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# Tayler-Spruit dynamo in a proton-neutron star: a new magnetar formation scenario

Magnetars are isolated young neutron stars characterized by the most intense magnetic fields known in the Universe, which power a wide diversity of high-energy emissions. The origin of their magnetic field is still a challenging question. In situ magnetic field amplification by dynamo action is a promising process to generate ultra-strong magnetic fields in fast-rotating progenitors. It is, however, unclear whether the fraction of progenitors harboring fast core rotation is sufficient to explain the entire magnetar population. To address this point, we investigate a new scenario for magnetar formation from a slow rotating progenitor, in which a slow-rotating proto-neutron star is spun-up by the supernova fallback. We show that this can trigger the development of the Tayler-Spruit dynamo while other dynamo processes are disfavored. This dynamo was only applied to stellar radiative zones and was elusive in numerical simulations until recently. I will present new 3D direct numerical simulations of the Tayler-Spruit dynamo. We demonstrate the existence of two distinct Tayler-Spruit dynamos, which differ by their magnetic field intensity and equatorial symmetry. Also, each dynamo branch follows a different theoretical scaling law: one predicted by H.-C. Spruit and the other by J. Fuller et al. Beyond supporting our astrophysical scenario, these findings raise new questions about the impact of Tayler-Spruit dynamo on stellar evolution.