Modal acoustic velocimetry: a new technique for rapidly rotating gas – Application to zonal flows

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We present a new laboratory experiment built to study zonal flows induced by thermal convection, called ZoRo (Zonal flows in Rotating fluids, TuDy ANR). ZoRo is a rapidly rotating spheroid (sphere flattened along the rotation axis) filled with air. Any seeds are thus rapidly centrifugated, disabling usual visualisation techniques (e.g. smoke). The velocity measurements are thus challenging. To tackle this problem, we implemented a new non-intrusive velocimetry technique based on acoustic resonances of the fluid cavity, the modal acoustic velocimetry (MAV) [1]. MAV allows a global 3D determination of the fluid flow from surface non-intrusive measurements. MAV should work for any enclosed fluid, including opaque ones. In order to accurately extract the flows, a good understanding of the acoustic spectrum is needed. We use a perturbation theory to predict the resonance frequency of the fluid [2], taking into account geometry [3], dissipation [4], rotation and flows [5].

We can then retrieve the flow velocity field using acoustic frequencies through a linear inverse problem. We test this method against both synthetic cases and real experimental flows measured in ZoRo. We prove that we are are able to image a turbulent flow with MAV, a promising innovative method.

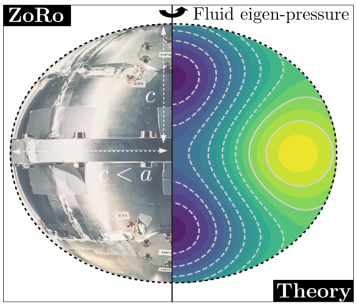

Figure 1. Left: Photo of the Zoro set-up. Right: Theoretical prediction of an acoustic mode pressure [2].

References

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