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Radio pulsars as the best (natural) laboratory to test aspects of fundamental physics

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Neutron stars are rapidly spinning, highly magnetised, extremely dense compact stars. They are believed to be composed of mostly neutrons and some amount of other baryons. There are even theories that free quarks exist near the core of neutron stars. Hence, knowing the properties of neutron stars observationally help us understand properties of matter at extreme densities. Neutron stars are best studied as radio pulsars. Timing analysis of radio pulsars in highly relativistic binary systems can lead to better constraints. This is possible via measurements of the mass of the pulsar and its
moment of inertia simultaneously. The mass measurement is possible by measuring multiple post-Keplerian parameters that include the decay of the orbital period, periastron precession,
Einstein delay, and Shapiro delay. The measurement of the moment of inertia is possible by decoupling the post-Newtonian terms and the frame-dragging term from the periastron
precession. However, to decouple the effect of the frame-dragging, the binary system should satisfy some specific criteria, most of which are satisfied for the double pulsar system.
Binary pulsars are also used to reconfirm general relativity and put limits on various alternative theories. Finally, radio pulsars can be used to detect low frequency (nano-Hz) gravitational waves originating from inspirals of supermassive black holes or cosmological reasons through experiments known as 'Pulsar Timing Array'. In this talk, I will touch above points, how radio pulsar observations can constrain the Equation of State of the dense matter, test theories of gravity and detect low-frequency gravitational waves.

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