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The Measurement of the Neutron Star Radius

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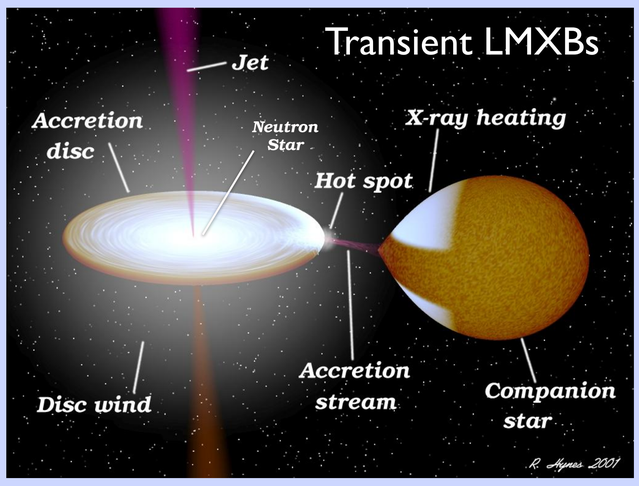
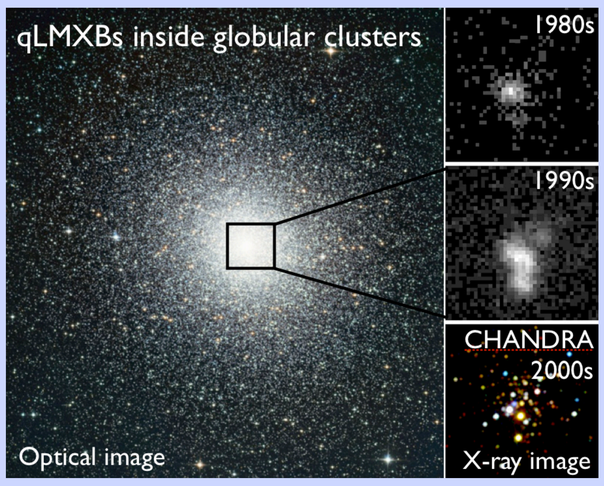
We use the surface thermal emission of five neutron stars (NSs) in quiescent low-mass X-ray binaries (qLMXBs) to constrain the dense matter equation of state (dEoS). By assuming that R_{NS} is quasi-constant for a wide range of M_{NS}, we find $R_{\rm NS} = 9.1^{+2.0}_{-2.2}\,{\rm km}$ (99% conf.), including uncertainties related to the absorption of X-rays and to the distances of the sources.

Guillot et al. 2013, ApJ v.772

Background

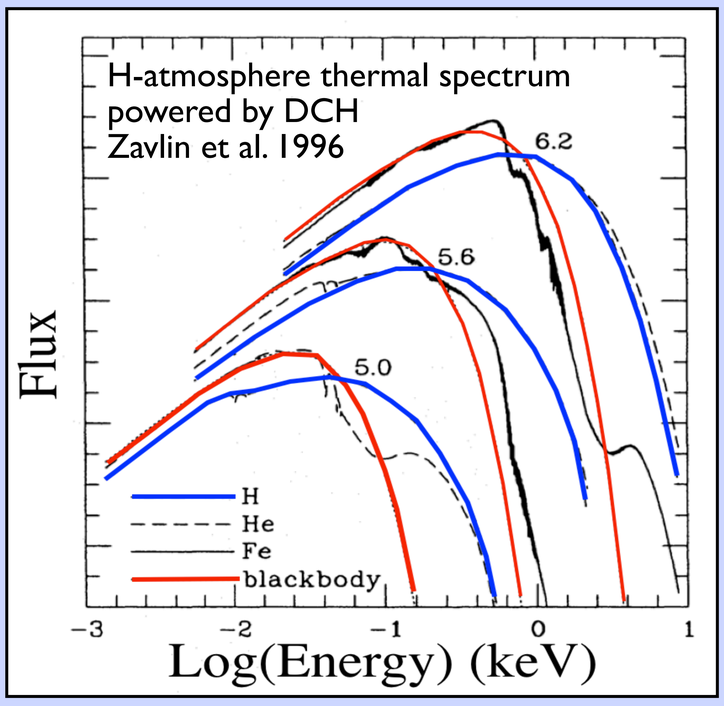


The NS **surface thermal emission** dominates the X-ray emission from qLMXBs.

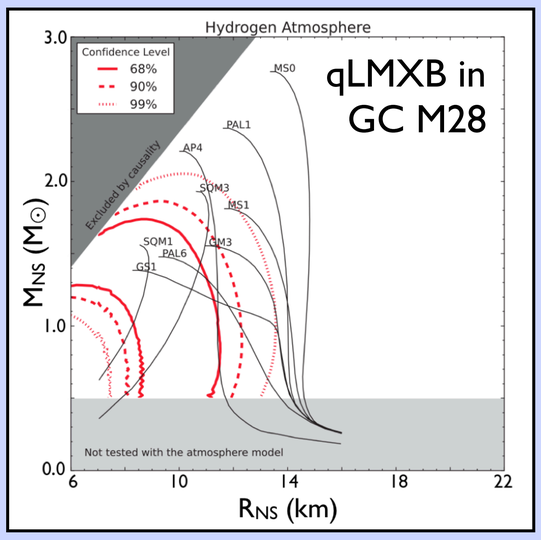


Globular clusters (GCs) have **distances known to ~10% uncertainties**, but require high-resolution X-ray imaging

Quiescent LMXBs are powered by deep crustal heating, radiating energy through **an hydrogen atmosphere**



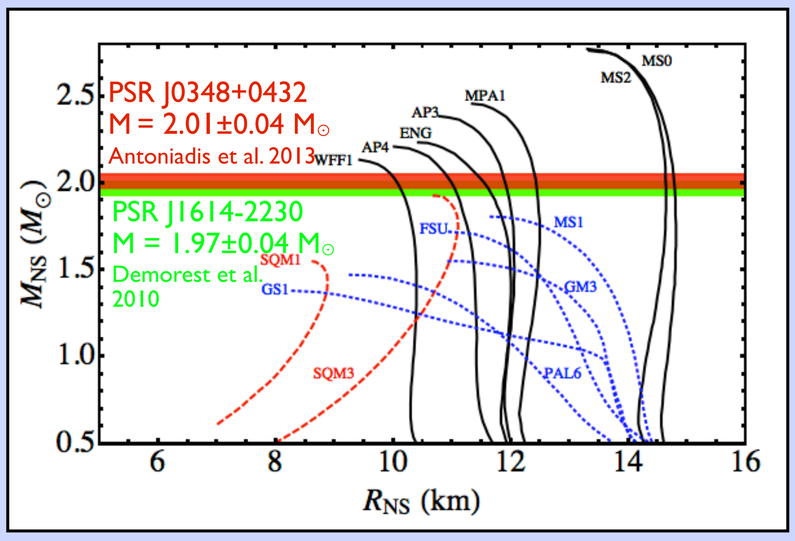
R_∞ measurements



Spectral analyses of qLMXBs provide **R_∞ measurements** to constrain the dEoS. (e.g., Servillat et al. 2012)

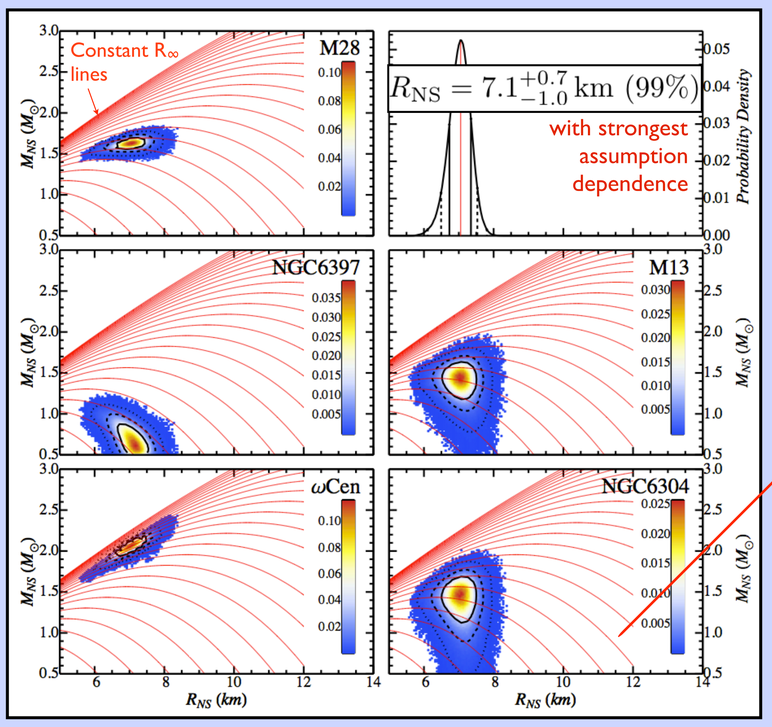
Spectra of qLMXB can be combined to provide more useful constraints.

Initial assumption



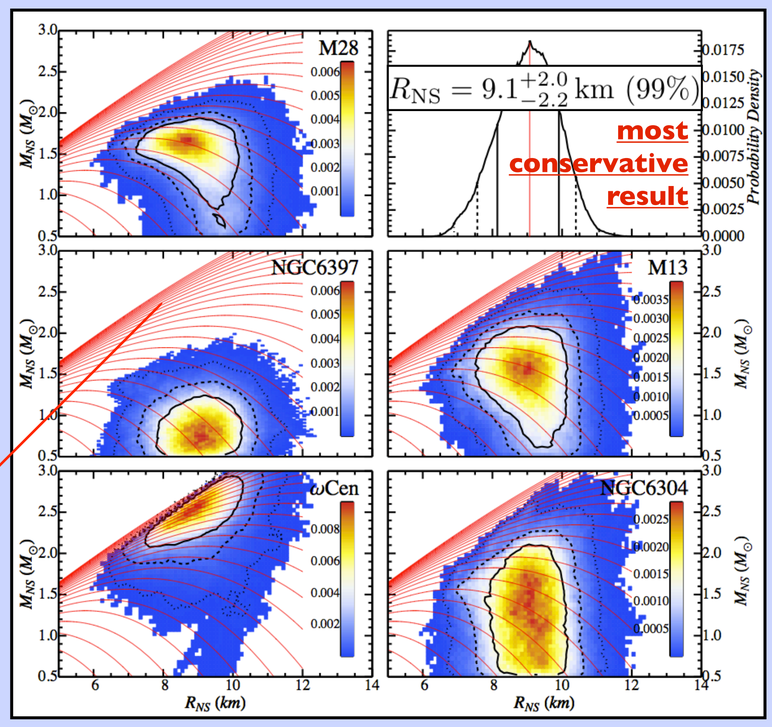
Assuming that **all neutron stars have a quasi-constant radius** (*based on observational evidence*), we perform a simultaneous spectral analysis of five NS qLMXBs, forcing the R_{NS} parameter to be the same for all five sources.

Results



With the **strongest assumption dependence**, we find:

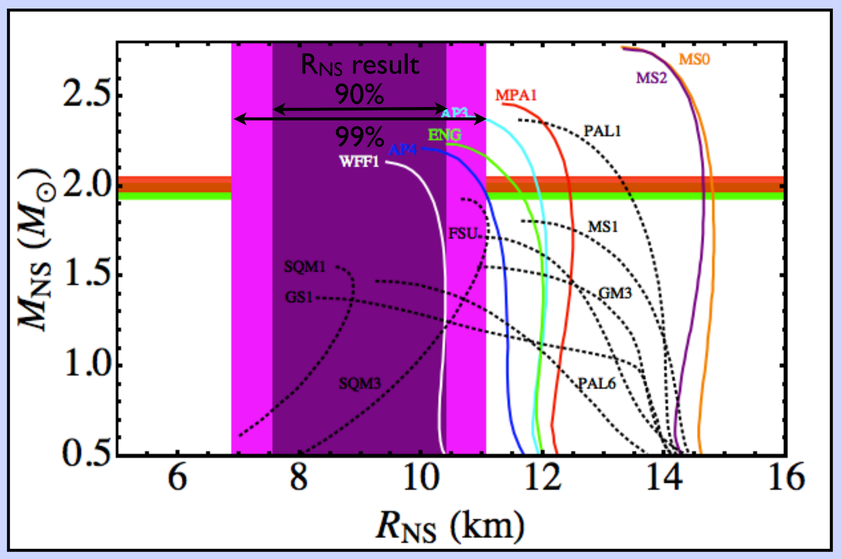
$$R_{\rm NS} = 7.1^{+0.7}_{-1.0}\,{\rm km}\ (99\%\,{\rm c.l.})$$



With the **most conservative assumptions** (distances, absorption N_H), we find:

$$R_{\rm NS} = 9.1^{+2.0}_{-2.2}\,{\rm km}\ (99\%\,{\rm c.l.})$$

Conclusions



Assuming neutron stars have a quasi-constant radius, our most conservative result **disfavours the stiffest dEoSs**.

Analysis assumption:

- Low-magnetic neutron stars
- Pure hydrogen atmosphere
- GC distance measurements
- Isotropic surface emission

Selection of references on the subjects related to this work:

- *Deep crustal heating*: Brown et al. 1998, ApJ. 504
- *NS-atmosphere models*: Zavlin et. al 1996, A&A. 315; Heinke et al. 2006, ApJ. 644
- *R_∞ measurements*: Heinke et al. 2006, ApJ 644; Guillot et al. 2011, ApJ. 732; Servillat et al. 2012, MNRAS 523
- *Pulsar mass measurements*: Demorest et al. 2010, Nat. 2010; Antoniadis et al. 2013, Sci. 340
- *Spectral identification of qLMXBs*: Rutledge et al. 2002, ApJ 578; Gendre et al. 2003, A&A 403; Guillot et al. 2009, Apj. 699