Spin down by dynamo action in simulated radiative stellar layers

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Abstract

The evolution of a star is influenced by its internal rotation dynamics through transport and mixing mechanisms, which are poorly understood. Magnetic fields can play a role in transporting angular momentum and chemical elements, but the origin of magnetism in radiative stellar layers is unclear. Using global numerical simulations, we identify a subcritical transition to turbulence due to the generation of a magnetic dynamo. Our results have many of the properties of the theoretically-proposed Tayler-Spruit dynamo mechanism, which strongly enhances transport of angular momentum in radiative zones. It generates deep toroidal fields that are screened by the stellar outer layers. This mechanism could produce strong magnetic fields inside radiative stars, without an observable field on their surface. Magnetic fields generated by dynamo action appear as a process to trigger turbulence in stellar interiors. Depending on the parameters or initial conditions, we report different dynamo branches that could explain stellar magnetism and the rotation profiles observed for stars with a thick radiative envelope.

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