An all-sky search for continuous gravitational waves from neutron stars in binary systems using the TwoSpect algorithm

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▸ GWs from spinning neutron stars in binary systems

- A significant fraction of known neutron stars (NSs) exist in binary systems
- Spinning NSs may emit GWs at frequency $f_{gw} = 2\nu$ where ν is the spin frequency of the NS
- Accretion or other perturbations might cause the emission to be stronger than that from an isolated source
- A number of unknown NSs likely exist in binary systems which could be emitting GWs strong enough to detect with LIGO, Virgo, or other similar GW detectors
- Methods have been developed to perform targeted searches for known NS and all-sky searches for unknown continuous wave sources (see, for example, [1])
- For unknown sources in binaries, we need new, efficient algorithms

▸ Overview of the TwoSpect analysis

- TwoSpect has been developed to take advantage of the periodic Doppler modulation of the source waves due to the binary system (see Figure 1)
- After pre-processing the detector $h(t)$ data, analysis proceeds through a multi- stage pipeline to find potential signals buried in noise: 1) incoherent harmonic summing, 2) so-called "Gaussian" templates, 3) and more precise "exact" templates (see Figure 2)
- At intermediate stages, a clustering algorithm is employed to isolate the best parameters for individual candidates, and reduce computational costs

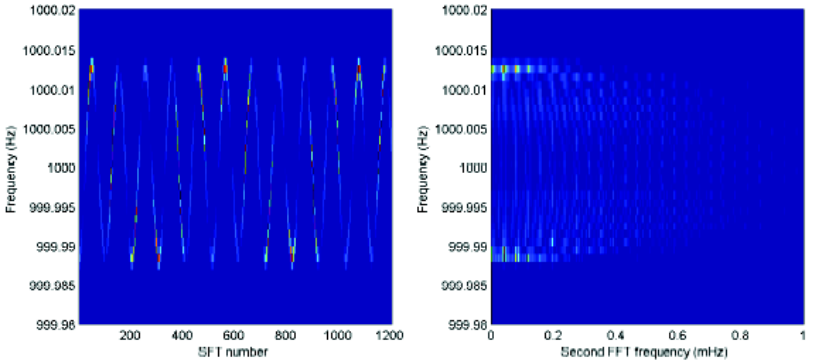

Figure 1: Simulated source of strong GWs in a binary system. Left: time-frequency plot shows the periodic nature of the binary Doppler modulation. The amplitude modulation is due to the changing antenna pattern of the detector. Earth's orbital and rotational modulation has been removed by shifting frequency bins of each SFT. Right: power spectra of each frequency bin as a function of time is computed. The brightest pixels are the fundamental or harmonics of the binary orbital period. Other bright pixels are due to the amplitude modulation caused by the daily variation of the detector antenna pattern.

▸ Search strategy

- Search over a wide band, 50 Hz to 1 kHz, in ~2 Hz segments and over all sky locations for candidates using incoherent harmonic summing passing threshold tests
- Candidates are passed to "Gaussian" and "exact" templates for further tests and analyzed according to the TwoSpect search statistic [2]:

$$R = \frac{\sum_n \epsilon_n (x_n - \langle s_n \rangle)}{\sum_n \epsilon_n^2} \qquad (1)$$