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Experiments: Detecting low-frequency gravitational waves with Pulsar Timing Arrays

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Pulsars are highly-magnetized, rapidly-rotating neutron stars that emit beams of radio waves from their magnetic poles. Due to the misalignment of the magnetic and rotation axes of the pulsar, our radio telescopes on Earth can detect a pulse for each rotation of the pulsar as in the 'lighthouse effect'. Monitoring those pulses and their arrival times at radio telescopes is called "pulsar timing". The extreme precision with which millisecond pulsars —the type of pulsars with rotation periods of a few tens of milliseconds —rotate make them the most precise "cosmic clocks"in the universe. Pulsar timing data collected over several months or years allows us to collect information about pulsars such as its period, motion, or interstellar medium characteristics. Pulsar timing also offers the exciting possibility of detecting gravitational waves passing through. Indeed, gravitational waves from astrophysical systems located far away, such as supermassive black hole binaries in distant galaxy mergers, can distort the spacetime fabric as it passes the pulsar-Earth system. This in turn will change the arrival times of the radio signals emitted by pulsars. Monitoring the arrival times for an array of pulsars over several years could enable us to detect low-frequency gravitational waves, which would be seen as a red noise signal in the pulsar timing residuals. In this talk, we review the principles of Pulsar Timing Arrays, the collaborations and radio telescopes working on GW detection, which include the European Pulsar Timing Array collaboration, the Large European Array for Pulsars project, the Sardinia Radio Telescope and synergy with the Gaia collaboration. Finally, we present recent results, which include the presence of a red noise signal that is common to all pulsars of the array and which is seen by all collaborations, and which could be the signature of a stochastic background of low-frequency gravitational waves. We discuss the steps needed to establish the true nature of this signal.

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