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# Experimental Confirmation of Linear Stability Results on Stratified Taylor-Couette Flows

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Understanding the mechanisms that can result in an outward transport of angular momentum is a central problem regarding astrophysical objects formation, particularly in the theory of accretion, on which turbulence might explain this phenomenon in accretion discs [1]. Among other candidates, the Strato Rotational Instability (SRI) has attracted attention in recent years as a possible instability leading to turbulent motion in these systems. The SRI is a purely hydrodynamic instability consisting of a classical Taylor-Couette (TC) system with stable density stratification due to, for example, salinity or a vertical temperature gradient.

Many information about the SRI can be obtained from numerical simulations and particularly designed laboratory experiments of axially-stratified TC setups, as the one in the laboratory of Aerodynamics and Fluid Mechanics (LAS) of the Brandenburg University of Technology (BTU) Cottbus-Senftenberg. For obtaining a stable density stratification along the cylinder axis, the bottom lid of the setup is cooled, and its top part is heated, establishing an axial linear temperature gradient between 3K and 5K per 0.7m.

Numerical simulations using the same configuration as the BTU experiment have been performed at the M2P2 laboratory at the Aix-Marseille University (AMU), and at the LAMPS laboratory at the University of Perpignan, with the temperature difference set as 4K between the bottom and top parts of the cylinder.

The inner and outer cylinders on the experimental setup rotate independently, each one driven by a DC motor unit controlled by servo amplifiers. The experimental results presented were obtained at a fixed rotation ratio of  $\mu = \Omega_{out}/\Omega_{in} = 0.35$ , where  $\Omega$  is the angular velocity of the cylinder. The velocity profiles shown are obtained from *Particle Image Velocimetry* (PIV), with the camera co-rotating with the outer cylinder. The PIV measurements absolute error is of less than 2%, and all experiments were repeated at least 2 times at different days, so that the result's reproducibility could be guaranteed.

The experimental results obtained with PIV are in agreement with the linear stability curves presented in [2] for constant values of  $Rn$ , a stratification related Reynolds number. The linear stability curve for  $Rn=250$  (adapted from [2]) is shown as a black solid line in figure 1, where some of the experimental results obtained during this work are also represented along the vertical red line of constant  $\mu = 0.35$ .

The red triangles represent unstable flows obtained for  $Re = 400$ ,  $Re = 600$ , and  $Re = 800$ , while the blue circle represents the stable case when  $\mu = 0.35$ ,  $Rn = 250$ , and  $Re = 1000$ . As it can be seen in fig.1, the stable case is just outside the marginal linear stability line. All the other experiments are inside the unstable regions. The instability can be observed

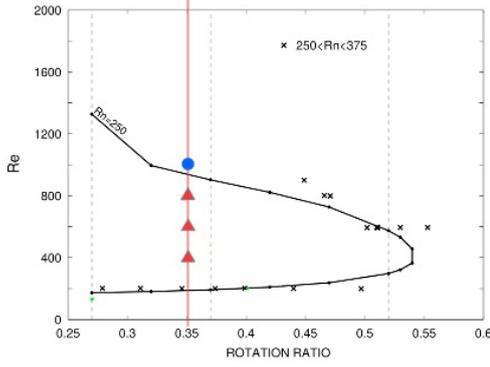


Figure 1: Linear stability map for  $Re=250$ . The solid red vertical line refers to the constant rotation ratio ( $\mu = 0.35$ ) of the performed experiments. The red triangles are unstable cases, and the blue circle represents stable cases.

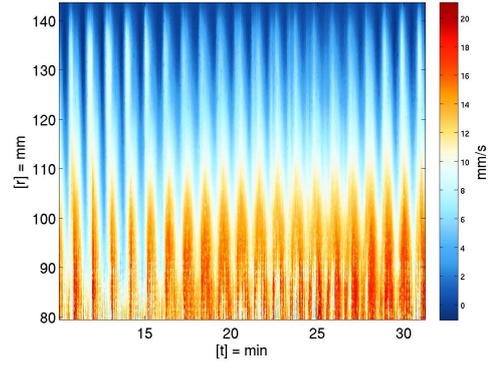


Figure 2: Hovmöller plot showing the azimuthal velocity as function of radius at constant angle and time. Parameters:  $Re=600$ ,  $\mu = 0.35$ ,  $\Delta T \approx 5K$ ,  $N=0.320$ ,  $Fr \approx 1.2$

in the Hovmöller plots (figure 2), as well as in the analysis of the Reynolds stress tensor components (e.g.,  $-\rho u'v'$ ), since it is zero for the stable case, and non-zero when the flow is SRI unstable.

Comparisons of the experimental results with numerical simulations using the codes described in [3] and [4] did show a good agreement regarding the SRI frequencies and the mean velocity profiles obtained. New high-performance numerical simulations considering all the same input parameters as the experiments shown in this abstract are now being performed for further comparison with linear stability analysis.

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