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Magnetic field evolution in neutron star cores

The study of the evolution of neutron star magnetic fields is likely to help us understand the connection between the different classes of NSs, which have magnetic fields of very different strengths, depending on their age. This observational evidence suggests that the NS magnetic field evolves in time. Numerous studies, both purely theoretical and numerical, have contributed to understand the processes that drive this evolution. However, most of the numerical efforts have focused in the crust, since the physics of the evolution of the magnetic field is conceptually much simpler there than in their core.

The NS core is a fluid mixture of neutrons, protons, and electrons (joined by other species at increasing densities) that scatter off each other through strong and electromagnetic interactions, causing effective friction forces, and can also convert to each other by weak interactions (“Urca reactions”). Likely, the dominant process evolving the magnetic field there is ambipolar diffusion, i.e., the joint motion of the charged particles and the magnetic field relative to the neutrons, driven by the Lorentz force and controlled by frictional forces and pressure gradients.

Using numerical simulations restricted to axially symmetric geometry, we study the long-term evolution of the magnetic field in the interior of an isolated neutron star under the effects previously described.

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