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Testing alternative theories of gravity using Pulsar Timing Arrays

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Pulsar timing experiments aimed at the detection of gravitational radiation have been performed for decades now. With the forthcoming construction of large arrays capable of tracking multiple millisecond pulsars, it is very likely we will be able to make the first detection of gravitational radiation in the nano-Hertz band, and test Einstein's theory of relativity by measuring the polarization components of the detected signals. Since a gravitational wave predicted by the most general relativistic metric theory of gravity accounts for six polarization modes (the usual two Einstein's tensor polarizations as well as two vector and two scalar wave components), we have estimated the single-antenna sensitivities to these six polarizations. We find pulsar timing experiments to be significantly more sensitive, over their entire observational frequency band (10^{-9} - 10^{-6} Hz), to scalar-longitudinal and vector waves than to scalar-transverse and tensor waves. At 10^{-7} Hz and with pulsars at a distance of 1 kpc, for instance, we estimate an average sensitivity to scalar-longitudinal waves that is more than two orders of magnitude better than the sensitivity to tensor waves. Our results imply that a direct detection of gravitational radiation by pulsar timing will result into a test of the theory of general relativity that is more stringent than that based on monitoring the decay of the orbital period of a binary system.