Electromagnetically driven flows in laboratory experiments

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We outline a planned liquid metal experiment in which zonal flows in a spherical shell are driven by an externally imposed Lorentz torque. The entire inner sphere is an electrode, with currents injected along the shafts holding it in place. From the inner sphere they flow throughout the fluid to a ring-shaped electrode around the equator of the outer sphere. Additionally, a predominantly axial magnetic field is imposed, by an external Helmholtz coil. The resulting $\mathbf{J} \times \mathbf{B}_0$ Lorentz force is oriented in the azimuthal direction, and drives a strong zonal flow, similar to a classical Dean flow. The entire apparatus is also in solid-body rotation. The parameters of the experiment are planned as: $r_i = 8$ cm, $r_o = 23$ cm, Ω up to $O(100)$ revolutions per second, B_0 up to 1 Tesla, and I_0 up to $O(100)$ Ampere. The numerical calculations indicate that these parameter values should be $O(100)$ times above the onset of non-axisymmetric instabilities of the basic zonal jets. We expect therefore that fully turbulent flows will be achievable. We also compare this planned experiment with existing MHD spherical Couette flow experiments, as well as with previous experiments involving electromagnetically driven flows.