Experimental study of mixing mechanisms in stably stratified Taylor-Couette flow

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We consider experimentally the mechanisms of mixing in stably stratified Taylor-Couette (TC) flow in a new TC apparatus for which both cylinders can rotate independently.

In the case for which only the inner cylinder rotates, centrifugal instability rapidly splits an initially linear density profile into an array of thin nearly homogeneous layers [1]. Shadowgraph and density profiles measured by a moving conductivity probe allow us to characterise this process and the resulting flow. In particular, we confirm the observation by Oglethorpe *et al.* [2] of turbulent intrusions of mixed fluid propagating relatively slowly around the tank at the interfaces between the layers, leading to a time-dependent variation in the sharpness and turbulent activity at these interfaces, whose period scales with (but is much larger than) the rotation period.

Interestingly, the turbulent intrusions are anti-correlated between adjacent interfaces leading to snake-skin-like patterns in the spatio-temporal diagrams of the density profiles as can be seen in figure 1. At lower Reynolds number, the flow is laminar and exhibits non-axisymmetric helical drifting vortices [3]. It is hypothesized that the periodicity of the turbulent intrusions are due to the helical structure of this laminar flow.

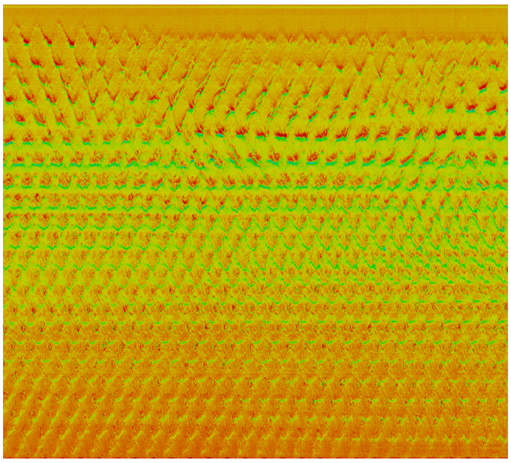

Fig. 1: Spatio-temporal diagram of the shadowgraph on the inner cylinder when the outer cylinder does not rotate and homogeneous layers have been produced by the centrifugal instability. The horizontal lines correspond to the interfaces between the layers and the spots to the periodic turbulent intrusions.

We also investigate the pseudo-Keplerian case for which both cylinders rotate and the strato-rotational instability develops [4]. For the highest Reynolds number reached, we observe a helical intermittent flow with bursts of turbulence and coherent structures. Strikingly, even in this turbulent regime, the mixing is much less efficient than in the case for which the outer cylinder does not rotate and homogeneous layers are not produced.

References

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