Exploring Alternative Instrumentation in the Three-Meter Spherical Couette Experiment

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The magnetohydrodynamics of Earth has been explored at the University of Maryland through experiments and numerical models. Experimentally, the interaction between Earth’s magnetic fields and its outer core is replicated using a three-meter spherical Couette device filled with liquid sodium that is driven by two independently rotating concentric shells and a dipole magnetic field applied from external electromagnets. Currently, this experiment is being prepared for design modifications that aim to increase the helical flows in the poloidal direction in order to match the turbulence of convection-driven flows of Earth. The experiment currently has 33 hall probes measuring the magnetic field, 4 pressure probes, and torque measurements on each sphere. We supplement the experiment with a numerical model, XSHELLS, that uses pseudospectral and finite difference methods to give a full picture of the velocity and magnetic field in the liquid and stainless steel shells. However, it’s impractical to resolve all the turbulence. Our ultimate goal is to implement data assimilation by synchronizing the experimental observations with the numerical model, in order to uncover the unmeasured velocity field in the experiment and the full magnetic field as well as to predict the magnetic fields of the experiment. Through numerical simulations (XSHELLS) and data analysis we probe the behavior of the experiment in order to (i) suggest the best locations for new measurements and (ii) find what parameters are most feasible for data assimilation. These computational studies provide insight on the dynamics of this experiment and the measurements required to predict Earth’s magnetic field. We gratefully acknowledge the support of NSF Grant No. EAR1417148 & DGE1322106.