Bridging planetary and stellar dynamos: scaling laws for anelastic spherical shell dynamos

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Numerical dynamo models always employ parameter values that differ by orders of magnitude from the values expected in natural objects. However, such models have been successful in qualitatively reproducing properties of planetary and stellar dynamos. This qualitative agreement fuels the idea that both numerical models and astrophysical objects may operate in the same asymptotic regime of dynamics. This can be tested by exploring the scaling behavior of the models. For convection-driven incompressible spherical shell dynamos with constant material properties, scaling laws had been established previously that relate flow velocity and magnetic field strength to the available power. Here we analyze 272 direct numerical simulations using the anelastic approximation, involving also cases with radius-dependent magnetic, thermal and viscous diffusivities. These better represent conditions in gas giant planets and low-mass stars compared to Boussinesq models. Our study provides strong support for the hypothesis that both mean velocity and mean magnetic field strength scale as a function of power generated by buoyancy forces in the same way for a wide range of conditions.