ON THE FORMATION OF COLUMNAR STRUCTURES IN A ROTATING TURBULENT FLOW.

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In this study we investigate the size of columnar structures that arise in various two-dimensional tubulent flows, specifically in the case of a continuously forced rotating turbulent flow field. Recent advancements by Potherat & Klein [1] in MHD turbulence at low magnetic Reynolds number showed a relation between the columnar structure size, the bulk flow velocity and the forcing parameters. It was shown that if the flow is continously forced by injecting a DC current I, the flow velocity (U) close to the forcing point scales linearly with I or $I^{2/3}$, depending on whether viscous or inertial forces promote three-dimensionality. Save for slightly different pre-factors, MHD turbulent and rotational turbulent flow fields are governed by the same equations. In this study we follow a similar approach to Potherat & Klein to elucidate the origin of the tendency to two-dimensionality in rotating flows.
Starting from the full Navier-Stokes equation a relation is derived between the size of the columnar structures and the local Re and Ro numbers. This in turn leads us to a relation between U and the forcing parameters, the rotation rate (Ω) and injected flowrate (Q). It is shown that $U \sim Q$ or $U \sim Q^{2/3}$ depending on whether viscous or inertial forces promote three-dimensionality, similar to the case of MHD turbulence at low magnetic Reynolds number.
These scaling are then sought experimentally. The experiment consists of a rectangular tank filled with fluid mounted on a rotating turntable, a basic sketch can be seen in figure 1. The flow is forced by simultaneously injecting and subtracting fluid through four small orifices arranged in a square pattern at the bottom of the tank. Using a single camera PIV system we are able to characterise the bulk flow as a function of Ω and Q for a given height (H). Our results show that in the core of the flow there is good agreement with the aforementioned scaling laws and that there is a transition to the inertial regime as Q is increased. Close to the points of fluid injection very strong stable three-dimensional structures are present, which appear largely independent on the forcing parameters. It is expected that the origin of these structures lies in fluid entrainment but their specific dynamics are still under experimental investigation.

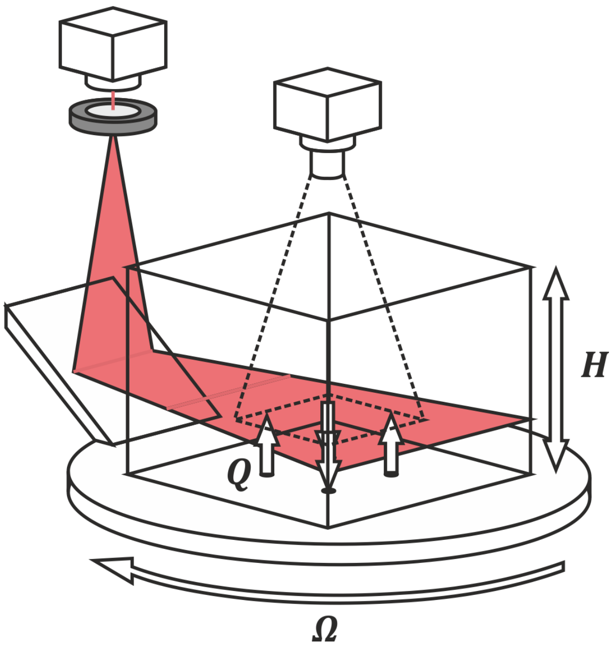

Figure 1. Sketch of the experimental setup.

References

[1] Potherat A., R.Klein (2014) *Why how and when MHD turbulence at low Rm becomes three dimensional* âĂŞ Journal of Fluid Mech. 761, pp.168-205