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Kinetic energy cascades in quasi-geostrophic convection

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The rapid rotation of planets causes cyclonic thermal turbulence in their cores, which may generate the large-scale magnetic fields observed outside the planets. In spite of the recent progress in modeling planetary dynamos, the models cannot cover the enormous span of scales required for a realistic parameter set. Our contribution is devoted to the study of geostrophic convection by tools of the turbulent community. This approach helps understanding of the origin of kinetic transport in the system as well as of the locality of energy transfer. We investigate numerically a model of thermal convection in two geometries: Cartesian coordinates (rectangular box) and a spherical shell.

For the 3D homogeneous isotropic turbulence (in the absence of rotation) there is a direct cascade of the kinetic energy from the large scales to the small scales, where dissipation takes place. The fluxes of kinetic energy are negative for large scales and positive for small scales, i.e. the large scales are donors and provide energy to the system, whereas the small scales absorb energy. The situation changes in 2D, where the cascade of kinetic energy is inverse: from the small to the large scales. Quasi-geostrophic flow is somewhere between 3D and 2D. In such a flow, one has still 3 dimensions, but the dependence of the fields on the vertical direction along the axis of rotation is degenerated. This flow is known by its columnar structures elongated along axis of rotation. The leading order wave number corresponds to the diameter of the columns. Two cascades of the energy (direct and inverse) thus take place simultaneously (Reshetnyak and Hejda, 2008; Hejda and Reshetnyak, 2009).

The spherical geometry changes partly the previous picture. Near the onset of convection, the graph of spectra of kinetic energy of quasi-geostrophic flow has saw-like shape with the largest maximum corresponding to the diameter of the vertical columns. Increase of Rayleigh number leads to the filling of the gaps in the spectra and transforming the saw-like structure to smooth curve. Rotation brings inverse flux into the first harmonics. In this way we can consider the excitation of the axi-symmetrical rotation of the columns around geographical axes to be the result of the inverse cascade. This phenomenon has no analogue in the case of convection in the box, where rotation destroys rotating rolls of the zero mode.

Hejda, P. and Reshetnyak, M., 2009. Effect of anisotropy in the geostrophic turbulence. Phys. Earth Planet. Inter. 177, 152-160.

Reshetnyak, M. and Hejda, P., 2008. Direct and inverse cascades in the geodynamo. Nonlin. Proc. Geophys. 15, 873-880.