What controls the large-scale magnetic fields of M dwarfs?

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Abstract

The magnetic fields of planets and rapidly rotating stars are maintained by convection-driven dynamos operating in their interiors. Scaling laws recently derived from geodynamo-like models successfully fit the magnetic field strength of a wide range of astrophysical objects from Earth and Jupiter to some rapidly-rotating stars. This emphasises the similarities between the dynamo mechanisms at work in planets and active M dwarfs.

Spectropolarimetric observations of rapidly-rotating M stars show a broad variety of large-scale magnetic fields encompassing dipole-dominated and multipolar geometries. Combining global-scale numerical dynamo models and observational results, we want to better understand the similarities of dynamos in planets and low-mass stars. To study the physical mechanisms that control the magnetic field morphology in these objects, we have explored the influence of rotation rate, convective vigor and density stratification on magnetic field properties in anelastic dynamo models.

In such models, the relative importance of inertia in the force balance - quantified by the local Rossby number - is thought to have a strong impact on the magnetic field geometry. The observed transition between dipole-dominated and multipolar large-scale dynamos in early to mid M dwarfs is therefore tentatively attributed to a Rossby number threshold. We interpret late M dwarfs magnetism to be the consequence of a possible dynamo bistability occurring at low Rossby number, and predict different amplitudes of differential rotation on these two dynamo branches.

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