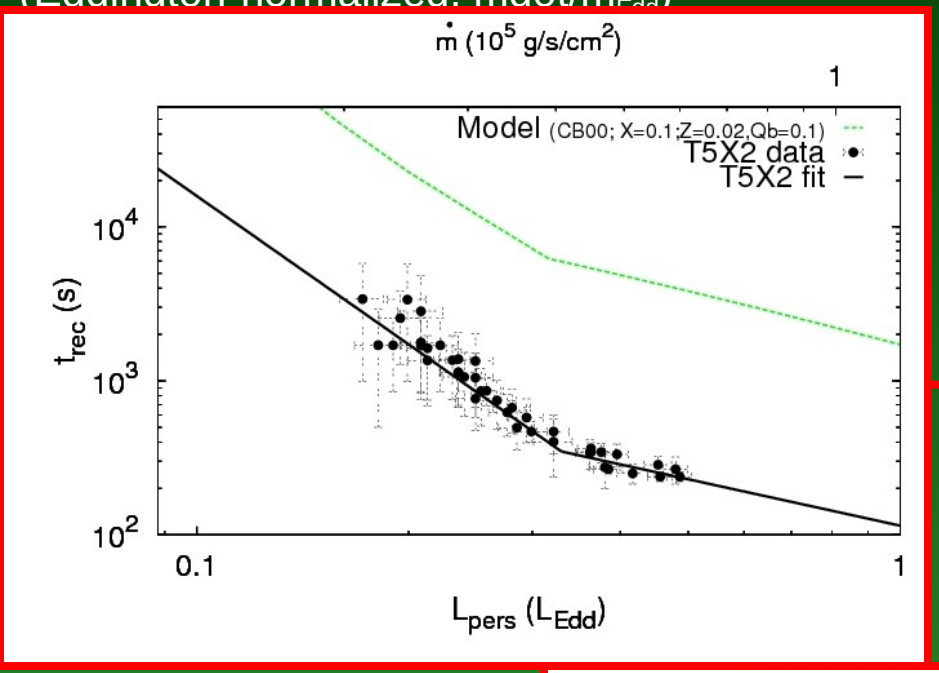
11 Hz X-ray pulsar in a ~21hr orbit. Smooth transition: bursts-mHz QPO-bursts!

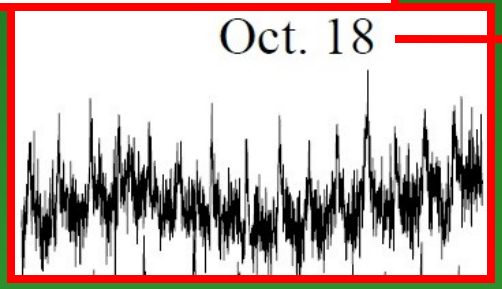
Bordas+ (2010); Linares+ (2010,2012); Strohmayer+ (2010); Papitto+ (2010); Motta+ (2011); Chakraborty+ (2011)

T5X2 vs. burning regimes

mdot=accreted mass/time/area

(Eddington-normalized: mdot/m_{Edd})





Increasing mdot

- **Unstable H burning:**

  mdot/m_{Edd}<0.01

  Thermally unstable H burning.

  → **Previous (atoll) mHz QPOs?(Revnivtsev'01)**

- **Pure He ignition:**

  0.01<mdot/m_{Edd}<0.04

  He ignites in the absence of H.

  → **He → H/He ignition transition!**

- **Mixed H/He ignition:**

  0.04<mdot/m_{Edd}<1

  He ignites in a mix of H&He.

  → **Marginally stable burning!**

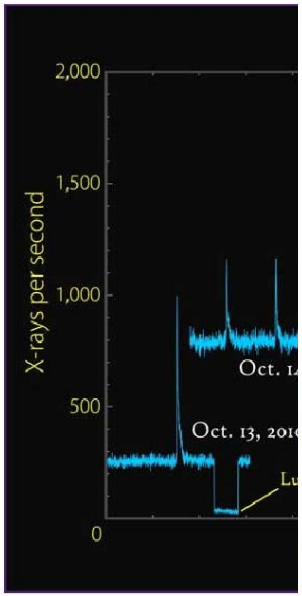
- **Stable H&He burning:**

  mdot/m_{Edd}>1

  Both H and He burn stably. No bursts.

Pic: Horowitz; Refs: Woosley & Taam (1976); Fujimoto ea (1981); Taam (1981); Bildsten (1998); Cumming & Bildsten (2000); Woosley ea (2004)

T5X2: bursting by the book



Credit: NASA/Goddard Space Flight Center

Stars are stars because, deep in their innermost regions, where densities
fusion, is normally hidden from view by the bulk of the star. But the end r
surface, where we call can watch it. These objects, called neutron stars, a
exhausted, when the star explodes as a supernova. But if the exploding sta
on the neutron star can be resuscitated by robbing mass from the compar
measurements, obtained by the Rossi X-ray Timing Explorer, of such a stu
is accreting matter from the companion. As hydrogen-rich material from
pressure of this layer reach a critical value, hydrogen can start to fuse in
nuclear burning surface layer, which can eventually rebuild itself and star
the rate of accretion onto the neutron star is high enough, the surface lay
Published: March 19, 2012

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CIENCIA

Así explota una estrella de neutrones

Por primera vez, científicos han podido ver en uno de estos espectaculares «cadáveres» estelares lo que la teoría predice. Cien kilos de materia impactan contra un área del tamaño de una moneda a cada segundo

ABC.ES / MADRID
Día 05/03/2012 - 13.19h

NASA
El plasma de una estrella vecina cae en la órbita de una estrella de neutrones, creando explosiones termonucleares

Por primera vez, un equipo de investigadores ha conseguido detectar todas las fases de la combustión termonuclear en una estrella de neutrones, uno de los objetos más espectaculares y grandiosos del Universo. La estrella, que se encuentra cerca del centro de la galaxia en el cúmulo globular Terzan 5, ha reventado exactamente como los modelos predecían. El descubrimiento, que aparecerá publicado en la revista Astrophysical Journal, no solo servirá para reforzar la autoestima de los científicos -«estábamos en lo cierto», podrán decir-, sino que servirá para explicar, precisamente, por qué esta actuación estelar de libro no había sido detectada hasta ahora.

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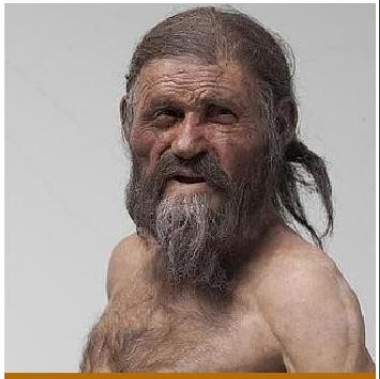
El «hombre de hielo»



Los parientes más cercanos de Ötzi

La secuenciación del genoma de la famosa momia descubre que padecía una infección bacteriana, tenía los ojos castaños y está relacionada con los modernos habitantes de Córcega y Cerdeña

La momia que sobrevivió a su destino

Publicidad

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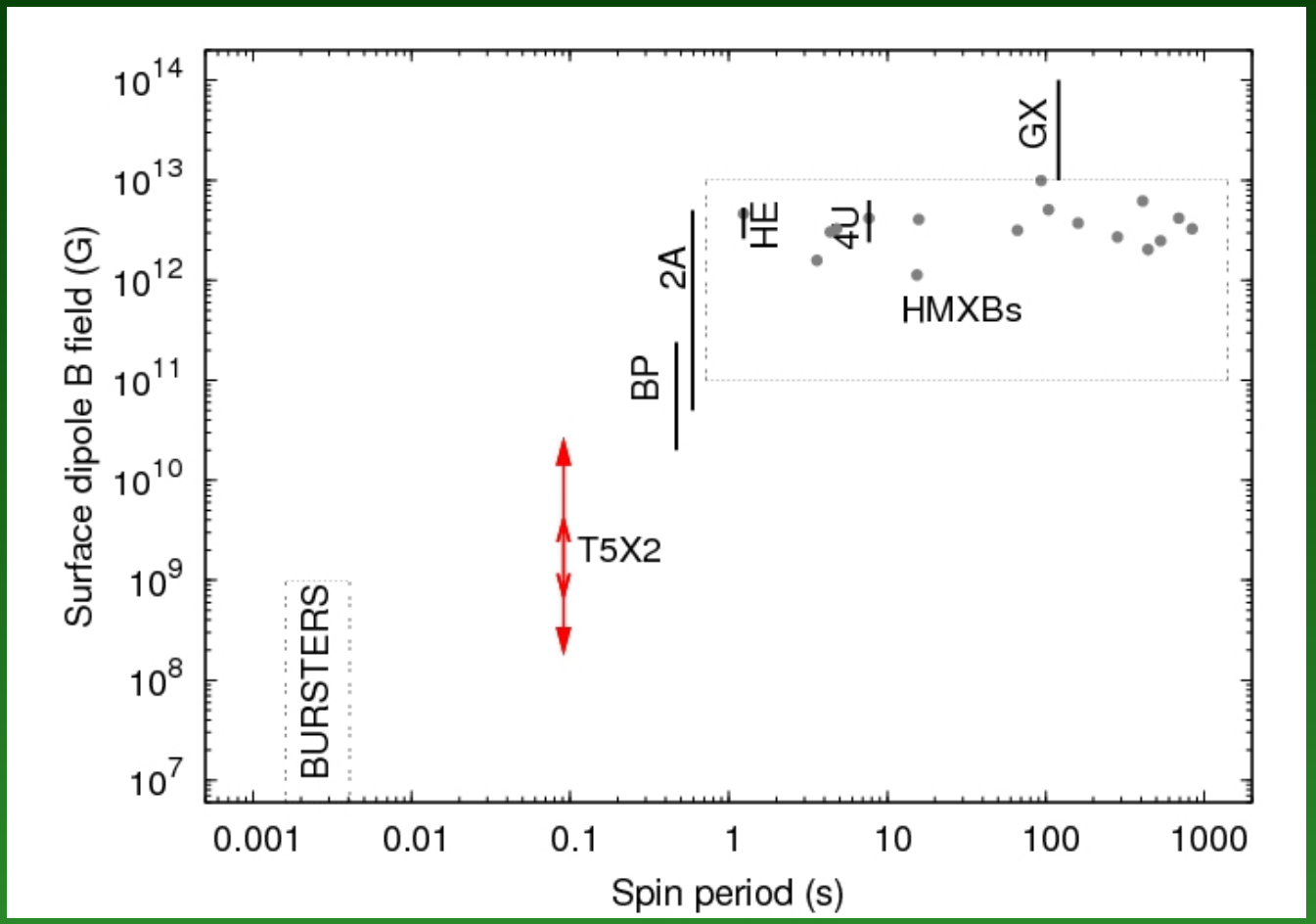
T5X2: bridging the gap

B and spin between typical LMXB and HMXB values:



Bildsten et al. (1997); Caballero & Wilms (2011); Papitto et al. (2011); Miller et al. (2011)

B needed to stabilize burning (below 0.5 L_{Edd}) is at least ~10^{10} G.

Did we underestimate influence of fast spin on burning regimes?

Summary & Conclusions

Unprecedented thermonuclear burst behavior from Terzan 5:

- mHz QPOs close to the expected stability boundary
- Qualitative agreement with theory → low spin?
- Quantitative discrepancy with theory → extra heat?

Millihertz Quasi-periodic Oscillations and Thermonuclear Bursts from Terzan 5: A Showcase of Burning Regimes (Linares et al. 2012, ApJ, 748, 82)

RXTE kept surprising us 15 years after launch → Future is bright!!


LOFT
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