Abstract

Title of Dissertation: LIQUID SODIUM EXPERIMENTS MODELING THE EARTH'S OUTER CORE

Nicholas L. Peffley, Doctor of Philosophy, 2000

Dissertation directed by: Assistant Professor Daniel P. Lathrop
Department of Physics

This dissertation discusses the results of two laboratory experiments that attempt to model the Earth's molten outer core. These experiments are done in order to gain insight into the Earth's persistent magnetic field which is thought to be created by the dynamo effect. A dynamo is a system that self-generates magnetic fields through feedback amplification between electrical currents and the magnetic fields they create. The dynamo process is a competition between diffusion of magnetic fields and stretching of magnetic fields via the motion of the liquid metal. This competition is quantified by the magnetic Reynolds number, $Re_m \equiv vL/\eta$, where v is a typical velocity, L is a typical length-scale, and η is the magnetic diffusivity. In the case of the Earth, it is believed that the fluid motions of the molten iron in the outer core are responsible for self-generation of the magnetic field of the Earth. In our two experiments liquid sodium is the molten metal. In both of these experiments, applied pulses of magnetic fields quantify

how close the system is to self-generation. The first experiment is a rotating convection experiment designed to emulate the thermal driving of the fluid in the Earth's outer core. This experiment has acheived a $Re_m \sim 4$, and we have seen diffusion of magnetic fields dominating advection. The second experiment mechanically drives fluid in a spherical geometry via the motion of propellors. This experiment has achieved much larger Re_m because of the relative ease to achieve larger velocities with propeller driven flows. The mechanically driven experiment shows a 35% change towards self-generation at $Re_m \sim 80$, and this experiment also shows many different modifications of the applied magnetic fields by the velocity as the system approaches self-generation. The experimental results are compared with the extensive body of current theoretical and numerical work concerning liquid metal dynamos.