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Geomagnetic/planetary dip poles at surface and magnetic fluxes at core-mantle boundary via satellite data

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Abstract

Using 2001-2009 satellite data 728 consecutive Gaussian geomagnetic potential decompositions with degree n=10 were constructed. The dip poles on the surface and magnetic fluxes on core-mantle boundary were modeled with n from 1 till 10. Models with n about 7 are virtually indistinguishable with n=10 models, while magnetosphere and dynamo related integral properties start to converge at n=5 already. Some correspondent estimates are given for planets.

1. Introduction

A magnetic dip pole is viewed as a point on the planetary surface where the magnetic field is entirely vertical. The geomagnetic dip poles located in the North and South hemisphere wander independently of each other. They can migrate rapidly: movements of up to 63 km per year have been observed. The direct measurement of the dip pole is hard and so scare that the first motivation of this study was to model the dip poles for the last decade that is actually not properly covered. In generic planetary respect dip poles are determining magnetosphere shape and dynamics of its most active places – cusps. However the intrinsic magnetic field of the planets is estimated not so well comparing to the Earth where having Gaussian decomposition degree n up to 13 we could perfectly model magnetic dip poles positions and dynamics. So, in this research we are looking for the lowest degree n at which the model properly resembles the dip poles modeled at the highest degree n. In the same fashion we are modeling geomagnetic field at core-mantle boundary of the Earth in order to set up the lower resolution limit for satellite magnetic measurements capable to detect at least some generic planetary dynamo properties.

2. Results

Gaussian coefficients for intrinsic geomagnetic field were found on each fourth day using 2001-2009 satellite data. The geomagnetic dip poles were modeled on the Earth’s surface for each half year average with Gaussian decomposition degree n from 1 till 10. The result is shown in Figure for the dip poles located in the Northern hemisphere. In the same fashion neglecting by the mantle conductivity we also modeled magnetic flux space-time distributions on core-mantle boundary. Final result is that models with n = 7 are virtually indistinguishable with n = 8, 9, 10 models, while magnetosphere and geodynamo related integral properties start to converge at n=5 already. Thus planetary magnetic field should at least be known up to n=5 degree in order to make plausible conclusions about related to the dip poles magnetosphere properties and related to the magnetic fluxes hydromagnetic dynamo features. Correspondent dip poles, magnetic fluxes, magnetosphere and hydromagnetic dynamo estimates are partly given for the Giant and Terrestrial planets.

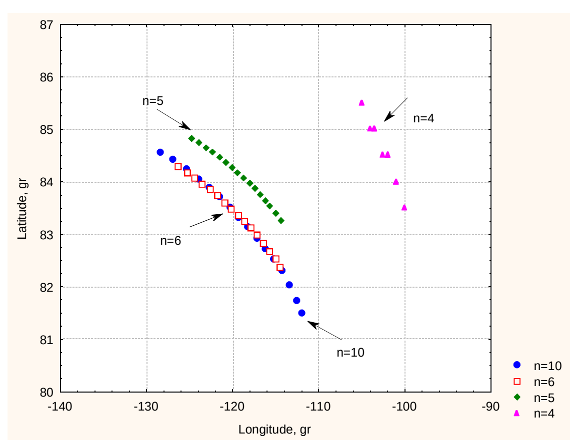

Figure: The North geomagnetic dip poles tracks for n = 4, 5, 6 and 10; n = 7, 8 and 9 tracks are not shown because they are almost equivalent to n=10 track.

3. Discussion

The current Cassini mission is providing an excellent opportunity to characterize the intrinsic magnetic field of Saturn with Gaussian decomposition degree up to n=5 or even better, while all the previous missions allow us to model it in Saturn and Jupiter with n not larger than 3. So, with developing of magnetic field models of Saturn we could proper model Saturn's magnetic dip poles and magnetic fluxes from the dynamo region.

Even better situation is with Jupiter where Galileo magnetometer measured the field continuously over 7 years (Dec 1995 – Sep 2003), while earlier Pioneer 11 mission also measured magnetic field not so far from the dynamo region of Saturn. However the proper Gaussian decomposition models with degree n sufficiently larger than 5 are still not available either for Jupiter or for Saturn.

Not so good is situation with other planets of the Solar system where reaching even n=3 is hard with the available satellite data. Thus we need new missions allowing us better directly to study the planetary magnetic fields. Alternatively we could hope on the MHD dynamo theory and experiments those may predict the generic planetary magnetic properties basing on the available data only.

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