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Exploring gravity and gravitational waves

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Extended Abstract

Radio photons are the least energetic ones used by astronomers. Yet, their origin is often associated with highly energetic processes, coming frequently from places of extreme conditions involving high energies, high gravitational or magnetic fields. As a result, this window of the electromagnetic spectrum is a doorway to an effective laboratory for fundamental physics. A prime example is the usage of radio astronomy for exploring gravitational physics.

The last years have seen continuing activities in the exploration of our understanding of gravity, motivated by results from precision cosmology, new precision astrophysical experiments and recently the detection of gravitational waves using Earth-bound detectors. At the centre of attention lies the question as to whether general relativity is the correct theory of gravity. In answering this question, scientists are not only working towards correctly interpreting the phenomena of "Dark Matter" and "Dark Energy" but also ultimately towards the desired goal of achieving a quantum theory of gravity. Whether this is possible depends heavily on constraints provided by experiments and observations. Here, the observations of pulsars, especially those in binary systems, play an important role. Pulsars did not only provide the first evidence for the existence of gravitational waves, but they also allow extremely precise tests of general relativity and alternative theories of gravity under strong-field conditions. Moreover, the regular observation of a large sample of so-called millisecond pulsars, also corresponds to the "construction" of a gigantic, galaxy-size gravitational wave detector. With the pulsar-Earth lines-of-sight acting as our measurement arms, this "Pulsar Timing Array" is sensitive to nHz-gravitational wave frequencies, i.e. a frequency range that is not accessible by any other detector.

This talk will concentrate on corresponding gravity experiments that are possible using pulsars and neutron stars; it will also cover ongoing radio astronomy experiments that aim to study the properties of black holes; and finally we give a status of the ongoing efforts to detect nHz-gravitational waves and provide the context to LIGO and other experiments.