Tidal dynamos in stratified fluids

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Gravito-inertial waves propagate in rapidly rotating and stably stratified flows [9] and can be coupled to generate the elliptical instability. It comes from a triadic parametric resonance between two inertial waves of the fluid and a flow with elliptical streamlines [5]. This phenomenon, generic in vortex dynamics [7], may play an role in geophysical and astrophysical turbulent flows (e.g. binary stars [6] or planetary liquid cores [1]), by enhancing transport and mixing. Moreover, it may generate self-sustained magnetic field by dynamo effect [2], which could drive magnetotohydrodynamic (MHD) turbulent flows. However, the effect of density stratification on the elliptical instability is not clear. Stable stratification can enhance the instability [3] or stabilizes it [4].

As a model of planetary or stellar fluid layers, we study here the elliptical instability in stratified fluid spheres undergoing a tidally-like forcing. To mimic an elliptical distortion in spherical geometry, we build a theoretical basic flow with elliptical streamlines and associated density profiles. It allows to keep the numerical efficiency of spectral methods in this geometry. We perform the stability analysis of the basic state using three-dimensional simulations to study both the linear and non linear regimes in function of the dimensionless Brunt-Väisälä frequency N (frequency of gravity waves normalised by the spin rate of the basic flow).

We show that elliptical instability grows upon a stable stratification ($N > 0$). When $N \leq 1$ turbulent flows of large amplitude are generated and enhance mixing. Instead when $1 < N < 3$ the amplitude of the driven flow is largely weakened by the stratification. The instability reappears when $N > 3$ and saturates in amplitude for very large N.

Finally we assess the dynamo capability of flows in the range of interest $0 < N < 2$. We find that turbulent flows driven by the elliptical instability act as dynamos for magnetic Reynolds number $Rm > 730$, in agreement with previous studies on precession-driven instabilities in spherical geometry [8].

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