Simulations of the magnetic field evolution in neutron star cores

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Abstract

The evolution of the magnetic field in neutron stars is strongly related to their internal structure. In the neutron star core, there 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 into 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. Here, we present simulations of the long-term evolution of the magnetic field in the interior of an isolated, axially symmetric neutron star core, under ambipolar diffusion.

Special attention is given to the characterization of the newly developed numerical approach, different physical processes involved, as well as their corresponding timescales, which happen to be in agreement with our numerical estimates.