The Plasmas of the Magnetosphere

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Magnetosheath
Ion Plasma Sheet
Electron Plasma Sheet
Ring Current
Plasmasphere and Plume
Warm Plasma Cloak
Electron Radiation Belt
Ion Radiation Belt
Empty Lobe
Low-Latitude Boundary Layer
Plasma-Sheet Boundary Layer
Mantle

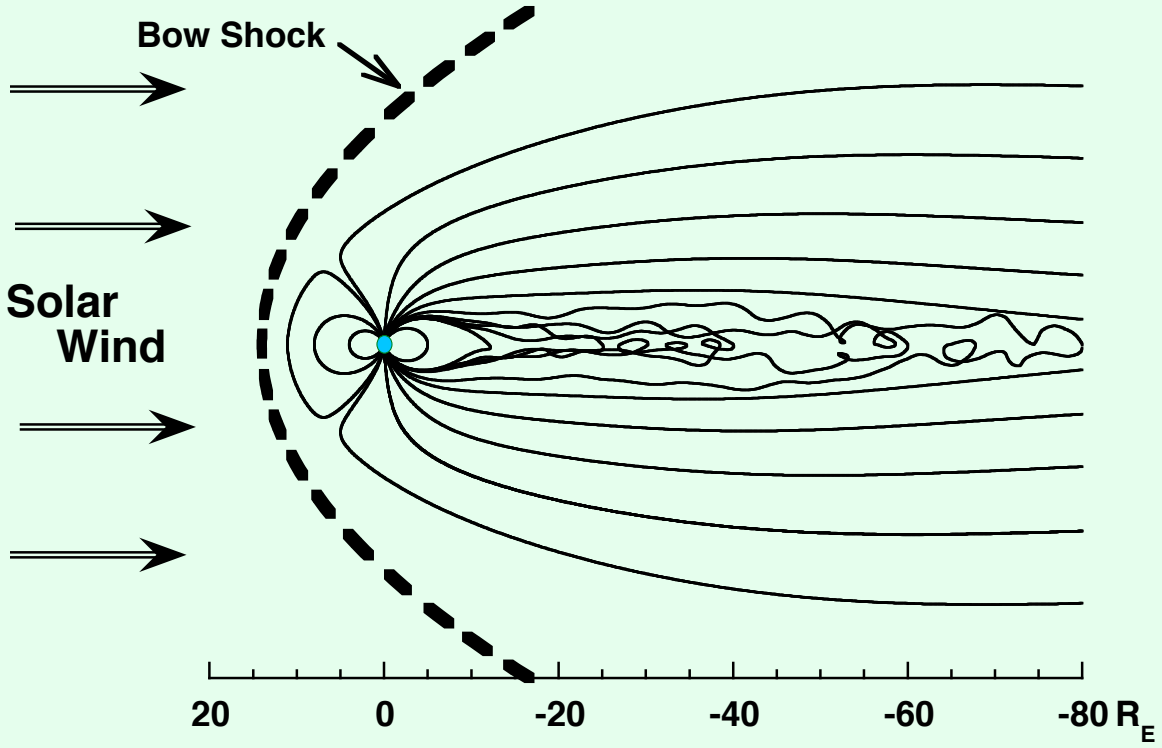
Oxygen Torus
Cleft Ion Fountain
Hydrogen geocorona

Useful Stuff

R_E = Earth radius = 6350 km **1 eV = 11600 ^oK**

geosynchronous orbit = 6.6 R_E

lunar orbit = 60.6 R_E



Download the pdf of the "NRL Plasma Formulary" at:

http://www.psfc.mit.edu/library1/catalog/online_pubs/NRL_FORMULARY_11.pdf

Two Sources for Magnetospheric Plasma

1. The Solar Wind

H^+, He^{++} (also O^{6+}, O^{7+}, C^{5+}, C^{6+}, ...)

2. The Ionosphere

H^+, O^+, He^+

The Magnetosheath

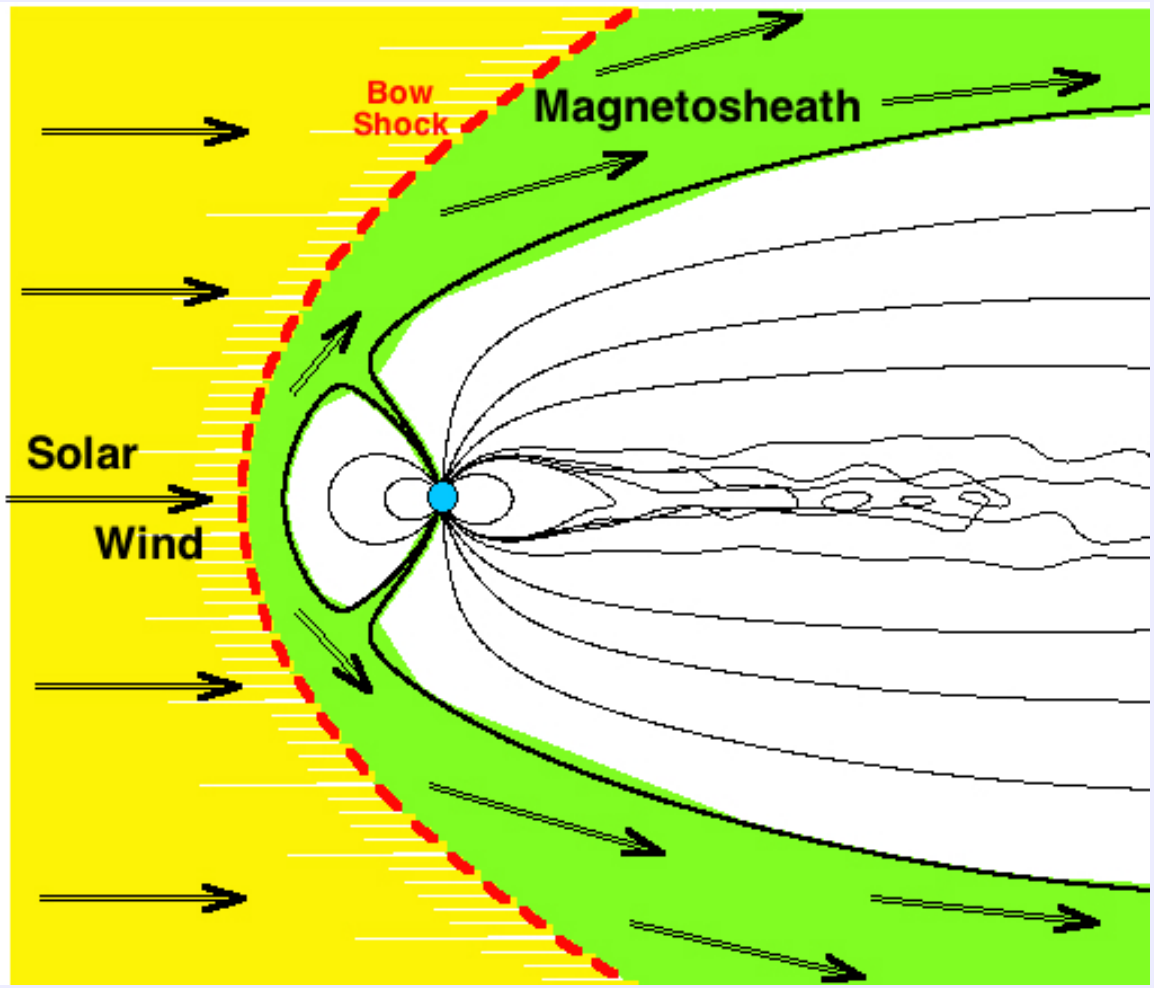
number density
$n \sim 4\, n_{sw}$

ion temperature
$k_B T_p \sim 0.5\, m_p\, v_{sw}^2$
~ 1 keV

electron temperature
$T_e \sim T_p/6$

Usually
$\beta = 8\pi n k_B T/B^2 > 1$

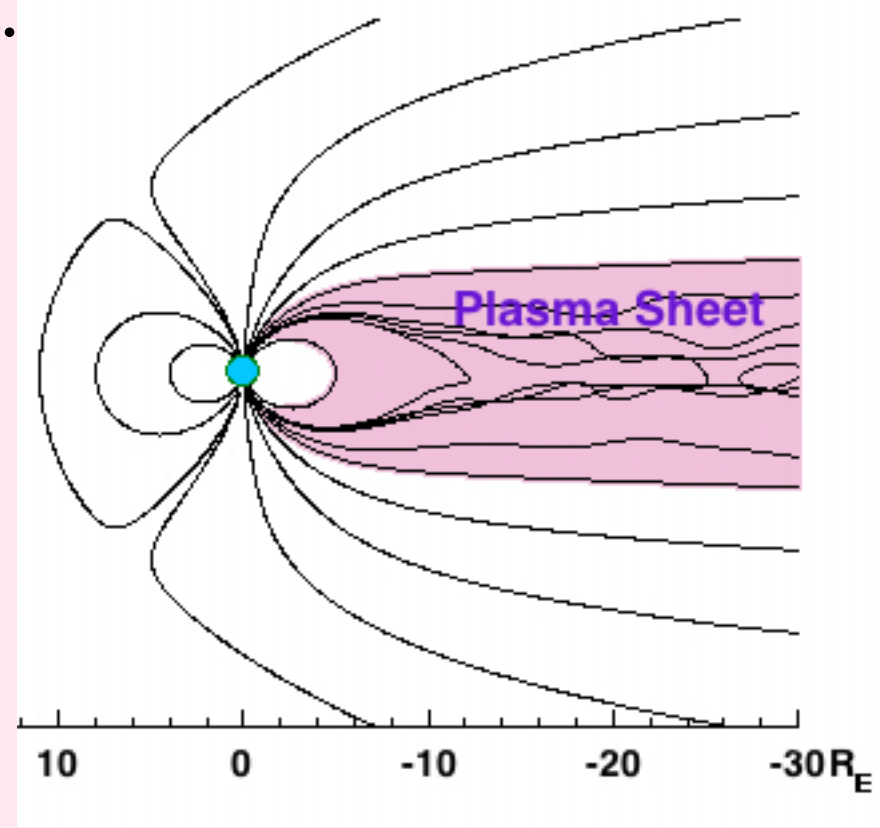
Lots of fluctuations:
- a) solar wind
- b) instabilities



Subsonic flow near nose
Supersonic flow at terminator

The Ion and Electron Plasma Sheet

Source: Mostly the solar wind, but during active times the ionosphere contributes.



n ~ 1 cm-3
T_i ~ few keV
T_e ~ T_i/6

In the ion plasma sheet comes into the dipole deeper than the electron plasma sheet does.

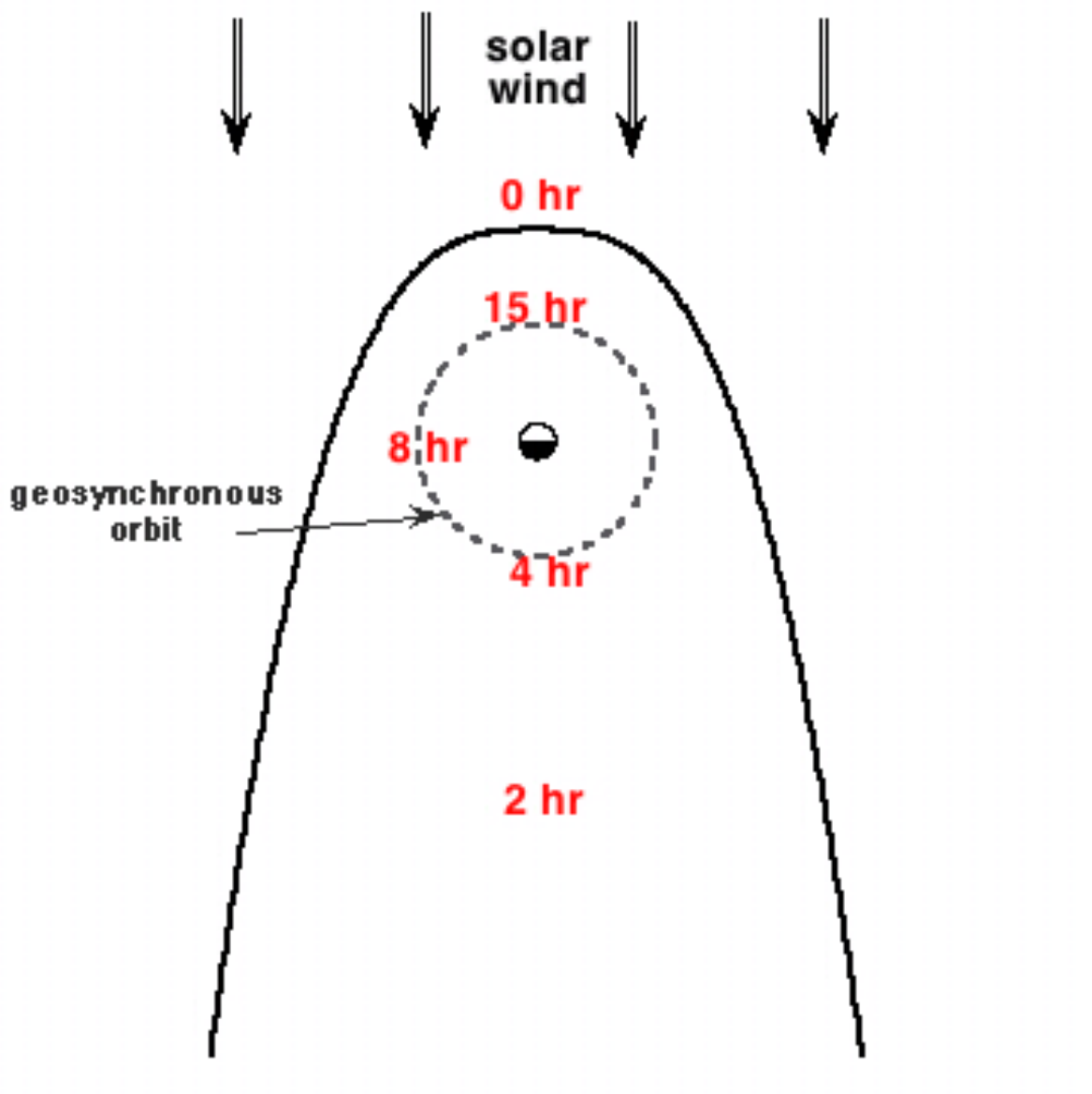
In the dipole, the ion plasma sheet is called the ring current.

In the magnetotail, the plasma sheet has a high value of $\beta = 8\pi n k_B T/B^2$

The plasma sheet exhausts downtail and out the front of the magnetosphere, and it also precipitates into the atmosphere.

The plasma sheet = the auroral zone.

Plasma Transport Times



The plasma sheet tracks the behavior of the solar wind.

Dense solar wind produces dense plasma sheet.

Fast solar wind produces hot plasma sheet.

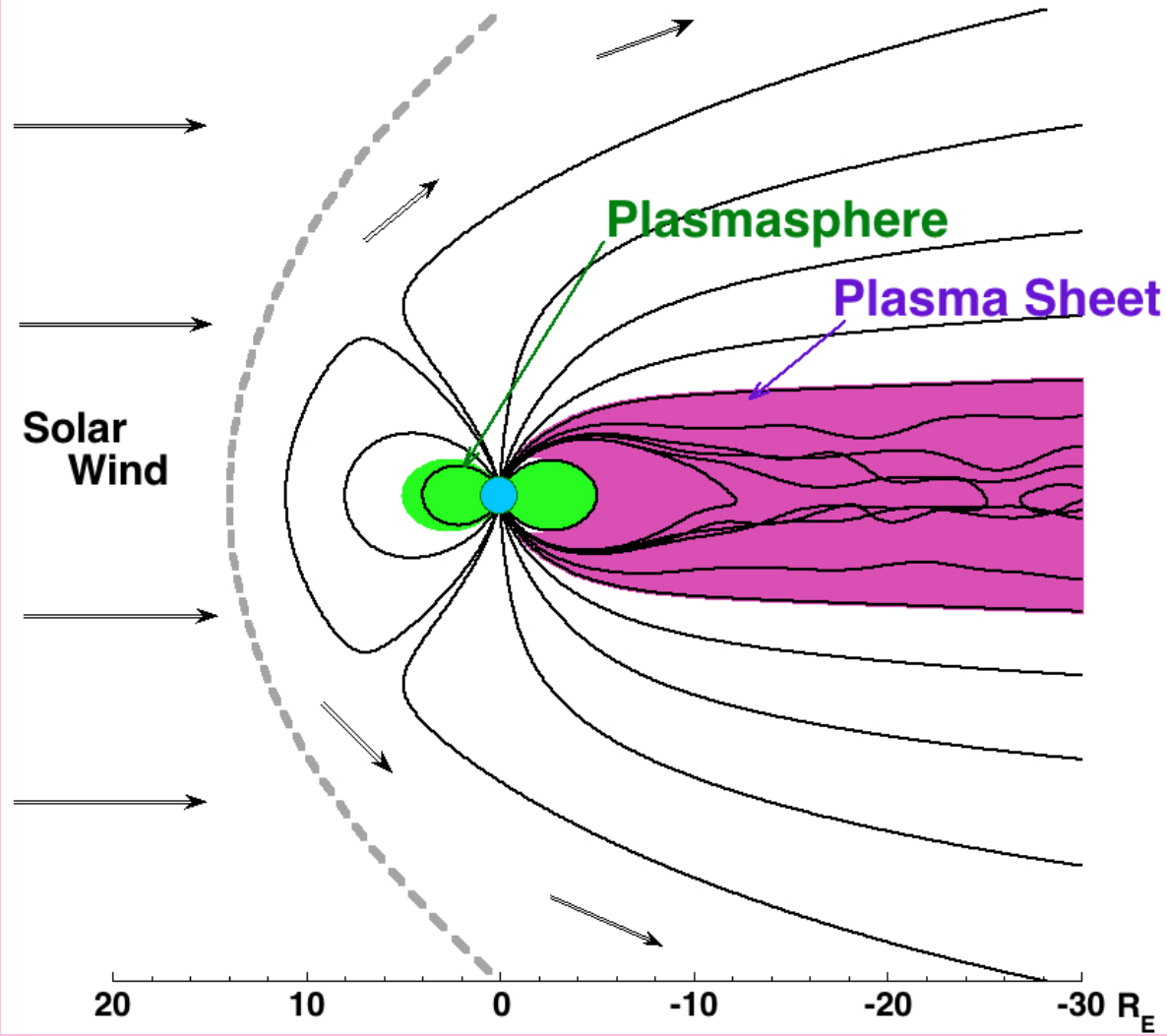
The Electron Trough

Owing to scattering into the atmosphere, the number density of the electron plasma sheet gets small going from the nightside to the dayside.

This is particularly true for the electron plasma sheet.

This low-density dawnside-dayside region is sometimes called the electron trough.

The Plasmasphere



The plasmasphere is a build up of plasma outgassed from the ionosphere.

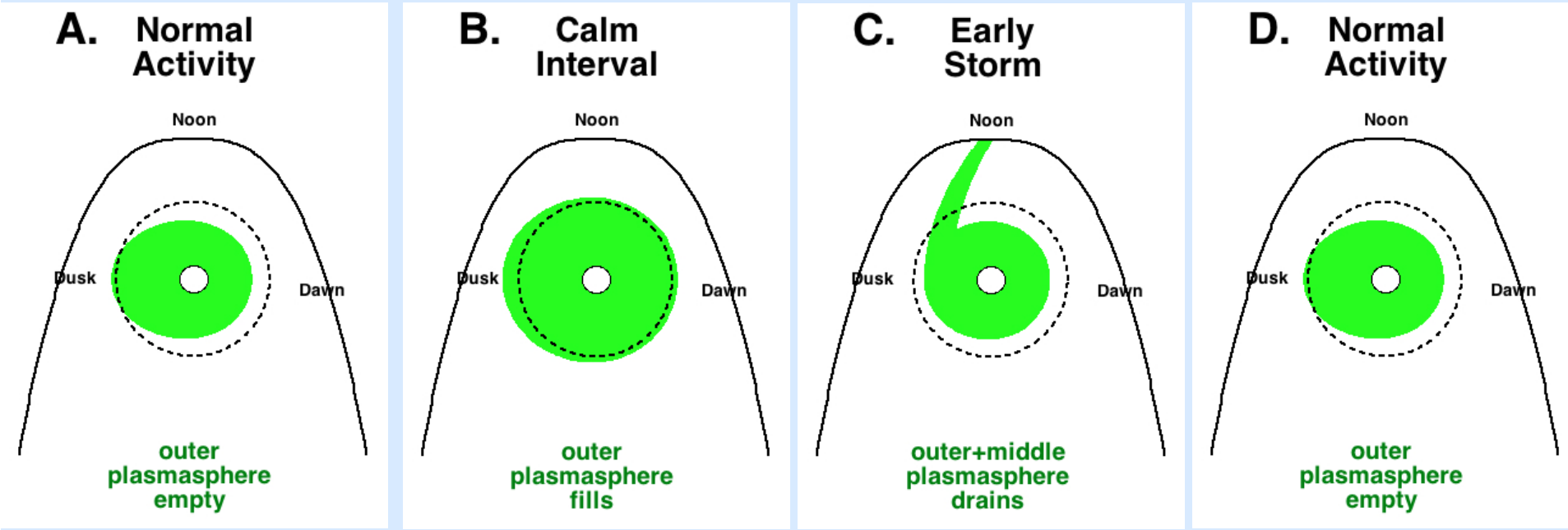
$n = 50 – 2000\ cm^{-3}$

$T_i = T_e \sim 1\ eV$

H^+, He^+, O^+

The plasmasphere has plasma waves (whistler-mode hiss) that are important for the electron radiation belts.

The Plasmapheric Drainage-and-Refilling Cycle



The plasmasphere drains via a sunward-flowing "plume" of plasma.

The Warm Plasma Cloak

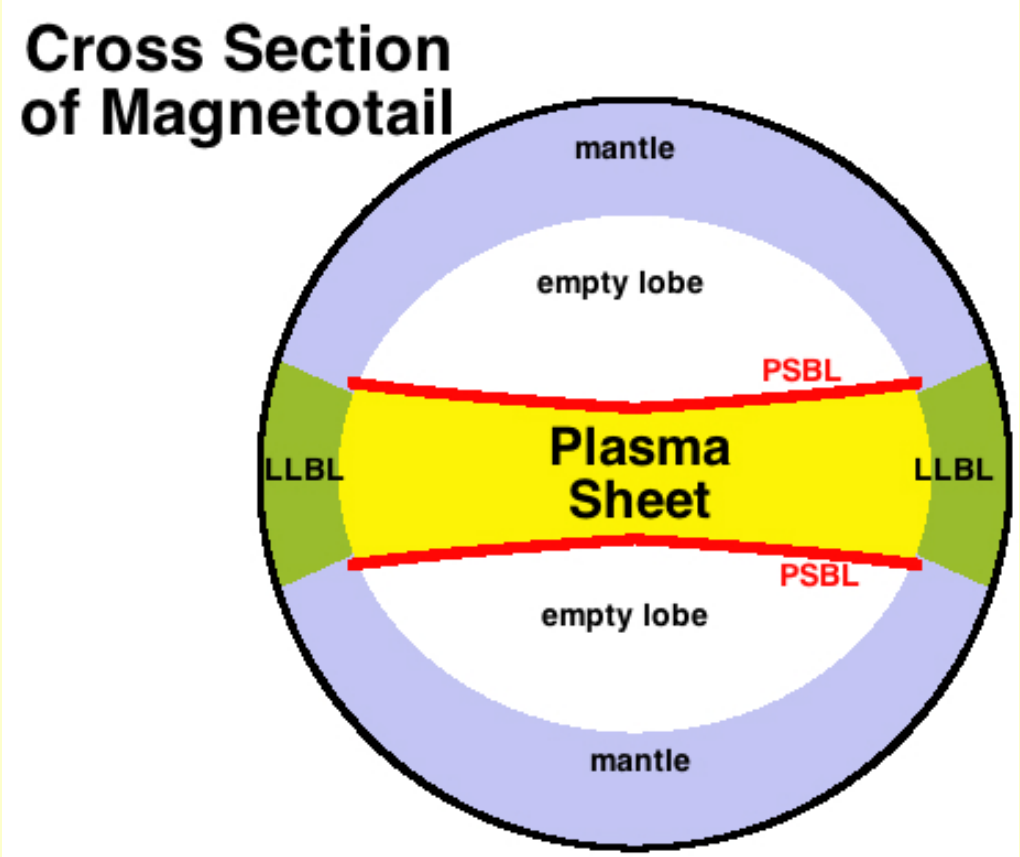
This plasma has been little studied, but may be important for solar-wind/magnetosphere coupling.

Throughout the dayside magnetosphere cool (10's of eV) ions are seen.

These ions are undoubtedly from ionospheric outflows.

There are old reports of an "oxygen torus": this torus is probably the same thing as the cloak.

Boundary Layers

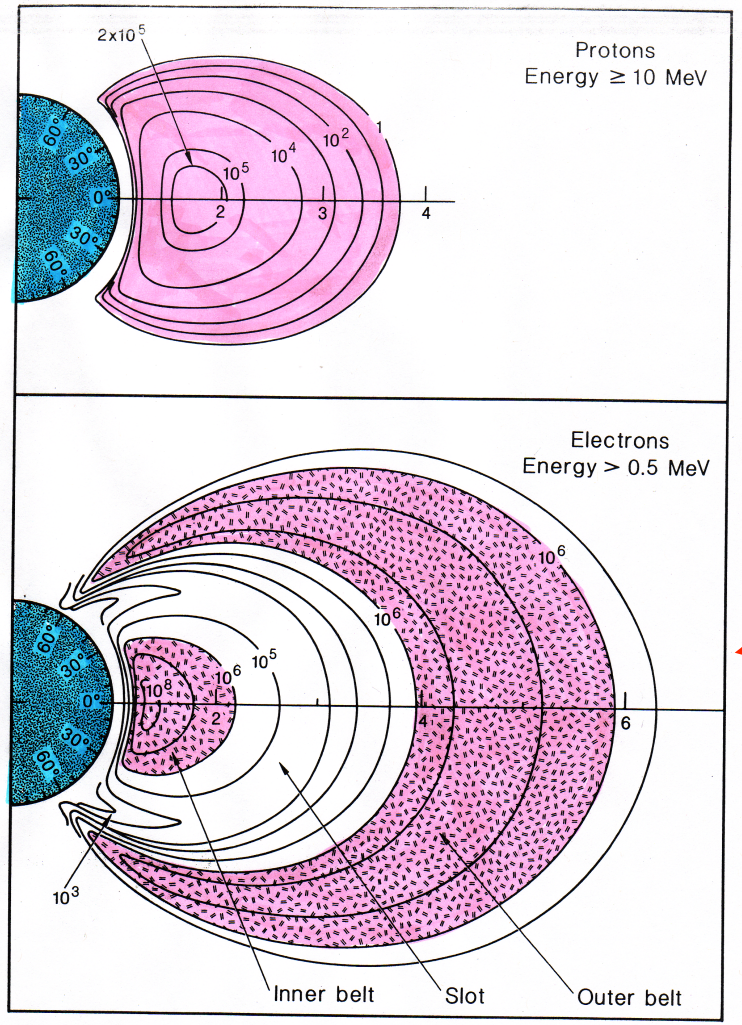


Plasma-sheet boundary layer (psbl) is a layer of field-aligned beams on the top and bottom of the plasma sheet in the magnetotail.

Low-latitude boundary layer (LLBL) is solar-wind plasma leaking into the magnetosphere along the sides.

Mantle (high-latitude boundary layer) is solar-wind plasma entering via the dipole cusp.

The Ion and Electron Radiation Belts



The inner electron belt and the inner portions of the ion belt are relatively stable.

The outer electron belt is very dynamic.

These maps outline regions where the particles can penetrate through 1 mm of aluminum. Top picture is ions, bottom picture is electrons.

The Dynamic Outer Electron Radiation Belt

Decay:

During geomagnetically quiet times the outer electron radiation belt decays.
Probably caused by pitch-angle scattering into the atmosphere by whistler waves living in the plasmasphere.

Dropout:

When the ram pressure of the solar wind becomes high, the magnetosphere becomes distorted and the outer electron radiation belt is rapidly lost.
Probably the electrons drift into the dayside magnetopause and are lost into the solar wind.

Recovery:

When the ram pressure of the solar wind drops, there is a sudden appearance of a new population of radiation-belt electrons.
?????

Energization:

During long intervals of fast solar wind and high geomagnetic activity the outer electron radiation belt grows in intensity.
Probably acceleration by whistler waves (chorus) outside the plasmasphere.

The Cleft Ion Fountain

A region of ionospheric outflow driven by the penetration of hot magnetosheath plasma into the magnetic cusp of the dipole.

The Hydrogen Geocorona

A cloud of neutral hydrogen outgassing from the atmosphere: very important for charge-exhanging with the hot plasmas in the dipole regions.

Excersize

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Look through the formulary and see what is useful. Pages 28 and 29 are particularly useful for space physics.