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Application of paraboloid model to the Mercury, Earth, Jupiter, and Saturn magnetospheres

I. Alexeev, and E. Belenkaya
Institute of Nuclear Physics, Moscow State University, Moscow, 119992, Russia (alexeev@dec1.sinp.msu.ru / Phone + 7-495-9391036 Fax: + 7-495-9393553

Abstract

To use the universal approach to modelling of the planetary magnetosphere we analyzed the global current systems which control magnetic field inside the magnetosphere. Usually these current systems included the magnetopause and tail currents but for rotate dominated magnetospheres of the Jupiter and Saturn we are needed to add the equatorial disk current. The magnetospheric structure can be fixed by a small number of the parameters. These parameters are determined by the planetary dipole, by the planetary rotation, by the solar wind pressure, by the mass loading of the satellite plasma, and by the interplanetary magnetic field

1. Introduction

Today four magnetized Solar system planets Mercury, Earth, Jupiter, and Saturn have the manmade satellites. MESSENGER, lot of Earth's satellites, Galileo, and Cassini orbits covers the significant part of the planetary magnetosphere volumes. We have now the measured magnetic field vectors along several tens orbits. We have information about the radial, longitudinal and latitudinal dependence of the magnetic field inside the planetary magnetospheres. Of course, even for the Earth's magnetosphere in which we have a huge data base of the magnetic field measurements, we have a lot of unresolved question and we are needed in more detail study of the magnetospheric field. Now it is a time for general looks on the planetary magnetospheres.

2. A comparative studding of the planetary magnetospheres

The least magnetospheric scale (Mercury) is about 2000 times smaller than the biggest one (Jupiter). The planetary magnetic moments of these four planets differs to 100 millions times. The subsolar magnetic field strength which stop the solar wind flow differs just to 20 times. Total electric currents which screened planetary magnetic field to preserve their penetration in interplanetary space differs to hundred times. To base on the paraboloid magnetospheric models which have been adopted to all four planets a comparative study of the all magnetosphere are presented. Jupiter's magnetosphere is more rich and complex object compare to Earth's magnetosphere. Main magnetospheric energy source is a Jupiter rotation (reconnection is smaller but controls the outer magnetosphere dynamics). The main aurora oval corresponds the transition from dipole-like to tail-like field lines (similar as for Earth magnetosphere). Jupiter magnetosphere have an equatorial magnetodisk. Renormalization of the planet dipole by plasma disk increase the effective dipole up to 4 times. Saturn magnetosphere magnetodisk moment increase with enhancement of the magnetosphere size.

In the placed below Table 1 have been summarized the specific scales of the Mercury, Earth, Jupiter, and Saturn magnetospheres. From the right to the left we are marked the planet orbit distance to the Sun, R_o in au; the subsolar magnetopause magnetic field strength B_m in nT; the planet magnetic moment M_p nT·m^3; the subsolar magnetopause distance R1 in 10^6 km; the total magnetopause current I_{cf} in MA; the interplanetary

Table 1

	Ro au	B_m nT	M_p nT·m^3	R_1 10^6 km	I_{cf} MA	B_{IMF} nT	$\Omega_p 10^{-4}$ rad/s	$\Delta\Phi_{rot}$ MB	$\Delta\Phi_{sw}$ MB	$\Delta\Phi_{rpc}$ MB	θ_{pc} degs
Mercury	0.38	196.	$2.84\cdot10^{12}$	0.003	0.53	9.3	0.01	1.4 B	.005	1 B	55
Earth	1.0	74.5	$7.86\cdot10^{15}$	0.069	4.09	3.5	0.73	0.09	.05	0.01	20
Jupiter	5.2	14.3	$1.53\cdot10^{20}$	5.72	65.0	.66	1.76	367.	.72	24.6	15
Saturn	9.5	7.8	$4.6\cdot10^{18}$	1.32	8.36	.37	1.61	12.2	.09	0.6	13

magnetic field B_{IMF} in nT; the angular planet rotation velocity Ω_p in 10^{-4}rad/s; the potential drop between the pole and equator due to the dipole rotation $\Delta\Phi_{rot}$ in MB; the potential drop applied to the open field line bundle due to the solar wind flow past $\Delta\Phi_{sw}$ in MB; the potential drop applied to the polar cap due to the dipole rotation $\Delta\Phi_{rpc}$ in MB; the polar cap angular diameter θ_{pc} in degrees.

3. Conclusions

Jupiter's magnetosphere is more rich and complex object comparable to Earth's magnetosphere. The main magnetospheric energy source is a Jupiter rotation (reconnection is smaller but controls the outer magnetosphere dynamics). The main aurora oval corresponds to the transition from dipole-like to tail-like field lines (similar as for Earth magnetosphere). Jupiter's magnetosphere is plasma generated magnetosphere. Renormalization of the planet dipole by plasma disk increases the effective dipole moment up to 3 times. Saturn's magnetosphere magnetodisk moment increases with enhancement of the magnetosphere size.

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