SCALING AND MODELING FOR PLANETARY CONVECTION AND MAGNETISM

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Assuming that viscous and diffusive effects do not play a primary role in planetary magneto-convection, I estimated key non-linear energy and force balances in order to find simple scaling laws for typical scale, velocity and magnetic field strength in the deep planetary interior. Those typical values are found to be dependent on the well-known planetary parameters and relatively well estimated electrical conductivity, heat and composition power fluxes.

Due to the fast planetary rotation the typical vertical (parallel to the rotation axis) scale sufficiently exceeds horizontal scale. Making use of those scales obtained by me I reduce multi-parameters planetary magneto-convection problem to a few parameters problem. Planetary spherical liquid shell could then effectively be modeled by ellipsoid shell with small vertical height and very large horizontal diameter. This model could be investigated in lab, by numeric and asymptotic methods for the real planetary parameters.

Equating typical turnover time for convective sell with convective shell half-thickness over Alfven velocity, I argue convection-driven magnetic dynamos are in the known MAC (Magnetic, Archimedean and Coriolis) force balance with rather strong and nearly symmetric to the rotation axis magnetic field in the deep interiors of the Earth, Jupiter and Saturn. That typical magnetic field strength depends on third power root of the cooling heat flux and scales independently from electrical conductivity and angular velocity, which is in perfect agreement with the corresponding planetary numerical dynamo models.

The dynamos of Uranus and Neptune and, perhaps, Ganymede and Mercury with their asymmetric internal magnetic fields should be supported by balance between (Archimedean, Coriolis and Inertia) ACI forces those exceed or are just about the magnetic Lorentz force. This basically non-magnetic balance could result in relatively higher velocities, but its magnetic dynamo action could be not so efficient due to its gyroscopic effects. The last could be the reason for the current magnetic dynamo absence in Venus and Mars.