Search for GWs from known Pulsar

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The signal received at the detector

Two components with two emission frequencies:

$$f_0 : h_1(t) = F_+ \frac{1}{8} h_0 \sin(2\vartheta) \sin(2\iota) \cos\Psi(t) + F_\times \frac{1}{4} h_0 \sin(2\vartheta) \sin\iota \sin\Psi(t)$$

$$2f_0 : h_2(t) = F_+ \frac{1}{2} h_0 \sin^2\vartheta (1 + \cos^2\iota) \cos 2\Psi(t) + F_\times h_0 \sin^2\vartheta \cos\iota \sin 2\Psi(t)$$

Phase model:

$$\Psi(t) = \phi_0 + 2\pi\left[f_0(T(t) - T(t_0)) + \frac{1}{2}\dot{f}_0(T(t) - T(t_0)) + \frac{1}{2}\ddot{f}_0(T(t) - T(t_0))^2 + \mathrm{O}(T^4) \right]$$

T(t) is the arrival time of a signal at SSB reference frame

f_0 rotation frequency

$\overset{n}{f}$ spin down parameter

$$h_0 = \frac{16\pi G}{c^4} \frac{\varepsilon I f^2}{r}$$

ι angle between the pulsar spin axis and line of sight

ϑ the wobble angle

The signal received at the detector

A GW signal the interferometer detect from a pulsar will be:

- Frequency modulated by relative motion of detector and source. The signal results frequency shifted. The amplitude of this shift depends on the frequency, position and velocity of the source.

$$\Delta\nu \approx 10^{-4}\,Hz$$

- Amplitude modulated by the motion of the antenna pattern of the detector. This modulation splits each component into five lines. The amount of power in each lines depends on position and orientation of source and detector and on the percentage of linear polarization.

- There are also relativistic effect which contributed to the frequency : we take in account Einstein delay due to the gravitational redshift and time dilation. It is a difference between the time at SSB an the time at the detector. $\Delta\nu \approx 10^{-8}\,Hz$

  The Shapiro effect is a time delay due to a waves propagation in a curve space time. $\Delta\nu \approx 10^{-13}\,Hz$

Search Method

- Data cleaning: noise events removal. (See Astone et al. Annecy2004).

- The data are heterodyned to reduce the sampled rate and take account of Doppler shift and pulsar slowdown:
  - -First stage: data are heterodyned at Pulsar frequency.
  - -Second stage: Doppler and spindown correction.
  - -Sixth order Butterworth low-pass filter applied in each step. The data is down-sampled via averaging.

- Then we analyze the periodogram executes of the resulting data (down- sampled complex time series).

Work in progress
and future

- Apply the method to the WSR Virgo run data.

- Realize the algorithm in one step only:
  the phase calculation is computationally expensive, it is possible to calculate detector position not for every sample but obtain it by interpolation.

- Apply the coherent SFT Pia's procedure to the targeted Pulsar search.