Pulsars as Laboratories for Fundamental Physics

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Pulsars — rapidly rotating neutron stars emitting regular electromagnetic pulses — are pivotal in astrophysical tests of fundamental physics. Their pulse timing precision allows the detection of subtle disturbances from gravitational waves, while their extreme density offers unique insights into theories beyond the Standard Model, especially those predicting baryon number violation (BNV). Stringent constraints on BNV, arising from its non-observation in experiments, motivate the search for its astrophysical consequences. This talk examines how slow BNV processes, leading to quasi-equilibrium evolution, influence pulsar orbital and spin dynamics. Observations of binary pulsar orbital periods, coupled with the effects of dense matter in neutron star cores, can place severe constraints on BNV. We propose that BNV in pulsars could manifest as anomalies in the second derivative of the spin frequency, transitions between states of spinning down and up, and a spectrum of braking indices. The talk concludes by exploring the potential for detecting these effects, particularly in the context of advancements in pulsar timing arrays and the broader implications for our understanding of fundamental physics.