Experimental studies of the strato-elliptical and strato-rotational instabilities

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M. Le Bars* [(1)], P. Le Gal [(1)], D. Guimbard [(1,2)], S. Le Dizès [(1)], S. Leblanc [(2)]

(1) IRPHE, CNRS & University of Aix-Marseille, 49 rue F. Joliot Curie, F-13013 Marseille, France
Email: lebars@irphe.univ-mrs.fr
(2) LSEET, CNRS & University of Toulon-Var, BP 20132, F-83957 La Garde Cedex, France

ABSTRACT

In this contribution, we present the main results of two investigations of fluid instabilities driven by coupling of gravito-inertial waves, of direct interest for geophysical and astrophysical flows.

The first study [1] is dedicated to the so-called strato-elliptical instability (SEI). SEI takes place in rotating and stratified flows whose streamlines are elliptically deformed. It could generically affect any vortex in the atmosphere and in the ocean. We have analysed the characteristics of SEI in a finite and elliptically deformed rotating cylinder, in the presence of background rotation and axial stratification. A general formula for the linear growth rate of the stationary sinuous modes has been derived including viscous and detuning effects in the limit of small eccentricity. This formula is discussed and compared to experimental results which are obtained in a cylinder filled with salted water for two different eccentricities by varying the stratification, the background rotation and the cylinder rotation. A good agreement with the theory concerning the domain of instability of the sinuous modes is demonstrated. Other elliptic instability modes, oscillating at the cylinder angular frequency are also evidenced. The nonlinear regime of the elliptic instability is documented. In contrast with the homogeneous case, no cycle involving growth, breakdown and re-laminarization is observed in the presence of strong stratification. The elliptic instability in a stratified fluid seems to yield either a persistent turbulent state or a weakly nonlinear regime.

The second study [2] is dedicated to the so-called strato-rotational instability (SRI). SRI affects rotating shear flows when the fluid is stably stratified in the axial direction. This instability may be relevant for accretion disks, where it provides an alternative explanation for the destabilisation of the Keplerian flow, in addition to the so-called magneto-rotational instability (MRI). In agreement with recent theoretical and numerical analyses, we describe in detail the destabilization of the stratified cylindrical Couette flow below the Rayleigh line (i.e. the stability threshold without stratification). We confirm that the unstable modes of the SRI are non axisymmetric, oscillatory, and take place (in the limit of our experimental set-up) as soon as the azimuthal linear velocity decreases along the radial direction. Generalization of SRI in an unbounded domain [3] will also be discussed.

REFERENCES

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[3] The strato-rotational instability of Taylor-Couette and Keplerian flows. S. Le Dizès and X. Riedinger. *J. Fluid Mech.* 660 , 147–161 (2010).