Geophysical Research Abstracts
Vol. 14, EGU2012-7278, 2012
EGU General Assembly 2012

Dynamos driven by differential rotation

J. Wicht
Max Planck Institute for Solar System Research, Planets and Comets, Katlenburg-Lindau, Germany (wicht@mps.mpg.de, +49 5556 979240)

Planetary or stellar dynamos are typically though of as driven by convection.However, differential rotation offers an alternative mechanism. Being much easier to implement mechanically it forms the basis for two second generation dynamo experiments in Grenoble and Maryland. Differential rotation effects may also play a role in planetary or stellar dynamos.

To explore these possibilities we numerically model the spherical Couette system: a spherical shell filled with a viscous and electrically conducting fluid where the outer boundary rotates with Ω and the inner boundary with a slightly slower or faster rate $\Omega + \delta\Omega$. Performing a large number of simulations at different parameters we find that larger Ω values (corresponding to low Ekman numbers) allow to decrease the magnetic Prandtl and Reynolds numbers. Similar to what has been found in convectively driven dynamo models, the ordering Coriolis force helps dynamo action.

An extrapolation of our results to the parameters of the Maryland experiment suggest that this may not work as a dynamo. The predicted critical magnetic Prandtl number where dynamo action is still possible lies at $Pm_c \approx \times 10^{-3}$ while the Prandtl number of liquid sodium used in the experiment is two orders of magnitude lower.

For super-rotation ($\delta\Omega > 0$) the produced magnetic field is very similar to recent Saturn field models: It is highly axisymmetric and strongly concentrated at high latitudes. When extrapolating our results to Saturn we find that Pm_c is around 10^{-7} which lies below possible Pm values estimated for Saturn. The required differential rotation is as small as $\delta\Omega/\Omega \approx 10^{-8}$. Using simple models for the Helium rain though to happen Saturn's metallic envelope we try to access whether this mechanism could maintain this small differential rotation and produce the required power.