The Parkes Pulsar Timing Array and detection of gravitational waves

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Gravitational waves are an important prediction of Einstein's general theory of relativity. Evidence for their existence has come from observations of orbit decay in double-neutron-star binary systems, but up to now, despite huge efforts, there has been no direct detection of these waves. In collaboration with groups from the Swinburne University of Technology, Melbourne, and the University of Texas, Brownsville, we have embarked on a major project to establish the Parkes Pulsar Timing Array (PPTA) with the principal goal of making a direct detection of gravitational waves of astronomical origin. The project involves making precision timing observations of 20 millisecond pulsars at intervals of 2 – 3 weeks using the Parkes 64-m radio telescope. Observations are made at three radio frequencies, 685, 1400 and 3100 MHz, to allow correction for interstellar propagation effects. The PPTA is most sensitive to gravitational waves with frequencies in the nanoHertz range and hence is complementary to ground- and space-based laser interferometer systems. Simulations suggest that, if timing precisions of order 100 nanoseconds can be reached for most of the observed sample over a 5-year data span, the stochastic background of gravitational waves from super-massive binary black holes in the cores of galaxies should be detectable. Currently we have achieved this level of precision for 3 or 4 pulsars and sub-microsecond precision for a further 8 or 9 pulsars. Improved hardware and software systems under development will hopefully allow us to reach our goal. The PPTA will also allow the establishment of a "pulsar timescale" which may be more precise than the best terrestrial timescales over long time intervals, as well as other investigations of pulsar and interstellar medium properties.