MAGNETIC FIELD GAIN IN A LABORATORY MODEL OF THE EARTH'S OUTER CORE

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Strongly nonlinear fluid flows germane to the planetary cores are possible in laboratory settings. Both measures of nonlinearity, Reynolds and magnetic Reynolds number, can be matched between the earth and experiments in rapidly rotating liquid sodium flows. The resulting observables, magnetic field gain, power dissipation, hydrodynamic states, were not predicted and are a challenge to simulate. There is much open territory for scientific discovery by the comparison of advanced modeling and laboratory experiments. The University of Maryland Three Meter Experiment is a world-unique spherical Couette experiment filled with liquid sodium and geometrically similar to the Earth's core[1]. It allows us to study hydrodynamic and hydromagnetic phenomena in rapidly rotating turbulence. An external coil applies an external magnetic field, while an array of 31 external Hall sensors measures the Gauss coefficients of the resulting magnetic field. We use this configuration to explore hydromagnetic effects relevant to the Earth's outer core, such as dynamo gain. The flow state is strongly dependent on the Rossby number, $Ro=(\Omega_I-\Omega_O)/\Omega_O$, where Ω_I and Ω_O are the inner and outer sphere rotation frequencies, respectively. We report on magnetic field gain in both dipole and quadupole magnetic fields. We also have progress in measuring the zonal flows[2], using modal acoustic velocemitry, that are responsible for our sizable azimuthal magnetic fields due to the Ω-effect of toroidal shear flows. This project is supported by the U.S. National Science Foundation grant EAR-1417148.

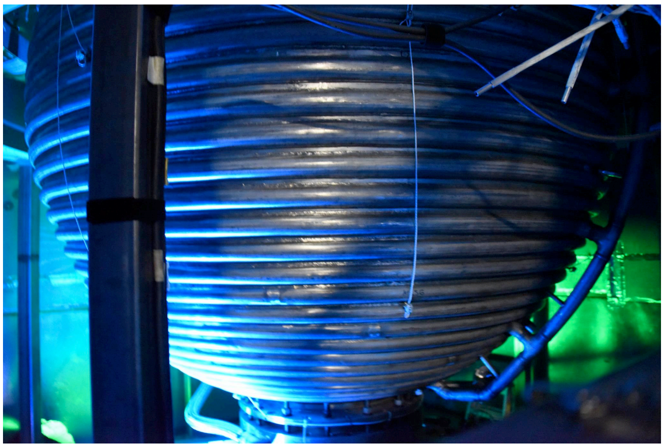

Figure 1. Image of the three meter liquid sodium system .

References

[1] D.S. Zimmerman, S.A. Triana, H.-C. Nataf, and D.P. Lathrop "A turbulent, high magnetic Reynolds number experimental model of Earth's core," J. of Geophysical Res.: Solid Earth, 119, 4538 (2014).
[2] S.A. Triana, D.S. Zimmerman, H.-C. Nataf, A. Thorette, V. Lekic, and D.P. Lathrop, "Helioseismology in a bottle: modal acoustic velocimetry," New J. of Phys. 16, 113005 (2014).