Gravitational waves from isolated neutron stars

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Outline

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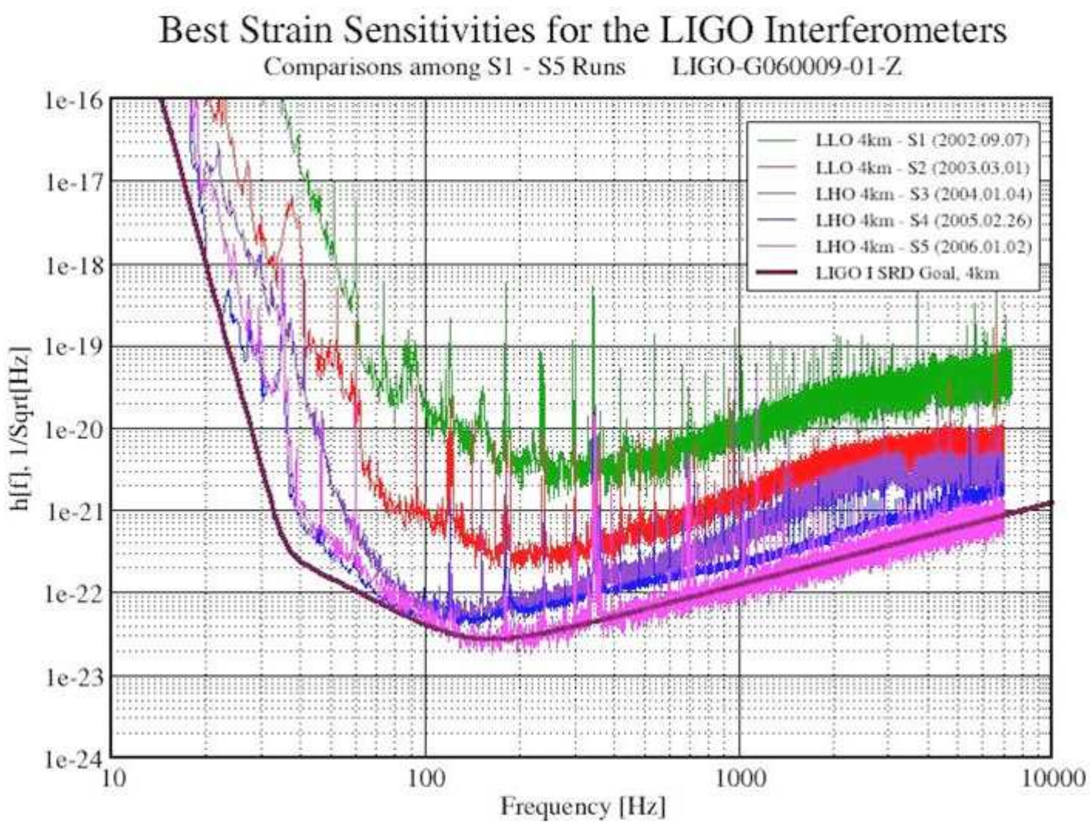
The state of gravitational wave detection

- The three US detectors, LIGO, have officially reached their initial design sensitivity.
- The Anglo-German detector GEO600 is at design sensitivity at frequencies above 200 Hz.
- The fifth science run, taking coincident data, began in November, and will last about 18 months.
- The Italian-French VIRGO is carrying out engineering runs, but is getting close to science mode.
- People are beginning to get jumpy...

LIGO performance



Ways in which neutron stars can emit gravitational waves

We are interested in continuous (approximately) monochromatic sources:

- Fluid oscillations, e.g. r-modes
- Free precession
- Triaxialty:

$$h = \left(\frac{2}{15}\right)^{1/2} \frac{G}{c^4}\frac{8\Omega^2}{d}\epsilon I,$$

where $\epsilon = \Delta I / I$ measures the fractional difference between two perpendicular moments of inertia.

Signal analysis difficulties

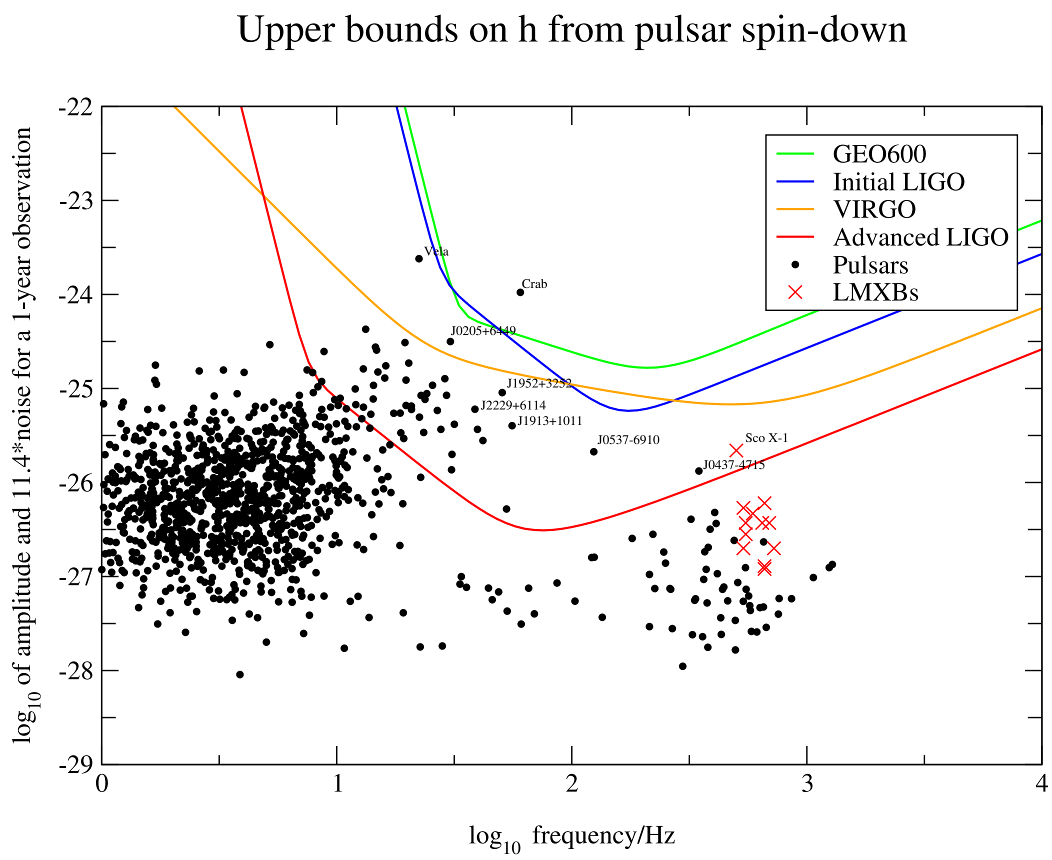
- A continuous monochromatic source is specified by 7 parameters:

$$\boldsymbol{\theta} = (h_0, f, \alpha, \delta, \phi_0, \iota, \psi)$$

- Real systems will probably require additional parameterisation, e.g. spin-down or binary-induced Doppler modulation.
- The way search proceeds depends upon whether source is *known* or *unknown*.

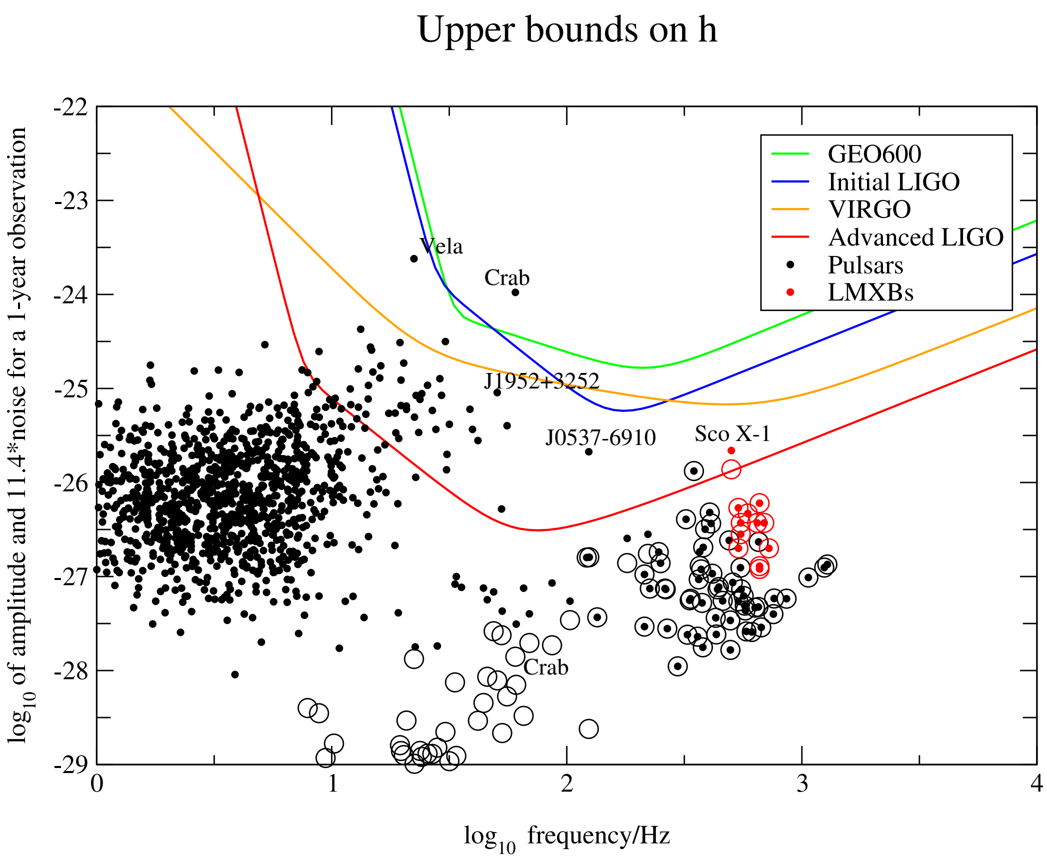
Known sources: *naive* bounds on amplitude

- Upper limits on GW emission from triaxial neutron stars can be used to decide which pulsars to target:



Known sources: *more realistic* bounds on amplitude

- A more realistic picture is obtained if we assume ϵ can be no larger than 10^{-7} (see Brynmor Haskell's poster):



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- Is it worthwhile targeting isolated non-pulsating stars?
- How secure is evidence that MSP spin-down is electromagnetically driven?

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- How realistic is the Blandford argument, i.e. how plausible is it that there exists a population of electromagnetically-quiet stars spinning down due to GW emission?
- In particular, is it possible to use existing (non-)measurements to constrain such a population?

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- Finding new targets
- Extracting further information from radio data
- Assessing GW interest of non-pulsating stars
- Deciding where best to look for unknown sources
- Assessing the likelihood of there being a sizable 'electromagnetically invisible' neutron star population (à la Blandford).