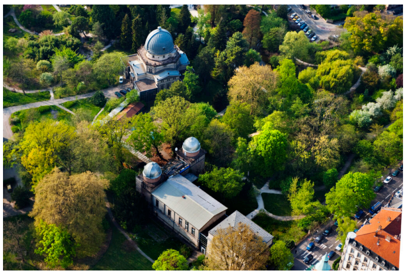

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# Influence of rotation on magnetic field stability and orientation in isolated neutron star

Neutron stars are the most compact horizonless objects in the Universe, exhibiting the strongest known magnetic fields. They are potential sources of coincident gravitational waves and electromagnetic radiation across the entire spectrum. However, the internal configuration of their magnetic fields and the mechanisms that stabilize them remain open questions. As a stepforward understanding the timescale for the emergence of magnetic instabilities that disrupt the stellar field configuration, we study the impact of stellar rotation using three-dimensional general relativistic numerical simulations of uniformly rotating neutron stars threaded by strong, poloidal, pulsar-like magnetic fields. The initial stellar configurations assume perfect conductivity and are stationary and axisymmetric. We explore a range of angular velocities, from non-rotating stars to those near the mass-shedding limit. We find that non-rotating neutron stars are unstable to the Tayler and Parker instabili- ties, which significantly change the magnetic field geometry. These instabilities lead to a rapid reduction of the initial magnetic energy by ~ 99% within ~ 4 Alfv´en times from their onset. In contrast, rotation significantly delays the development of these instabilities and, in some cases, mitigates their effects. Highly rotating models retain up to ~ 30% of their magnetic energy for at least ~ 10 Alfv´en times. Additionally, our simulations show that neutron stars spontaneously develop differential rotation in their cores. At larger distances from the star, the magnetic field strength becomes misaligned with the angular velocity, with the degree of misalignment increasing for higher angular velocities. Our results suggest that rotation plays a crucial role in stabilizing the magnetic field of neutron stars, regardless of its initial configuration.

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