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Dipolar stability in spherical simulations: the impact of an inner stable zone

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Abstract.

Keywords. Dynamo, Stably stratified, Numerical simulation, etc.

1. Introduction

2. Governing equations

We perform $3D$ magnetohydrodynamic simulations of a stratified fluid in a spherical shell of outer radius r_{o} and inner radius r_{i}. We use the anelastic version of the code MagIC to solve the non-dimensional equations that govern convective motions and magnetic field generation.

$$\frac{\partial \vec{\mathbf{u}}}{\partial t} + \vec{\mathbf{u}} \cdot \boldsymbol{\nabla} \vec{\mathbf{u}} + \frac{2}{\mathrm{E}} \hat{\mathbf{e}}_z \times \vec{\mathbf{u}} = -\boldsymbol{\nabla} p^\star + \frac{\mathrm{Ra}}{\mathrm{Pr}} g s' \hat{\mathbf{e}}_r + \frac{1}{\mathrm{Pm}\,\mathrm{E}\,\bar{\rho}} (\boldsymbol{\nabla} \times \vec{\mathbf{B}}) \times \vec{\mathbf{B}} + \vec{\mathbf{F}}_\nu, \tag{2.1}$$

$$\boldsymbol{\nabla} \cdot (\bar{\rho} \vec{\mathbf{u}}) = 0, \tag{2.2}$$

$$\bar{\rho}\bar{T} \left(\frac{\partial s'}{\partial t} + \vec{\mathbf{u}} \cdot \boldsymbol{\nabla} s' \right) + u_{\mathrm{r}} \frac{\mathrm{d}\bar{s}}{\mathrm{d}r} = \frac{1}{\mathrm{Pr}} \boldsymbol{\nabla} \cdot \left(\bar{\kappa} \bar{\rho} \bar{T} \boldsymbol{\nabla} s' \right) + \frac{\mathrm{Pr}\,\mathrm{Di}}{\mathrm{Ra}} Q_\nu + \frac{\mathrm{Pr}\,\mathrm{Di}}{\mathrm{Pm}^2\,\mathrm{E}\,\mathrm{Ra}} \lambda (\boldsymbol{\nabla} \times \vec{\mathbf{B}})^2, \tag{2.3}$$

$$\frac{\partial \vec{\mathbf{B}}}{\partial t} = \boldsymbol{\nabla} \times \left(\vec{\mathbf{u}} \times \vec{\mathbf{B}} \right) - \frac{1}{\mathrm{Pm}} \boldsymbol{\nabla} \times \left(\lambda \boldsymbol{\nabla} \times \vec{\mathbf{B}} \right), \tag{2.4}$$

$$\boldsymbol{\nabla} \cdot \vec{\mathbf{B}} = 0, \tag{2.5}$$

Our reference state is represented by an ideal gas nearly adiabatic, given by

$$\frac{1}{\bar{T}} \frac{\partial \bar{T}}{\partial r} = \epsilon_{\mathrm{s}} \frac{\mathrm{d}\bar{s}}{\mathrm{d}r} - \mathrm{Di}\, \bar{\alpha} g(r), \tag{2.6}$$

$$\frac{1}{\bar{\rho}} \frac{\partial \bar{\rho}}{\partial r} = \epsilon_{\mathrm{s}} \frac{\mathrm{d}\bar{s}}{\mathrm{d}r} - \frac{\mathrm{Di}\, \bar{\alpha}}{\Gamma} g(r) \tag{2.7}$$

3. Implications

References

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