Anisotropic turbulent diffusivities and rotating magnetoconvection problems

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Earth’s core Physics inspires the magnetoconvection models. Turbulent state of the core can increase the viscosity, the thermal diffusivity and also the magnetic diffusivity. The change of magnetic diffusivity is also called β-effect and it is important in dynamo mechanisms. Moreover, the turbulence suggests that the dynamics can be more complicated than it is usually presented. For instance, due to turbulence the diffusivity coefficients could be anisotropic as it was described in some recent studies, which stress how anisotropy in many cases facilitate convection and in other cases inhibits it. For example, if there is anisotropy some types of convection can occur also with very small values of Ekman numbers, which are usual for the Earth’s core. This is important because the convection can be the main cause of dynamo action. We present several rotating magnetoconvection models in horizontal plane layer with gravity and rotation axis in vertical direction and homogeneous magnetic field in horizontal direction. Different models correspond to different cases of anisotropic diffusivities. In other words, we consider several anisotropic models: one with anisotropy in all diffusivities and other models with various combinations of anisotropic and isotropic diffusivities. Comparisons with other former models (e.g. with isotropic case, \(p\)-case, partial anisotropy case when only magnetic diffusivity is isotropic, and \(f\)-case, full anisotropy case with all diffusivities anisotropic) are thoroughly performed. In all models we consider two distinct kinds of anisotropy, Stratification Anisotropy – SA, determined by direction of single gravity (buoyancy) force and Braginsky-Meytis one – BM, determined by directions of magnetic field and rotation axis. All systems described by these models are prone to instabilities, so analysis in term of normal modes and search for preferred modes are very useful to study such systems. We focus our attention on stationary modes and SA anisotropies. Furthermore, we distinguish two sub-cases of SA anisotropy: atmospheric – Sa, if the diffusion in the vertical direction is greater than in the horizontal ones and oceanic – So, if opposite holds. In Sa (So) anisotropy the convection is in major cases facilitated (inhibited). This fact suggests that it is important to study Sa as well as So anisotropies in the Earth’s core. Our main results concern cases of anisotropic diffusivities, when preferred modes give new dynamics (unexpected in isotropic case) in the system in which geodynamo can work.