Instabilities of conducting fluid flows in cylindrical shells under external forcing

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Flows created in neutral conducting flows remain one of the topics less studied of fluid dynamics. But there is a great variety of unexplained behaviours in these systems, with strong consequences both in fundamental research (dynamo action, MHD instabilities, turbulence suppression) and applications (casting, aluminium production, biophysics).

Having in mind a biological application, in this experiment we present the effect of a time-dependent magnetic field parallel to the axis of an annular cavity. Due to the Lenz's law, a current is induced in the bulk when the magnetic field increases or decreases, producing a radial force that alternatively changes its orientation. This force produces the destabilization of the static fluid layer, and a flow is created.

The geommetry of the experimental cell is a cylindrical layer with external and internal diameters 94 and 84 mm respectively. The layer is 20mm depth, and we use as conducting fluid an In-Ga-Sn alloy. There is no external current applied on the problem, only an external magnetic field. This field evolves harmonically with a frequency up to 10Hz, small enough to not to observe skin depth effects. The magnitude ranges from 0 to 0.1 T. With a threshold of 0.01T a dynamical behaviour is observed, and the main characteristics of this flow have been determined.

Previous works have shown that very thin layers (extended drops) destabilize from a circular shape to star-like or labyrinth shapes. With these geometries, induced currents can be interrupted, and there is no dynamical behaviour. Here, we deal with a shallow layer and bulk forces caused by the induced currents cannot disappear.