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Using the "Current-Free" Magnetospheric Field Region to Model the Internal Field of Jupiter and Deduce its Rotation Rate

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Abstract

Scalar potentials can be used to model magnetic fields in regions where there are no significant currents, such as in the atmosphere of the Earth. If we are to use this approach in the magnetosphere of Jupiter, we should attempt to restrict our attention to the regions not affected by mass-loading moon Io. Thus we should use field observations only inside the region of field lines reaching 5.8 jovian radii. For this purpose, we have a data set from Pioneer 10 and 11 that is dominated by the close (1.6 R_J) retrograde pass of Pioneer 11 with very little contribution from Pioneer 10. Voyager and Ulysses provide little additional data as they did not make close approaches to Jupiter. Galileo obtained some data in this radial range at orbit insertion and late in the mission. We use these data to create a best-fit internal, dipole-plus quadrupole-plus-octupole model, with an external dipole term. From the apparent shift of the longitude of the dipole moment between the Pioneer epoch and the Galileo epoch, we refine the rotation rate of Jupiter. We also compare our result with previous analyses inverting data obtained in the current containing region and find a significant change in the dipole moment possibly because of underestimation of the effect of the Io torus on the inversion.