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Why it is Impossible to Determine the Rotation Rate of the Interior of Saturn from its Magnetic Field

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Abstract

Scalar potentials can only be used successfully to model magnetic fields in regions where there are no significant currents. If we use this approach at Saturn, we should attempt to restrict our attention to the regions not affected by its mass-loading moon, Enceladus. Thus we will use field observations only inside the magnetic shell extending to 3.8 saturnian radii.

The amount of data suitable for scalar potential modeling at Saturn has become quite significant on the Cassini mission. This is very helpful for our study since we need to define the properties of the magnetic field much more precisely at Saturn than say Jupiter because we are trying to measure a very small tilt angle and deduce from it the rotation rate. We find that the extent of the data coverage in longitude and latitude strongly affects the resulting inversions. Having good coverage is essential when one is varying the planet's rotation period as part of the solution. In particular, at some frequencies the periodic orbits used by Cassini can coalesce at a particular pseudo-longitude. Our analysis shows that the tilt angle of the dipole field must be less than 0.06° and that the residual fields do not exhibit the properties expected for a tilted dipole. These observations suggest that the dipole field is so closely aligned with the rotation axes that we will never deduce the rotation rate from the Saturnian intrinsic magnetic field.