

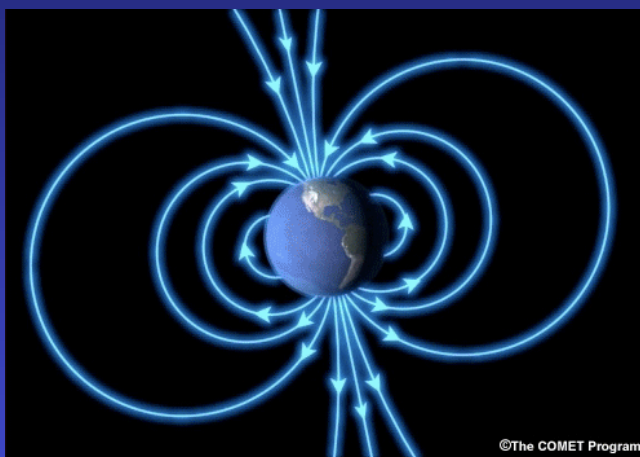
Remote sensing of magnetospheric processes: Lesson 1: Configuration of the magnetosphere

AGF-351
Optical methods in auroral physics research
UNIS, 24.-25.11.2011

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The Earth's dipole magnetic field

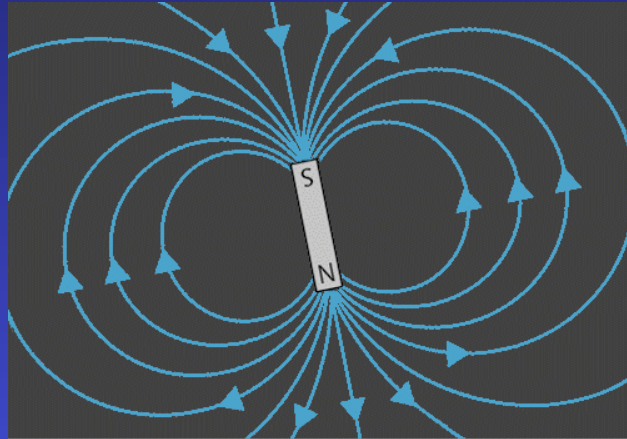
The intrinsic geomagnetic field of the Earth is about 50,000 nT in the polar regions and about 30,000 nT at the equator.



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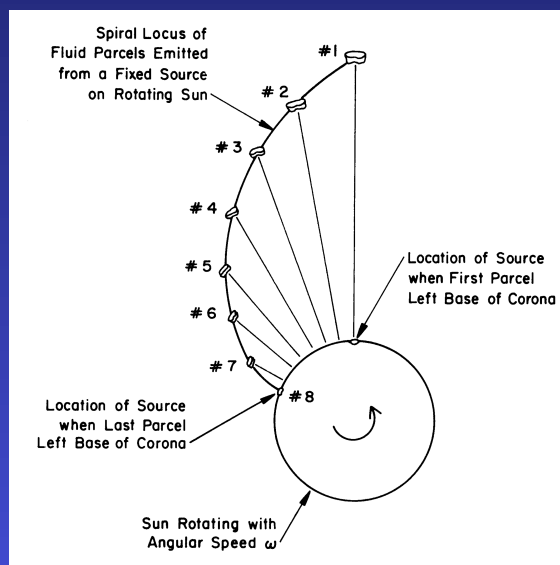
The Earth's dipole magnetic field

The intrinsic geomagnetic field of the Earth resembles that of a magnet, but...



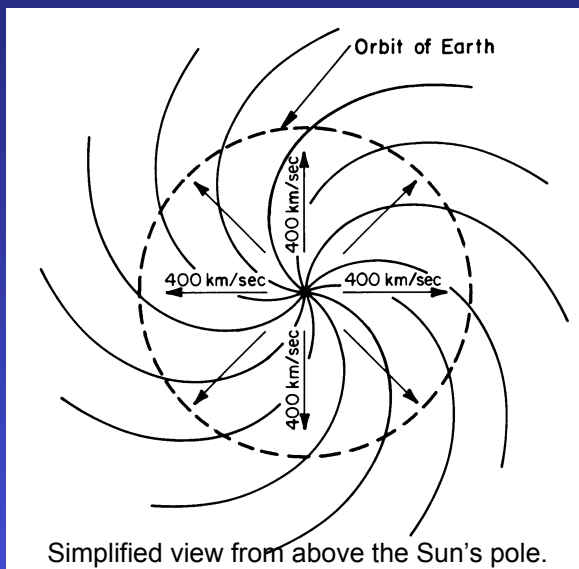
Solar wind

There is a continuous flow of plasma from the Sun, called solar wind, out to the interplanetary space. The plasma flow is radial and it carries along the magnetic field of the Sun, the interplanetary magnetic field, IMF (conductivity in the solar wind plasma is infinite \Rightarrow magnetic field is "frozen" into the plasma).

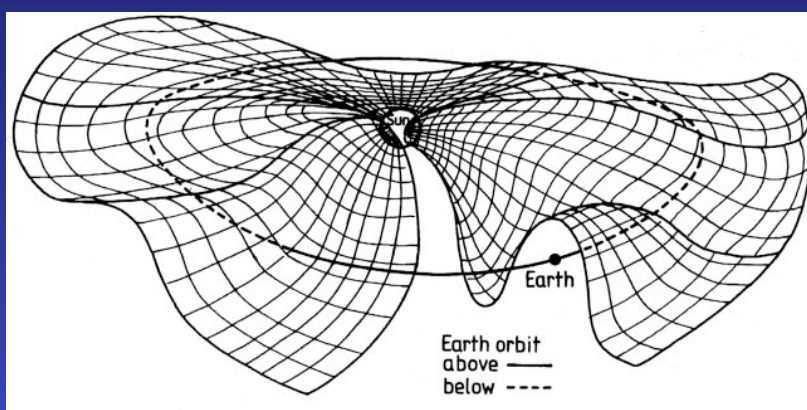


Interplanetary magnetic field, IMF

At the orbit of the Earth, the solar wind speed is typically 300-400 km/s and the IMF magnitude is 5 nT. However, there are large variations due to solar activity variations. The IMF structure is called Parker (or Archimedes) spiral.



Ballerina model of the IMF



The solar magnetic field is also basically of dipolar type, where magnetic field lines leave from one hemisphere and enter into the other heliosphere. But since the IMF expands into the space, a heliospheric current sheet is formed at the magnetic equator. This current sheet fluctuates like a ballerina skirt.

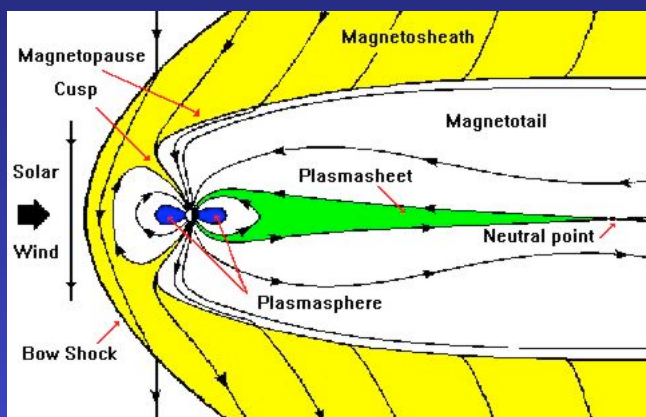
Formation of the magnetosphere

Earth's magnetic field is an obstacle for the solar wind: it can't penetrate inside, but flows past and modifies the dipolar field so that it is extended on the night side to so called magnetotail.



Magnetosphere

The region of space dominated by the Earth's magnetic field is called the magnetosphere (white). 3-4 Re ahead of magnetosphere forms the bow shock, where the SW velocity suddenly drops. Between the bow shock and magnetosphere we have the magnetosheath (yellow, contains SW plasma).

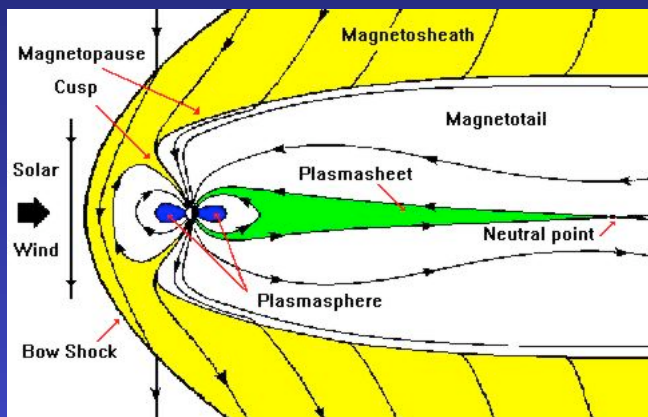


Typical solar wind conditions give a standoff distance of the magnetopause at about 10 Re (Earth radius = 6370 km) upstream of the Earth.

Magnetospheric plasma regions

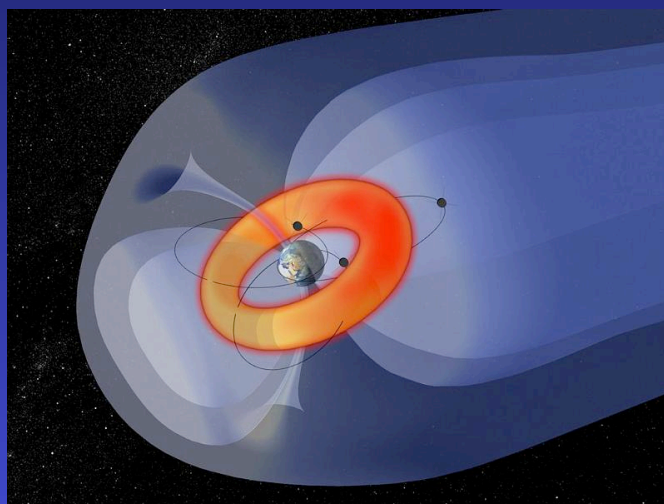
Plasmasphere (blue) contains plasma, which originates from the ionosphere. It is dense and cold (low-energy ions)

Plasmasheet on the nightside contains plasma that may originally come from the SW or from the ionosphere. It is more energetic than the plasma in the surrounding lobes or in the plasmasphere.



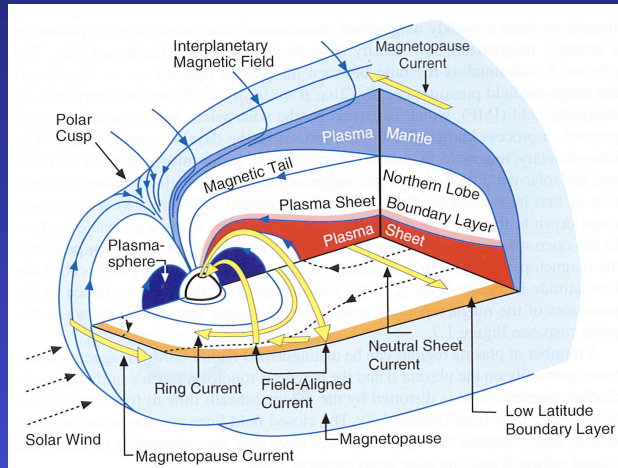
Ring current

Ring current is carried by protons at 4-6 R_E distance from the Earth. It is highly variable in intensity and in the energy of the protons (1 keV - hundreds of keV) that carry the current.



Magnetosphere in 3D

The region between the PSBL and the magnetopause is called lobe. There are two lobes, one in the northern and one in the southern hemisphere.



Plasma characteristics in the magnetospheric regions

β parameter gives the ratio of the plasma thermal pressure to the magnetic field pressure

$$\beta = nk_B T / \frac{B^2}{2\mu_0}$$

Table: Typical parameters for magnetospheric regions

parameter	solar wind at 1 AU	magnetosheath	tail lobe	PSBL	plasma sheet
n (cm^{-3})	5	8	0.01	0.1	0.3
T_i (eV)	10	150	300	1000	4200
T_e (eV)	11	25	50	150	600
B (nT)	5	15	20	20	10
β	1.8	2.5	0.003	0.1	6

How do these regions map along the magnetic field lines to the ionosphere?