X-ray bursts from 4U1728-34 and other He-rich bursters

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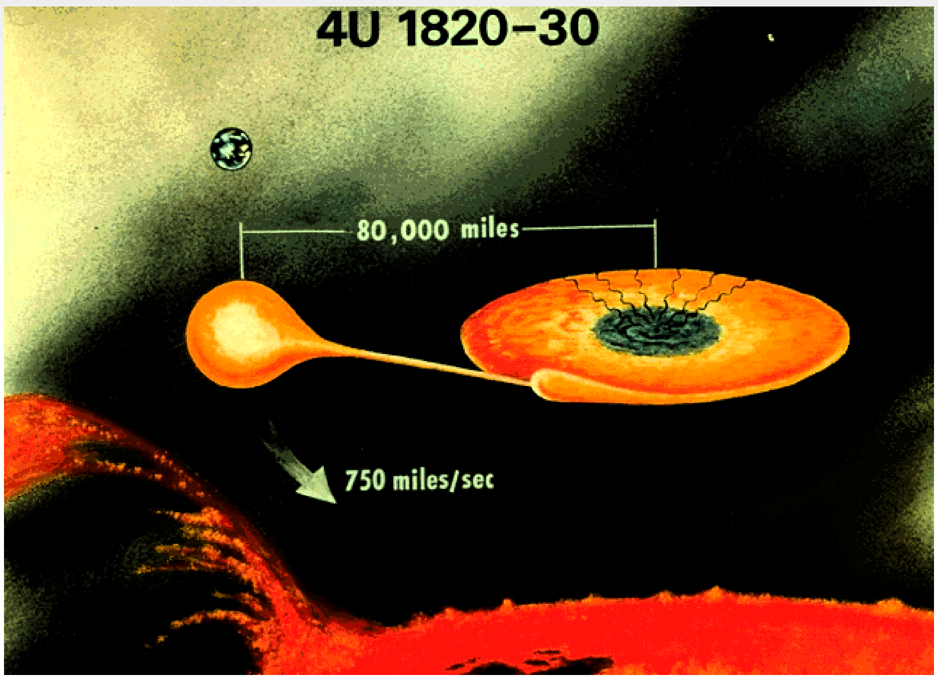
Low-mass X-RAY Binaries



- Compact object: NS or BH
- Companion: old star
- Accretion disk: H/He (Roche lobe overflow)
- Lx ~ 10^{36} - 10^{39} ergs/s
- X-rays from the disk and corona
- ~100 detected in our gal.

X-ray (Type I) bursts

- observed in LMXB as sudden increase of X-ray luminosity
- fuel accumulates on the NS surface
- compressed and heated
- T sufficiently high – the fuel ignites and burns stably

- E~10^{39} – 10^{40}ergs/s
- burst rise time ~ sec
- duration ~ min
- rec. time ~ hrs/days
- more than 1000 bursts in the RXTE catalogue (Galloway et al. 2008)

Burst ignition models

- dF/dy = - heat + neutrino emissivity
- $dT/dy = F/\rho K$ (K thermal conductivity)
- Heat produced by pycnonuclear reactions deep in the crust (1.9 MeV/nucl; Haensel & Zdunik 2008)
- A fraction of this heat flows outward and heats the fuel layer

- The rest of heat flows inward through the crust and to the core and is released via neutrinos (direct, modified, suppressed modified URCA).
- Input: core conductivity and crust emissivity to get the base heat flux
- So, measuring the heat flux → NS thermal properties
- But in H-rich fuel - base heat provided by stable H burning
- **He-rich bursts probe NS interiors**

He-rich accretors and superbursts

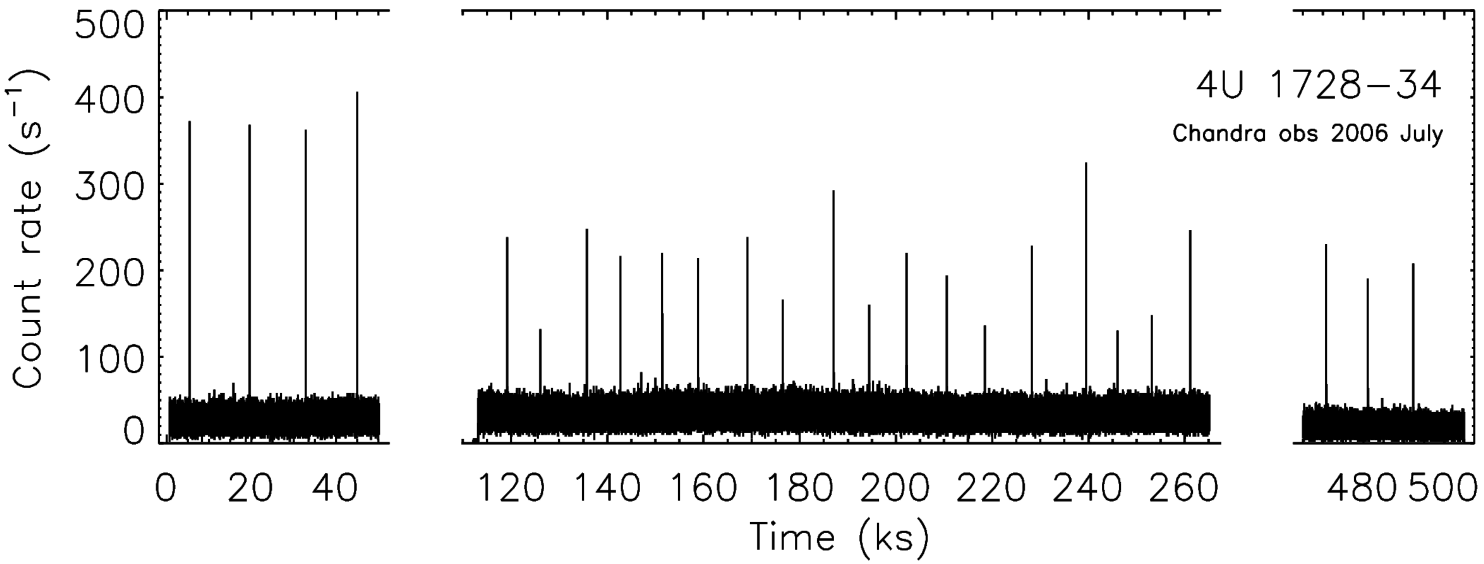
- Superbursts (long-duration, energetic, fuel C) also sensitive to internal NS heating, but their recurrence times too long (~years)
- ignition depth for superbursts determined from modelling their cooling light curves (as the recurrence times difficult me measure)
- ignition models suggest additional heating or strange quark matter (the energy produced by converting accreted material to strange matter not well constrained (Cumming et al. 2006)

4U 1820-30

- Ultra-compact binary (orb. period 11.4 min; Stella et al. 1987)
- bursts for ~40 days around the minimum and then in non-bursting mode for ~140 days
- 7 bursts observed by EXOSAT (Haberl et al. 1987) with rec. time of ~ 3 hours and Mdot ~ 0.08
- ignition models: suppressed modified URCA and low thermal conductivity of the crust, Qcrust~0.4; or the accretion rate larger by a factor of 2-3 (with H) to 6 (pure He) – Cumming et al. 2003, 2006.

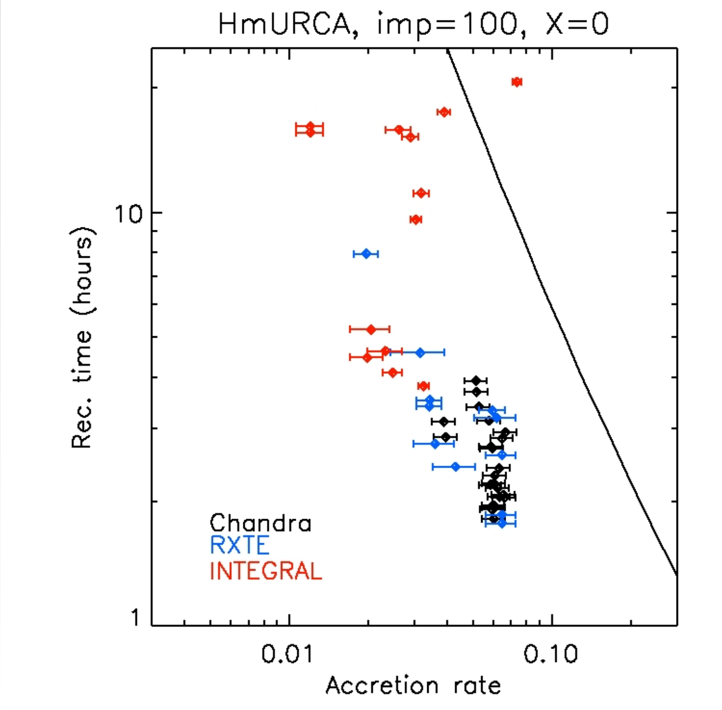
4U 1728-34

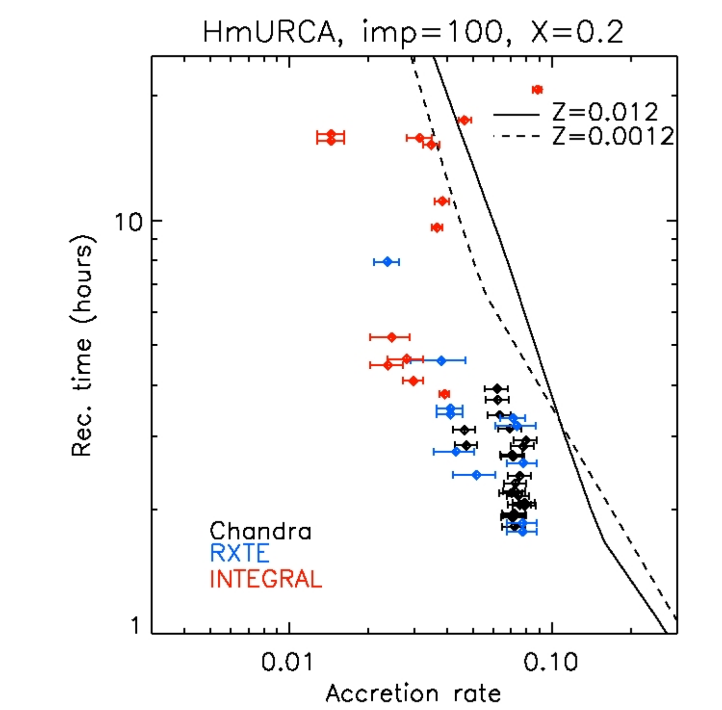
- Chandra (HETGS) 250 ks – 25 bursts
- Orbital period 10.77 min (Galloway et al. 2009)
- UcLMXB ------> pure He (or He-rich)



Accretion rate estimates

- **RXTE** 2.5-25 keV BB+PL(+Fe) or compTT model (bolometric correction from 0.1-200 keV)
- **Chandra** 1.5-6 keV (HETG, CC-mode) compTT with fixed parameters (model parameters from BepoSAX in 0.1-100 keV)
- **INTEGRAL** 3-200 keV





- model based on Cooper & Narayan 2005
- slow cooling in the core: suppressed modified URCA (nucleon-nucleon bremsstrahlung), and large crust impurity to maximize the burst ignition region temperature (i.e minimize the burst recurrence time)
- **additional heat required to match the data**

Summary & conclusions

- X-ray bursts of He-rich accretors probe the NS internal heat structure
- heat for burst ignition supplied by internal processes – interior physics completely determines ignition conditions
- models: slow suppressed modified URCA and large crust impurity still predict <u>significantly longer burst recurrence times</u>

Summary & conclusions

- one possibility: accretion rates underestimated – not very likely as we measured Lx from broadband spectra and already estimated bolometric corrections
- models wrong: additional (shallow) heating source required to explain frequent bursting – this is in agreement with a recent measurements of quiescent emission from NS transients (Brown & Cumming 2009 and Brown et. al, in prep.)