

Detection Feasibility of Continuous Gravitational Waves

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A simulation-based feasibility study for continuous gravitational wave detection using a matched filtering procedure evaluated across two neutron star targets and two detector sensitivity scenarios is presented. For the Crab Pulsar (PSR J0534+2200), a monochromatic gravitational wave signal was modeled using the Einstein quadrupole formula at $f_{gw} = 59.4$ Hz under Advanced LIGO Zero Detuning High Power (ZDHP) sensitivity. For PSR J0437-4715, a nearby millisecond pulsar at 0.156 kpc with $f_{gw} = 347.38$ Hz, detection feasibility was evaluated under the projected Cosmic Explorer design sensitivity. Colored noise was measured via fast Fourier transform (FFT) spectral shaping using measured and design amplitude spectral density (ASD) files, injected with monochromatic continuous gravitational wave signals, and processed through a matched filtering pipeline created in Python. Signal-to-noise ratio was tracked as a function of coherent integration time and compared against a detection threshold of $\rho^* = 11.4$. For the Crab Pulsar, an ellipticity sweep over $\varepsilon \in 10^{-6}, 10^{-7}, 10^{-8}$ shows that no detection is expected at physically realistic ellipticities under current aLIGO sensitivity. For PSR J0437-4715 under projected Cosmic Explorer sensitivity, only 54 seconds of coherent integration at $\varepsilon = 10^{-7}$ is predicted under the assumed Cosmic Explorer design sensitivity.

The primary limitations of this study are the assumption of perfect phase coherence over the full integration period, the absence of spin-down and Doppler correction terms in the signal model, and the use of design sensitivity curves rather than measured noise realizations for the Cosmic Explorer scenario.