Observations of the magnetorotational instability in spherical Couette flow

Daniel P. Lathrop
University of Maryland, College Park, MD 20904

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Experiments conducted in liquid sodium confined between a rotating inner sphere and a concentric stationary outer sphere show a host of magneto- hydrodynamic behavior.

The experimental system consists of a 10 cm diameter copper rotating inner sphere and a 30 cm diameter stainless steel stationary outer sphere. A coaxial external magnetic field is supplied using an external electromagnet. The base state shows a rotation rate profile which is Rayleigh stable (Ωr^2 rising in cylindrical r), and magnetorotationally unstable (Ω falling in cylindrical r) [1]. The rotation rate profiles and oscillations were measured using ultrasound Doppler velocimetry.

With a sufficiently strong external applied field, this system exhibits the magnetorotational instability. The angular momentum transport increases at the instability onset. The primary instability shows a continuous bifurcation to a rotating m=1 pattern in the magnetic field, and concomitant oscillations in the velocity field.

By varying both the rotation rate and the external magnetic field (made dimensionless as the magnetic Reynolds number and the Lundquist number respectively), we have navigated the parameter plane to observe a number of states with distinct dominant wavenumber and parity. These include states with dominant patterns with even and odd symmetry with respect to inversion through the origin. Patterns with dominant azimuthal wavenumbers $m = 0$, $m = 1$, and $m = 2$ have been observed.

The onset conditions compare favorably with expectations from linear stability calculations [2]. This is remarkable considering the significant background turbulence (15

Finally we have explored the suitability of spherical Couette flow to show dynamo action. We conjecture that for a rotating outer sphere and a stationary inner sphere, that (using the notation of Dudley and James [3]) a S_2T_1 velocity pattern suitable for dynamo action can be achieved. We will present measurements of pulse decay measurements for external magnetic fields to test this conjecture.

References

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