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Detection possibility of continuous gravitational waves from isolated rotating magnetized compact objects

In the past decades, several neutron stars (NSs), particularly pulsars, with mass $M > 2M_{\odot}$ have been observed. Hence, there is a generic question of the origin of massive compact objects. Here we explore the existence of massive, magnetized, rotating NSs with various equation of states (EoSs) using XNS code, which solves axisymmetric stationary stellar equilibria in general relativistic magnetohydrodynamics (GRMHD). We visualise the deformation of NS due to magnetic field (Toroidal and/or Poloidal) and rotaion (Uniform or Differential), by solving the Einstein equation (describes space-time metric) and Magneto-Hydrostatic Equilibrium (provides distribution of matter/energy) simultaneously. Such rotating NSs with magnetic field and rotation axes misaligned, hence (triaxial system) having non-zero obliquity angle, can emit continuous gravitational waves (GW), which can be detected by upcoming detectors, e.g., Einstein Telescope, etc. We discuss the decays of magnetic field, angular velocity and obliquity angle with time, due to Hall, Ohmic, ambipolar diffusion and angular momentum extraction by GW and dipole radiation, which determine the timescales related to the GW emission. Further, in the Alfvén timescale, a differentially rotating, massive proto-NS rapidly loses angular momentum to settle into a uniformly rotating, less massive NS due to magnetic braking and viscous drag. These explorations suggest that detecting massive NSs is challenging and sets a timescale for detection. We calculate the signal-to-noise ratio of GW emission, which confirms that any detector cannot detect them immediately, but detectable by Einstein Telescope, Cosmic Explorer over months of integration time, leading to direct detection of NSs.

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