Gravitational waves from isolated neutron stars

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Outline

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• Astrophysical input for known sources
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• 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

Best Strain Sensitivities for the LIGO Interferometers
Comparisons among S1 - S5 Runs  LIGO-G060009-01-Z.
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:

\[ \theta = (h_0, f, \alpha, \delta, \phi_0, \iota, \psi) \]

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

Upper bounds on h from pulsar spin-down

- Crab
- Vela
- J0537-6910
- J1952+3252
- Sco X-1
- J0205+6449
- J2229+6114
- J1913+1011
- J0437-4715

Known sources: **naive** bounds on amplitude
Known sources: more realistic bounds on amplitude

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

![Graph showing upper bounds on $h$](image)
Known sources: astrophysical inputs/issues

- Find *new* stars, probably MSPs or young close stars

Can one extract further information from radio data, viz, the inclination angle via pulsar beam width (à la Rankin) or via polarisation sweep? How reliable is this?

Is it worthwhile targeting isolated non-pulsating stars?

How secure is evidence that MSP spin-down is electromagnetically driven?
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Unknown sources: astrophysical inputs/issues

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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?
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In particular, is it possible to use existing (non-)measurements to constrain such a population?
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- 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).