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Global stability of pancake vorticies in rotating and stratified fluids

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We investigate the stability of an axisymmetric pancake vortex in a continuously stratified and rotating fluid.

The characteristics and domains of existence of the different instabilities are determined as a function of the Froude number Fh, Rossby number Ro, aspect ratio a and Reynolds number Re. The centrifugal instability is almost independent of the aspect ratio of the vortex due to its short-wavelength nature and depends mostly on the Rossby number Ro and the buoyancy Reynolds number R=Re F_h^2.

The shear instability exists for the azimuthal wavenumber m = 2 only when Fh/a is below a threshold depending on Ro. This condition comes from confinement effects along the vertical. The shear instability transforms into a mixed baroclinic-shear instability when the Burger number Bu = a^2Ro^2/(4Fh^2) is smaller than unity. The baroclinic instability develops when Fh/a|1 + 1/Ro| > 1.46 in qualitative agreement with an analytical model. In stably stratified rotating fluids, vortices have a pancake shape with a small thickness compared to their radial extent. An example is the Mediterranean eddies (Meddies) which are formed by salty water flowing from the Mediterranean sea into the Atlantic ocean. The stability of such vortices has been studied with multi-layer models under the quasi-gesotrophic or shallow water approximations. More recently, continuously stratified non-rotating fluids or quasi-geostrophic fluids have been considered. In order to link these two limits, the linear stability of an isolated axisymmetric pancake vortex is studied here in a continuously stratified fluid with arbitrary background rotation.

References

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Hua B.L *et al*. 2013 J. Fluid Mech

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(a)

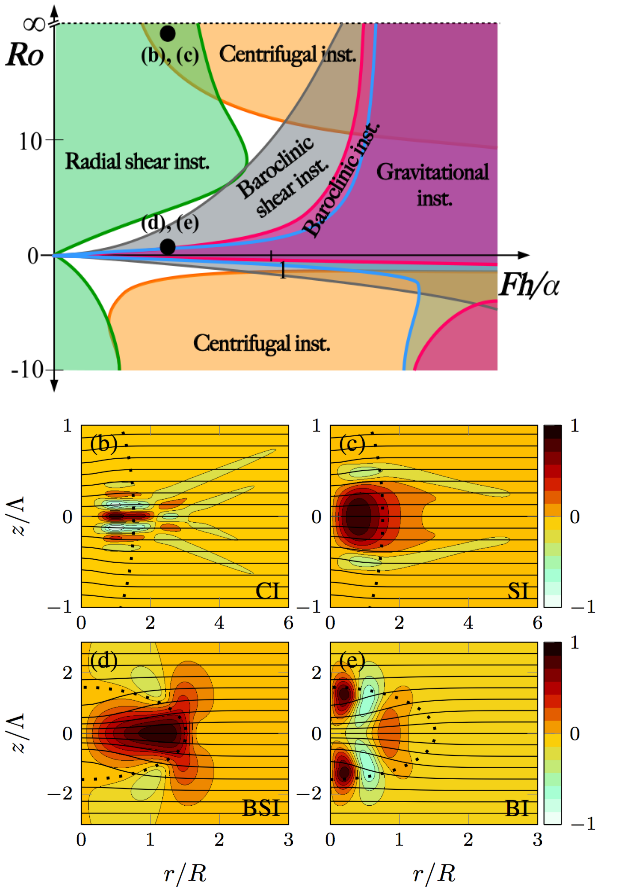

Figure: (a) Stability diagram as a function of Fh/a and Ro. (b,c,d,e) the typical cross section of the instabilities. (b) centrifugal, (c) shear (d) baroclinic-shear and (e) baroclinic instabilities.