# Latest news on continuous-wave sources

Benjamin J. Owen
Albert Einstein Institut, Golm bei Potsdam

March 16, 2000

LIGO-G000038-00-D

## Summary

Lots of papers on r-modes, one monster paper on electron capture.

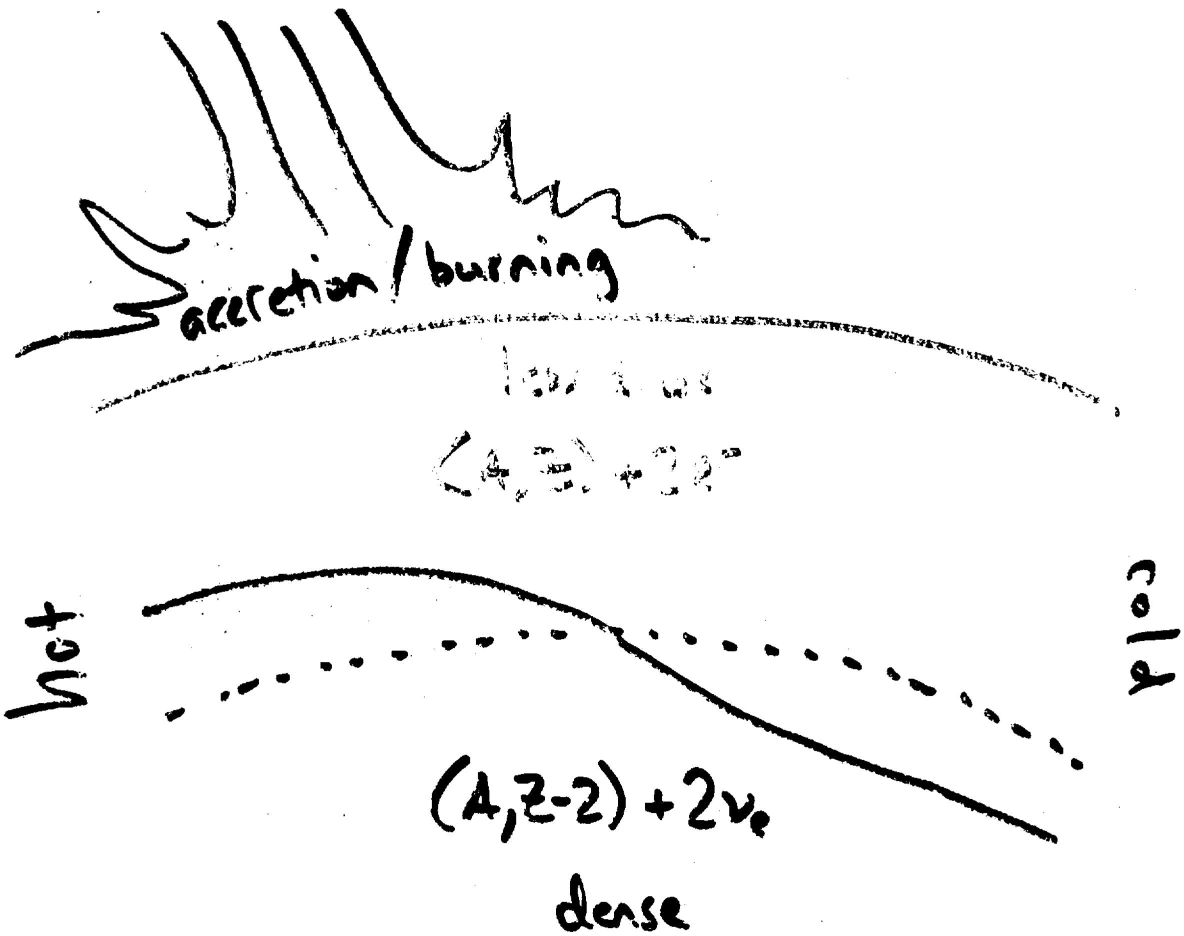
LMXBs are sure to have large electron-capture quadrupoles (LIGO-II).

**The r-modes are dead**, at least in LMXBs.

**Long live the r-modes** in newborn neutron stars, though not as long as we thought (still good for LIGO-II).

## Electron capture in crust

Bildsten (1998): Strong temperature dependence of e-capture lets accreting neutron stars have quadrupoles detectable by LIGO-II.

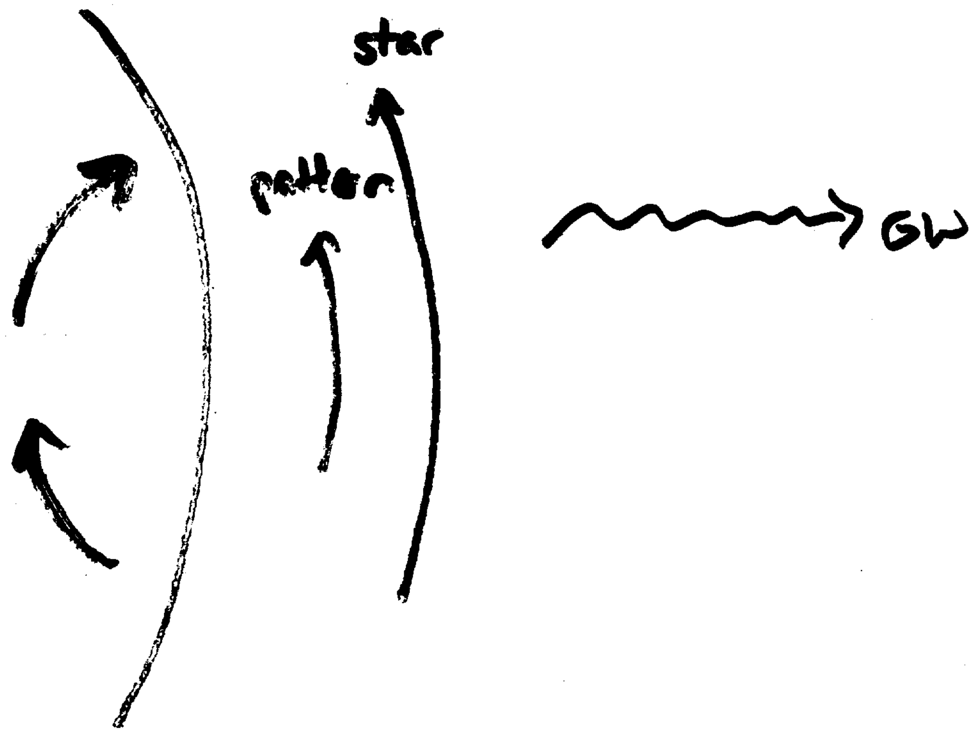



... but neutron-star $\mu/p$ is basically Jell-O, mountains tend to sink.

## R-mode instability

Owen et al. (1998): Fluid r-modes are CFS unstable in newborn neutron stars, detectable by LIGO-II at several per year.

Bildsten (1998), Andersson, Kokkotas, & Stergioulas (1999): LMXBs too?




Driving beats damping for about a year then superfluid transition.

*G. Ushomirsky, C. Cutler & L. Bildsten, astro-ph/0001136*

Quadrupole down by 20-50 due to sinkage, but comes back up thanks to multiple layers deep in crust.

Tooth fairy only needs few % lateral temperature gradients, fraction of % (Z/A) gradients (reasonable from x-rays).

Needs breaking strain $10^{-2}$, higher than known materials.

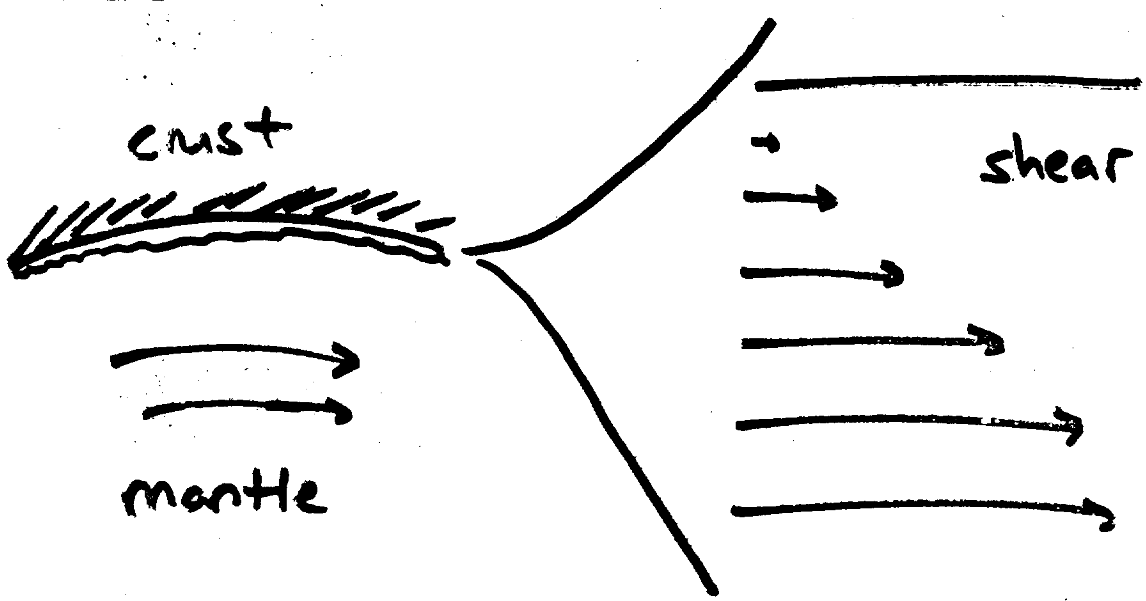
Turned around, maybe Eddington-rate accretion pushes crusts to the breaking point, explaining the 300Hz hangup.

Some (?) quadrupole left over long after accretion stops, hope for old neutron stars.

## Boundary layer

*L. Bildsten & G. Ushomirsky, ApJ 529, L33*

Shear in boundary layer under crust damps $10^5$–$10^7$ times faster than we thought, r-modes are no longer unstable with crust, kills LMXBs.




*N. Andersson et al., astro-ph/0002114.* dispute this, *M. Rieutord, astro-ph/0003171* confirms it.

*B.J. Owen, unpublished*

Crust forms around $10^{10}$K, when r-modes are already growing in newborn neutron stars.

Boundary layer $\rightarrow$ extreme localized heating, neutrino emission and thermal conduction cannot compensate $\rightarrow$ crust melts (stays melted) if r-mode is big enough.

'Big enough' means $\delta v/v \sim 10^{-3}$, reasonable.

But very sensitive to crust melting temperature (among other things).

## Magnetic fields

*W.C.G. Ho & D. Lai, astro-ph/9912296*: Magnetic braking of spin substantially reduces SNR for $B > 10^{14}$G (reliable).

*L. Rezzolla, F.K. Lamb, & S.L. Shapiro, ApJ 531, L139* and *Y. Levin & G. Ushomirsky, astro-ph/9911295*: r-modes $\rightarrow$ differential rotation $\rightarrow$ field windup (in toy models), substantial loss of SNR for $B > 10^{10}$G.

But it's a nonlinear hydro effect they're trying to get with linear hydro. *P.M. Sa, unpublished* has found severe problems with the toy models.

# Parameter-space grid for Hough hierarchical pulsar search

Benjamin J. Owen
Albert Einstein Institut, Golm bei Potsdam

March 16, 2000

## What we've got

Parameter space metric: power loss $= g_{\mu\nu} d\lambda^\mu d\lambda^\nu$ for parameters $\lambda^\mu$ guessed wrong by $d\lambda^\mu$.

Define a canonical time so signal $\sim e^{i2\pi f_0 t_c}$,

$$t_c = t_b + \sum_{k=1}^{s} \frac{f_k}{k+1} t_b^{k+1}. \qquad (1)$$

Ptolemaic astronomy is good enough for the metric (CPU-friendlier than JPL ephemeris):

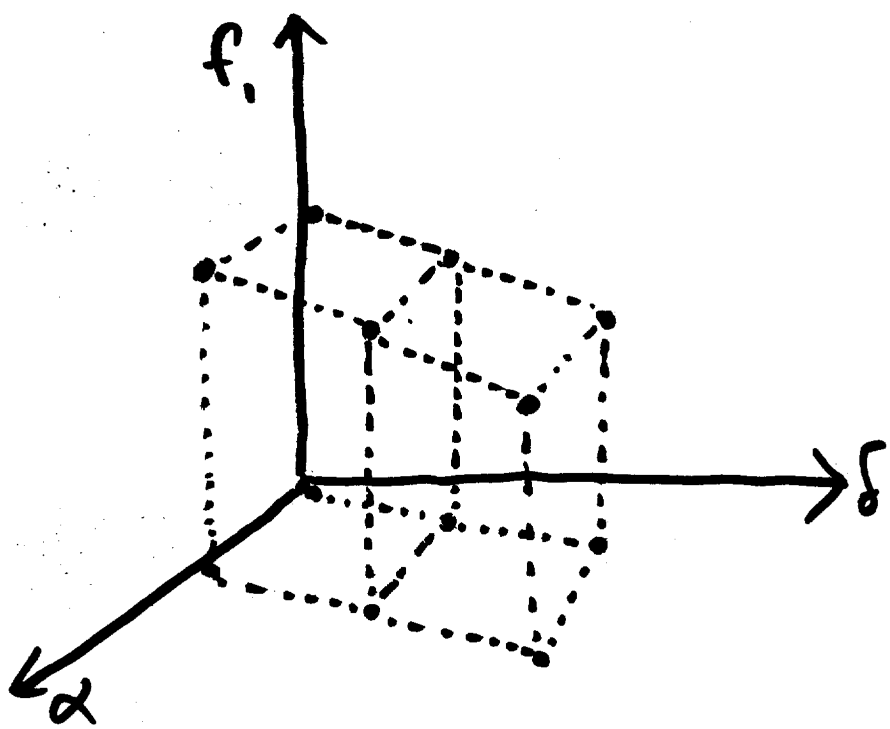
$$t_b = t + r\cos\delta\, \cos(\omega t + \psi_0) + R\cos\beta\, \cos(\Omega t + \phi_0) \qquad (2)$$

Metric is obtained from derivatives

$$g_{\mu\nu} = 4\pi^2 \left[\langle (f_0 t_c)_{,\mu} (f_0 t_c)_{,\nu}\rangle - \langle (f_0 t_c)_{,\mu}\rangle \langle (f_0 t_c)_{,\nu}\rangle\right]. \qquad (3)$$

Right now just $\sim$ 1 day coherent integration (coarse stage of hierarchical search), include only daily modulation and spindown (fake yearly as spindown). Harder than expected.

Input: maximum $f_0$, minimum spindown age, coherent integration time, sky area to search.




Output: grid points (neglect spindown-position correlations for now, converting to LAL specs)

# What's next

LAL specs instead of quick and dirty

Spindown-position correlations change, can't be neglected on longer timescales (fiddle with spindown definitions?)

How to (efficiently) do Hough histogram when the bins are changing? How much are they changing?

*Note 1, Linda Turner, 04/27/00 02:37:44 PM*
LIGO-G000038-00-D