r-modes, gravitational waves and extreme physics

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accreting systems

Accreting neutron stars in LMXBs may be relevant gravitational-wave sources. Their rotation appears to be limited by some mechanism;

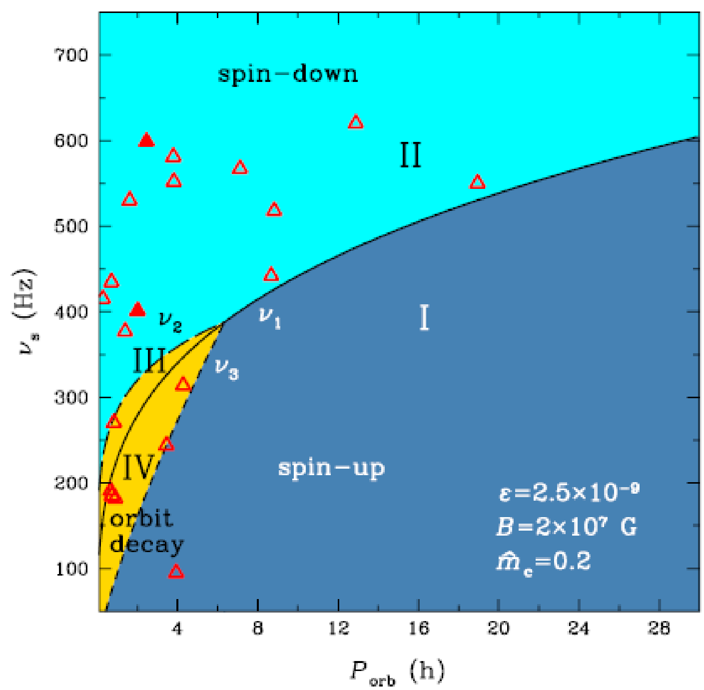
– non-standard accretion torque

– additional spin-down (mountains, r-modes, B-field)

Possible indirect evidence for a gravitational-wave component from spin vs orbit period in the observed systems.

Required deformation significantly below current LIGO limits, but may (just?) be within reach of the third generation Einstein Telescope.

(Ho, Maccarone & NA, ApJL 2011)

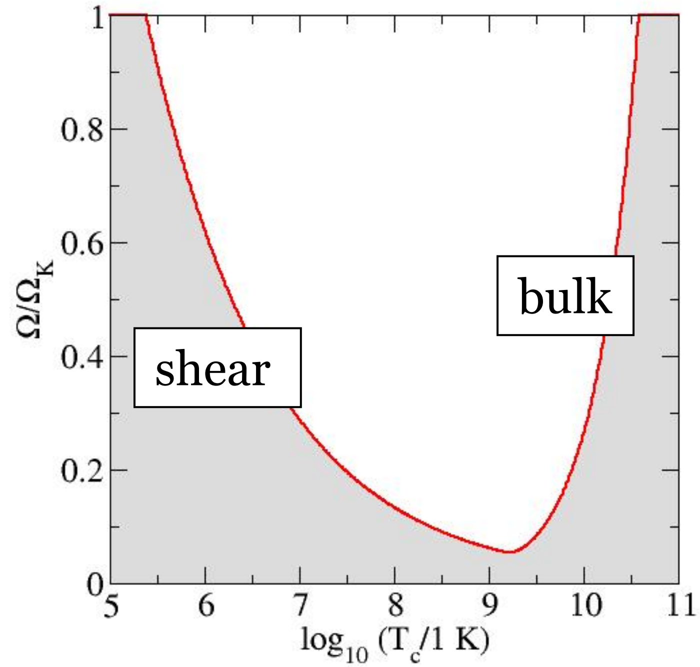


the r-mode instability

The r-modes belong to a large class of "inertial" modes, which are driven unstable by the emission of gravitational waves.

The $l=m=2$ r-mode grows due to current-multipole radiation on a timescale of a few tens of seconds.

Instability window depends on uncertain core-physics, i.e. provides a probe of exotic physics



The simplest models account for damping due to shear- and bulk viscosity.

Leads to a very large instability window.

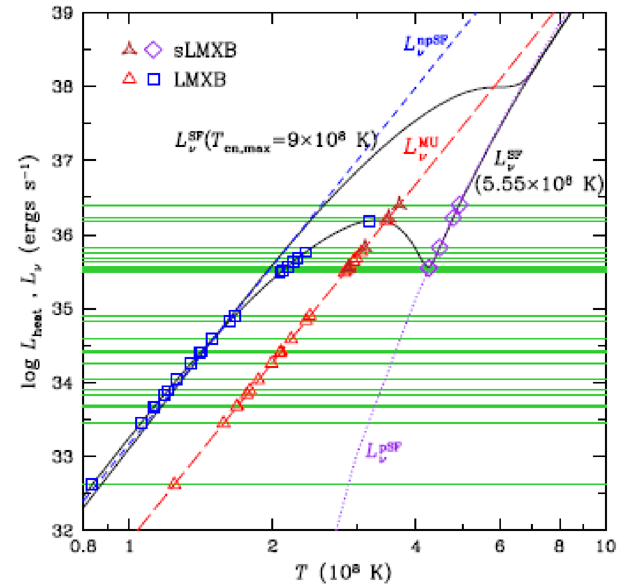
In principle, we should not observe any "usual" neutron star inside the instability region. Can we use this to "rule out" theoretical models?

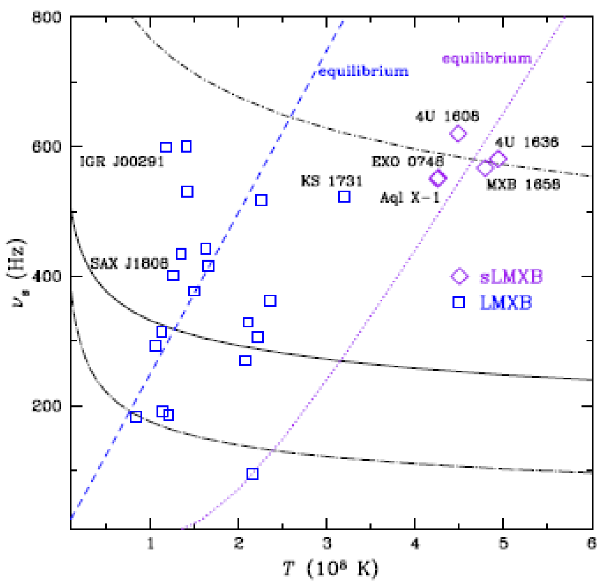
superfluid cores

Revisit core temperature in accreting systems in light of recent evidence for neutron superfluidity in Cassiopeia A remnant.

Standard cooling channel (mUrca) suppressed, but Cooper pair breaking channel open.

Assume r-mode balances accretion…





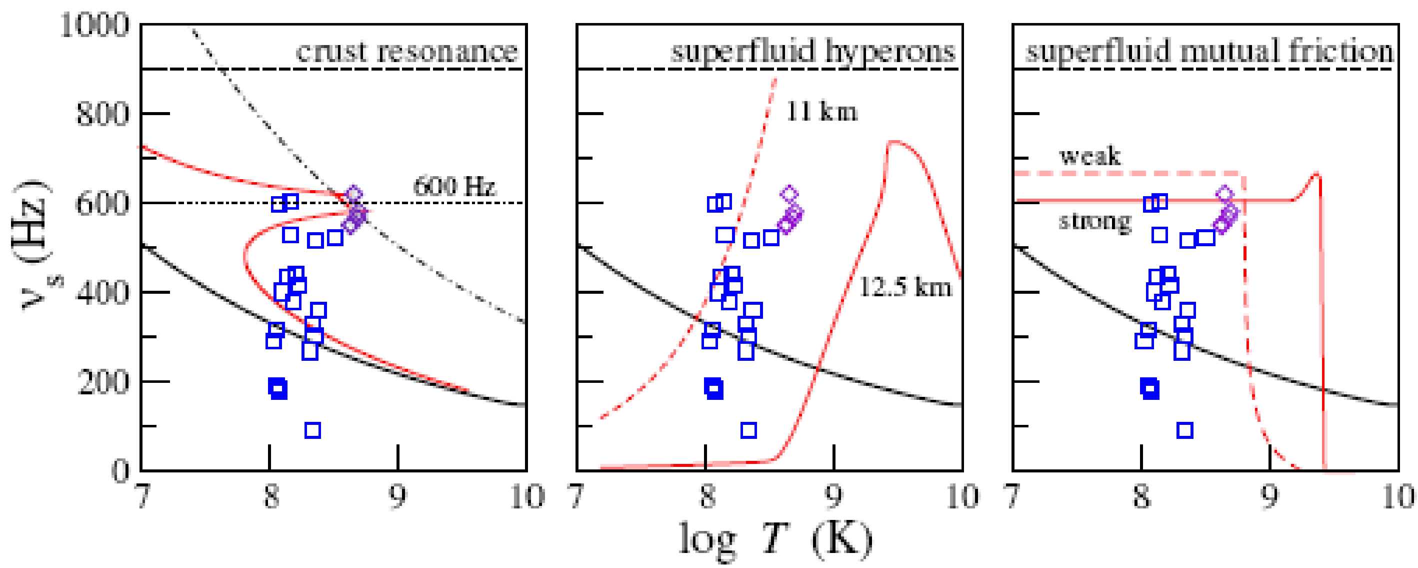
Suggests that many systems are inside instability window (crust Ekman layer with “slippage”).

If unstable, these systems should behave “differently” (rapid recurrence time X-ray bursts?).

If stable, we need to understand physics better.

(Ho, NA & Haskell, submitted 2011)

explanations?



Consider how “exotica” may impact instability, sufficiently to stabilize systems;

– transition to superconducting core (not considered yet)

– “resonances” between r-mode and toroidal crust modes (need detailed model)

– hyperon (or quark) bulk viscosity (but… problematic for ms radio PSRs)

– stronger superfluid vortex mutual friction (fluxtube cutting?)

Quite a lot of work to do here…