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Coriolis force influence on the AKA effect

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Large-scale instability in incompressible fluid driven by the so called Anisotropic Kinetic Alpha (AKA) effect satisfying the incompressible Navier-Stokes equation with Coriolis force is considered. The external force is periodic; this allows applying an unusual for turbulence calculations mathematical method developed by Frisch et al [1]. The method provides the orders for nonlinear equations and obtaining large scale equations from the corresponding secular relations that appear at different orders of expansions. This method allows obtaining not only corrections to the basic solutions of the linear problem but also provides the large-scale solution of the nonlinear equations with the amplitude exceeding that of the basic solution. The fluid velocity is obtained by numerical integration of the large-scale equations. The solution without the Coriolis force leads to constant velocities at the steady-state, which agrees with the full solution of the Navier-Stokes equation reported previously. The time-invariant solution contains three families of solutions, however, only one of these families contains stable solutions. The final values of the steady-state fluid velocity are determined by the initial conditions. After account of the Coriolis force the solutions become periodic in time and the family of solutions collapses to a unique solution. On the other hand, even with the Coriolis force the fluid motion remains two-dimensional in space and depends on a single spatial variable. The latter fact limits the scope of the AKA method to applications with pronounced 2D nature. In application to 3D models the method must be used with caution.

[1] U. Frisch, Z.S. She and P. L. Sulem, “Large-Scale Flow Driven by the Anisotropic Kinetic Alpha Effect,” Physica D, Vol. 28, No. 3, 1987, pp. 382-392.