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Growing oscillations in a sheared rotating stratified flow

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A simple exact solution of the nonlinear Boussinesq equations of motion, thermal energy, and mass conservation is obtained for an oscillatory flow regime in a stably stratified rotating fluid. The flow is two-dimensional in the sense that all flow variables are independent of one of the Cartesian coordinates, however the three velocity components are generally non-zero. The flow is unbounded and characterized by velocity gradients that vary with time but are spatially uniform – the basic state of Craik-Criminale flows. The motion consists of (i) a temporally periodic convergent-divergent mode (sloshing or divergent mode) characterized by hyperbolic streamlines, as in stagnation point flow, and (ii) a secularly growing oscillatory shear mode (nondivergent mode). The divergent mode is independent of the non-divergent mode, but forces the non-divergent mode at the natural frequency of the non-divergent mode. In response to this forcing, the amplitude of the non-divergent mode oscillation grows with time.

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