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DTS : a liquid sodium experiment in the magnetostrophic regime

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The geodynamo team in Grenoble has designed an experiment to study flows in the magnetostrophic regime expected for planetary cores. The set-up consists of a 40cm-diameter stainless steel sphere filled with 40 liters of liquid sodium, which can be rotated around a vertical axis at angular velocities up to 2000rpm. At the center of the sphere, a 15cm-diameter inner sphere is made of a permanent magnet covered with copper. After magnetization, this inner sphere will provide a dipolar magnetic field reaching 0.15T at its poles. The liquid sodium is set into motion by differential rotation of the inner sphere, which is entrained at angular velocities up to 2000rpm through a magnetic coupler (see Cardin et al, MHD 2002).

The sphere is instrumented with ultrasonic velocity profilers, pressure sensors, magnetometers and electrical probes. In DTS, we plan to explore the following physical phenomena :
1) the features and instabilities of the super-rotation layer that forms in the liquid by electromagnetic coupling (Dormy et al, EPSL 1998), with particular attention to the strength of the resulting torque between the inner sphere and the liquid. Will the magnetic field help or fight the destabilization of the shear layer ?
2) torsional oscillations (Alfvèn waves in a rapidly rotating sphere). These waves play an important role in a geophysical context, but it is difficult to achieve a realistically small magnetic Prandtl number in numerical models of their behaviour.
3) characteristics of the small-scales in the presence of Coriolis and Lorentz forces, and comparison of the viscous and ohmic dissipations.

Numerical simulations have shown that the turbulent flows created by differential rotation in a rapidly rotating sphere are able to produce a magnetic field when the magnetic

Reynolds number is large enough. Thus, the DTS experiment also serves as a scaled-down model of a future dynamo experiment. Several technological solutions will be tested.