Time-dependent solutions of a fluid which viscosity depends on temperature

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ABSTRACT

We analyse time-dependent and stationary solutions of a two dimensional fluid layer in which viscosity depends on temperature with periodic boundary conditions along the horizontal direction. These solutions are compared with solutions obtained at constant viscosity. A similar problem has been previously addressed in [1], however our lateral boundary conditions introduce the symmetry $SO(2)$ in the problem, for which new classes of solutions are expected [2]. We also consider different dependences of viscosity with temperature. This problem takes in features of mantle convection, since large viscosity variations are expected in the Earth's interior.

Our numerical approach considers the structure of the solutions of the equations in the phase space and its temporal evolution. Fields are expanded with Chebyshev polynomials in the vertical direction and Fourier modes along the horizontal axis. The temporal evolution scheme is similar to the one described in [3]. The temperature is obtained each time by solving a Helmholtz type problem, however we treat the pressure differently, following the scheme proposed in [4]. With the same spatial discretization, nontrivial stationary solutions are computed via an iterative Newton-Raphson's method. The stability properties of these solutions confirm the results obtained with the temporal evolution scheme.

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