Abstract Submitted
for the DFD07 Meeting of
The American Physical Society

Instabilities in the spin-up of a rotating, stratified fluid R.J. MUNRO, U. Nottingham, M.R. FOSTER, RPI, P.A. DAVIES, U. Dundee — Experiments were performed on a density-stratified fluid in a circular cylindrical container that is initially rotating at a steady speed, and is then spun up by increasing the rotation rate of the bottom disk of the container. The stratification is initially linear, with salt in water ($\sigma \sim 700$). Initially, a layer of well mixed fluid is observed to form above the disk (which is essentially spun-up). After $O(10\tau)$ (where $\tau = E^{-\frac{1}{2}}N^{-1}$ is the spin-up timescale based on the Ekman number and buoyancy frequency), a step-like density sub-structure is observed to develop in the linearly-stratified fluid above the mixed layer. The instability criterion based on conventional normal mode analysis is dependent on local values of the vertical and radial gradients of the background density field and zonal velocity. These quantities have been measured using a combination of zonal-plane PIV and an array of traversing conductivity probes. The standard criterion does predict that the upper layers of fluid, at mid-radii, are unstable. Further, the length scales of the perturbations predicted by this basic linear theory are an order of magnitude smaller than the step structures of the experiments. Curvature effects and non-uniform values of zonal flow and density gradient induce instabilities with larger length scales and slower growth rates, that may be examined by multiple-scale analysis. The length scales of these modes are consistent with the observations.

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Date submitted: 30 Jul 2007 Electronic form version 1.4