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Effects of Equatorially-peaked Boundary Heat Flow on Dynamo Action

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The influence of heterogeneous thermal boundary condition on dynamo action in terrestrial planets has been explored with different emphases and applications: the core-mantle boundary (CMB) heat flow pattern inferred from lower mantle seismic tomography has been implemented in geodynamo models to seek a possible link to the observed features of the geomagnetic field; a hemispherical CMB heat flux pattern is also debated as a possible explanation for the observed dichotomy of the Martian crustal magnetic field.

In this work, we explore the influence of a sinusoidal variation of the super-adiabatic outer boundary heat flux that peaks at the equator on dynamo solutions driven by uniformly distributed buoyancy sources. The variation amplitude is gradually increased until the superadibatic flux reaches twice its mean value at the equator and becomes adiabatic at the poles.

With Rayleigh number lower than $\sim$10 times critical, the equatorially-peaked outer boundary heat flow drives a thermal wind structure consisting of a prograde jet near the equator and retrograde jets at mid to high latitudes. The dynamo action is highly oscillatory featuring a broad magnetic spectrum and quickly reversing banded surface magnetic fields. With Rayleigh number beyond $\sim$10 times critical, a hemispherical convection mode featuring zonal jets with opposite directions in the northern and southern hemispheres develops. Small equator-to-pole heat flow contrast would promote oscillating hemispherical dynamos. With moderate equator-to-pole heat flow contrast, a stable hemispherical dynamo can be reached.