Interactions between solar wind and geomagnetosphere

Space weather & Space climate

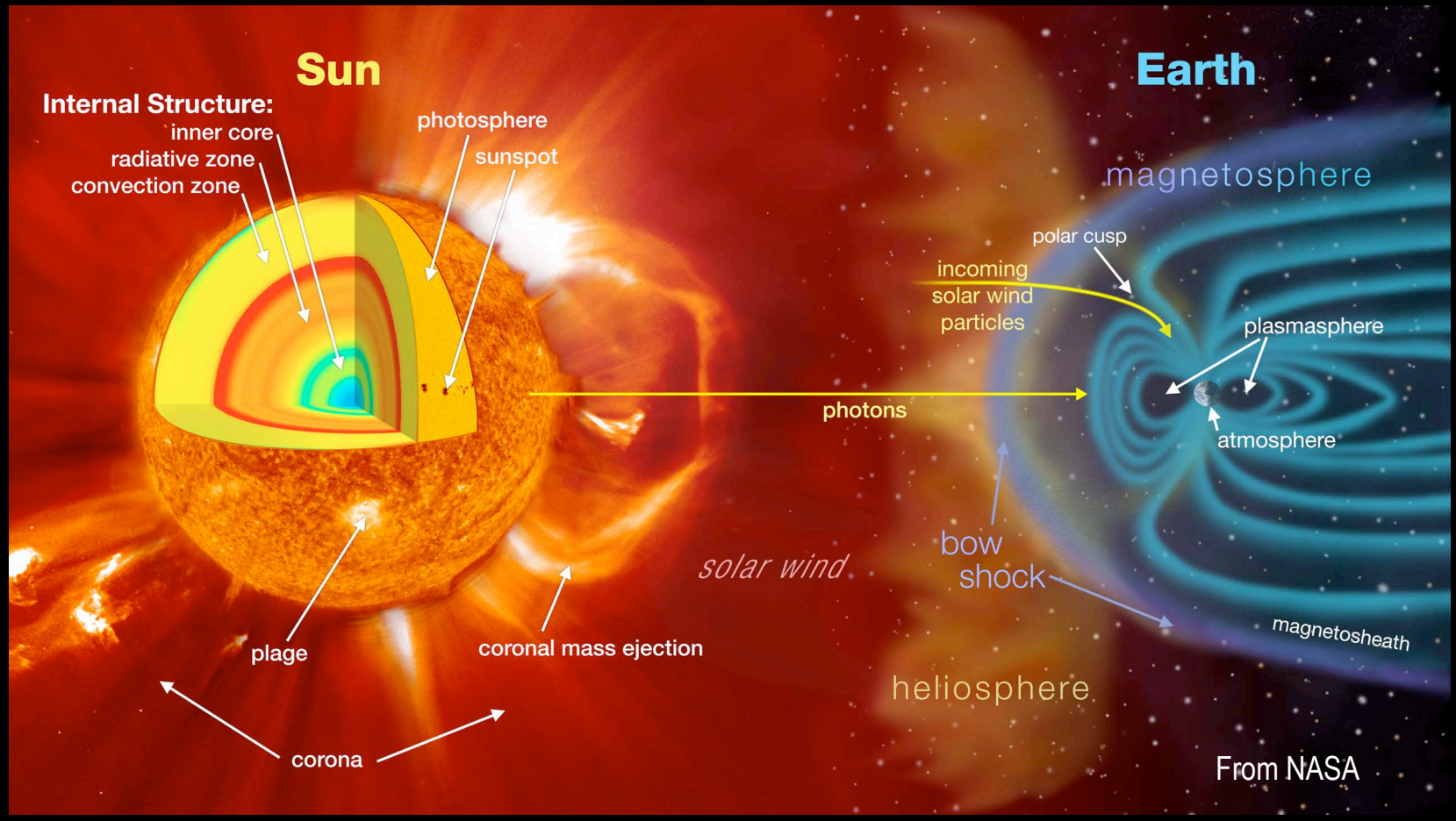
Topics discussed in this section...

- Models of solar wind
- Interplanetary magnetic field (IMF)
- Disturbances in IMF (ICME, CIR)
- Interaction between IMF and terrestrial magnetic field
- Space weather
- Space climate

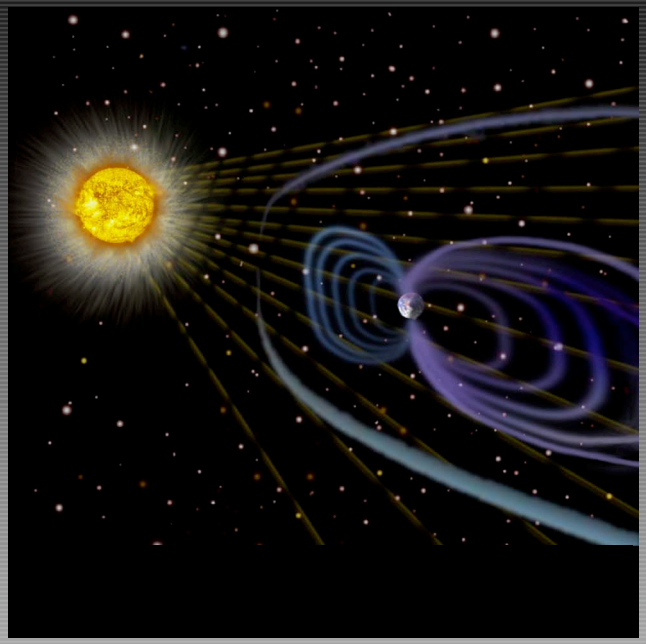
Space weather

short-term variation

Sun–Earth system



*Solar winds carry **charged particles** and **magnetic fields** to the Earth, which have **collisional** and **electromagnetic** effects on terrestrial environment.*



high-energy particle => ***collisional effect*** on objects around the Earth

magnetic field => ***electromagnetic effect*** on magnetic structure formed around the Earth

bulk flow => ***collisional (dynamic pressure) effect*** on those objects and the magnetic structure

Structure of magnetosphere

Magnetosphere and its boundary (magnetopause)

Solar wind plasma generally does not cross terrestrial magnetic field, so a distinct space is given to terrestrial plasma around the Earth (***magnetosphere***), which is separated from interplanetary space by ***magnetopause***.

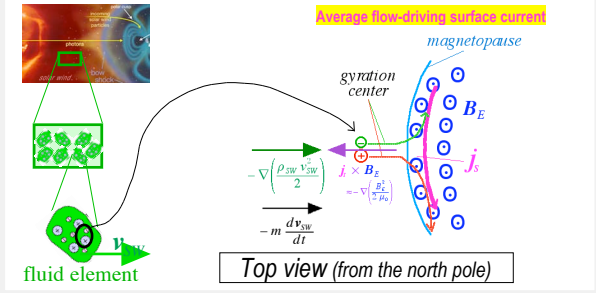
Front side of *the magnetosphere*

Terrestrial magnetic field is **compressed by solar wind**.

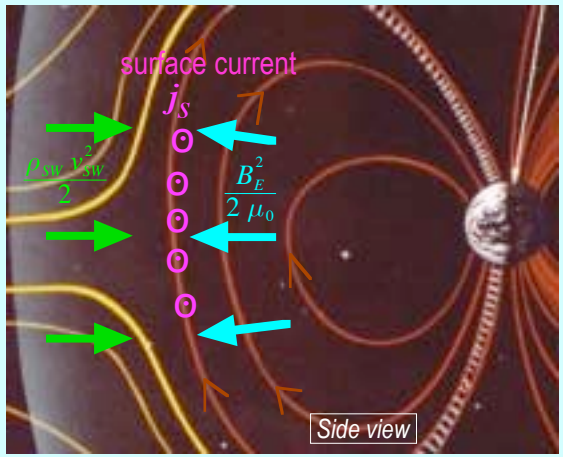
Pressure balance at magnetopause

Solar wind dynamic pressure ~ **Terrestrial magnetic pressure**

$$\frac{\rho_{SW}\, v_{SW}^2}{2} \qquad \frac{B_E^2}{2\,\mu_0}$$



Chapman & Ferraro

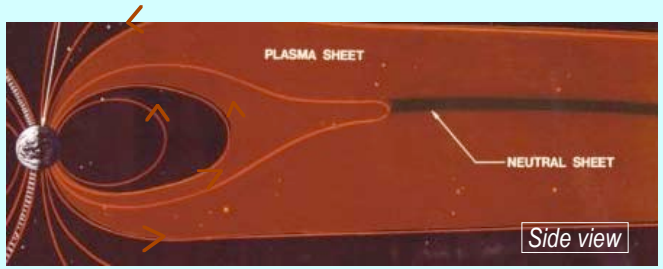


≤ 10 R_E

Back side of *the magnetosphere*

Terrestrial magnetic field is **elongated by solar wind**.

=> forms "***magnetotail***"



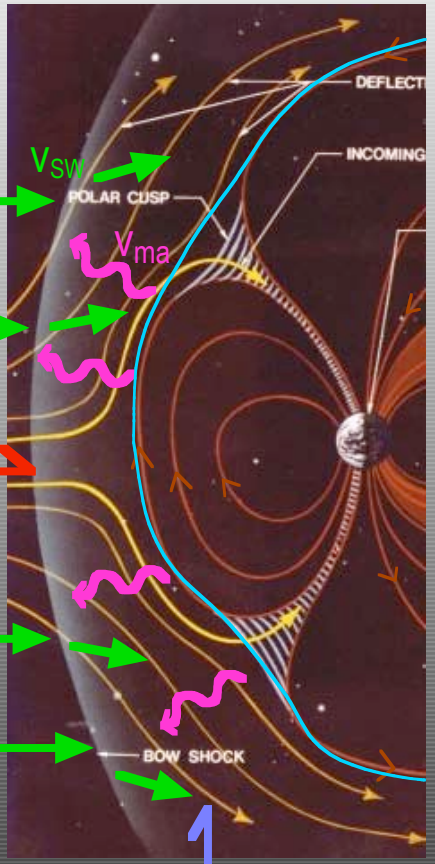
≥ 200 R_E

Bow shock

Solar wind... **super-magnetoacoustic flow**

speed of *magnetoacoustic wave*... v_{ma} = 100 km/s

speed of (*slow*) *solar wind*... v_{sw} = 450 km/s

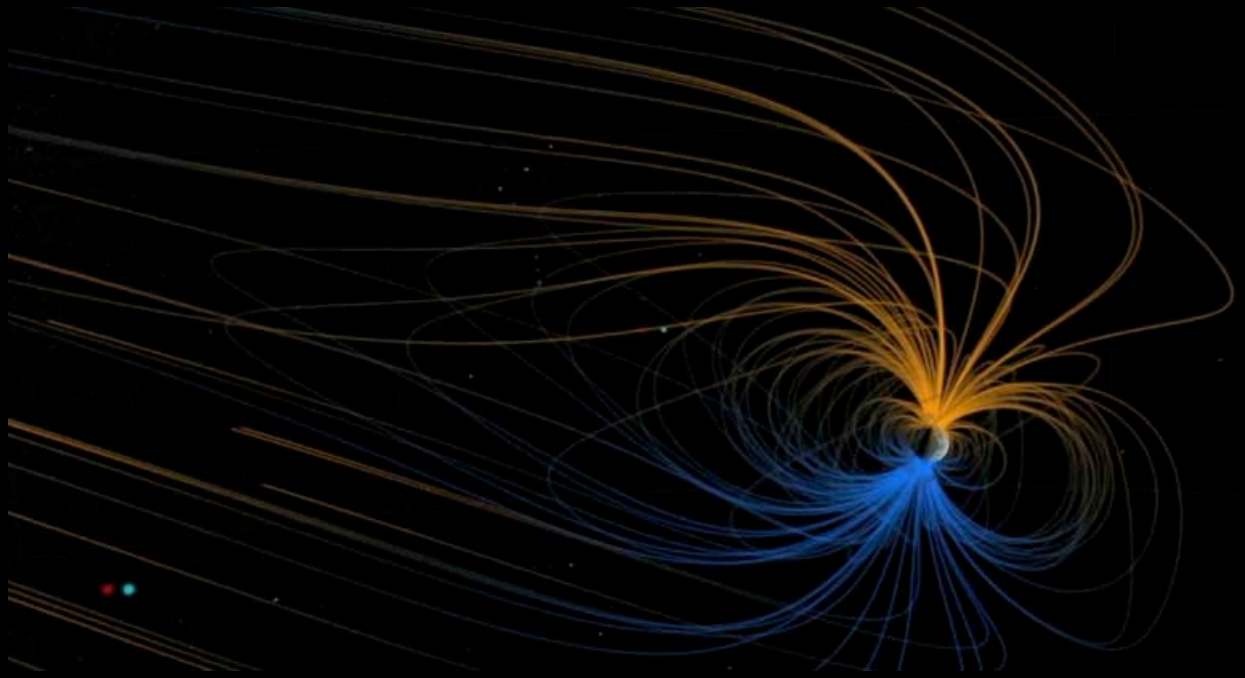


$v_{SW} > v_{ma}$ => **shock wave (*bow shock*)** is formed in front of ***magnetopause***

Magnetosheath*...** region between ***bow shock and ***magnetopause***

sub-magnetoacoustic flow ($v_{SW} < v_{ma}$) with **enhanced density & temperature**

Magnetic structure of magnetosphere



https://www.youtube.com/watch?v=k67OGI-ur3I

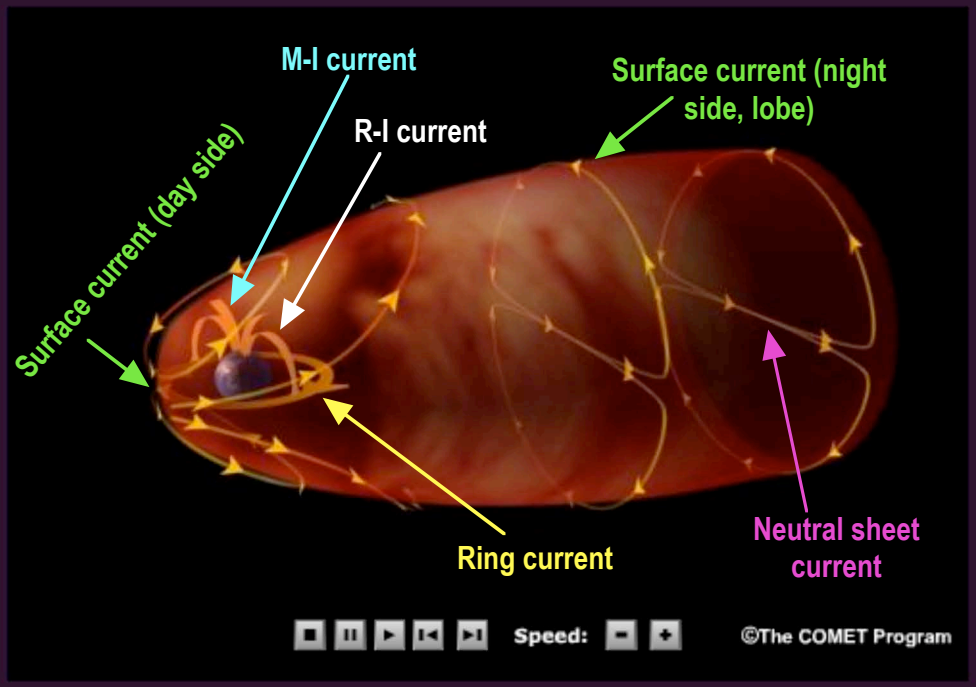
Current structure of magnetosphere (steady state)

magnetosphere

magnetosphere-ionosphere current system

Because the magnetopause boundary separates a region of relatively strong magnetic field (the magnetosphere) from a region of relatively weak magnetic field (the magnetosheath), the boundary must carry a surface current to ensure force balance across the boundary. This magnetopause current flows differently on the day side and night side of the Earth.

The ***magnetopause current*** encircling the magnetotail lobes closes through the middle of the tail in a ***neutral sheet current*** that separates the oppositely directed magnetic fields in the two tail lobes.



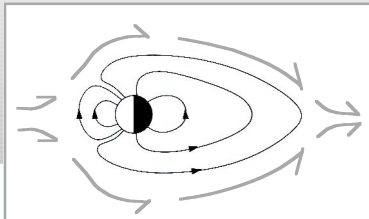
Injection of solar wind plasma into magnetosphere

Explosive injection of solar wind plasma into magnetosphere via *reconnection* & *convection* of *southward IMF* *frozen into the SW plasma*

Dungey's convection model

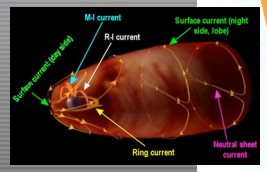
1 (reconnection) -> 2 -> 3 -> 4 -> 5 -> 6 (reconnection) -> 7 -> 8 (rotation) -> 9

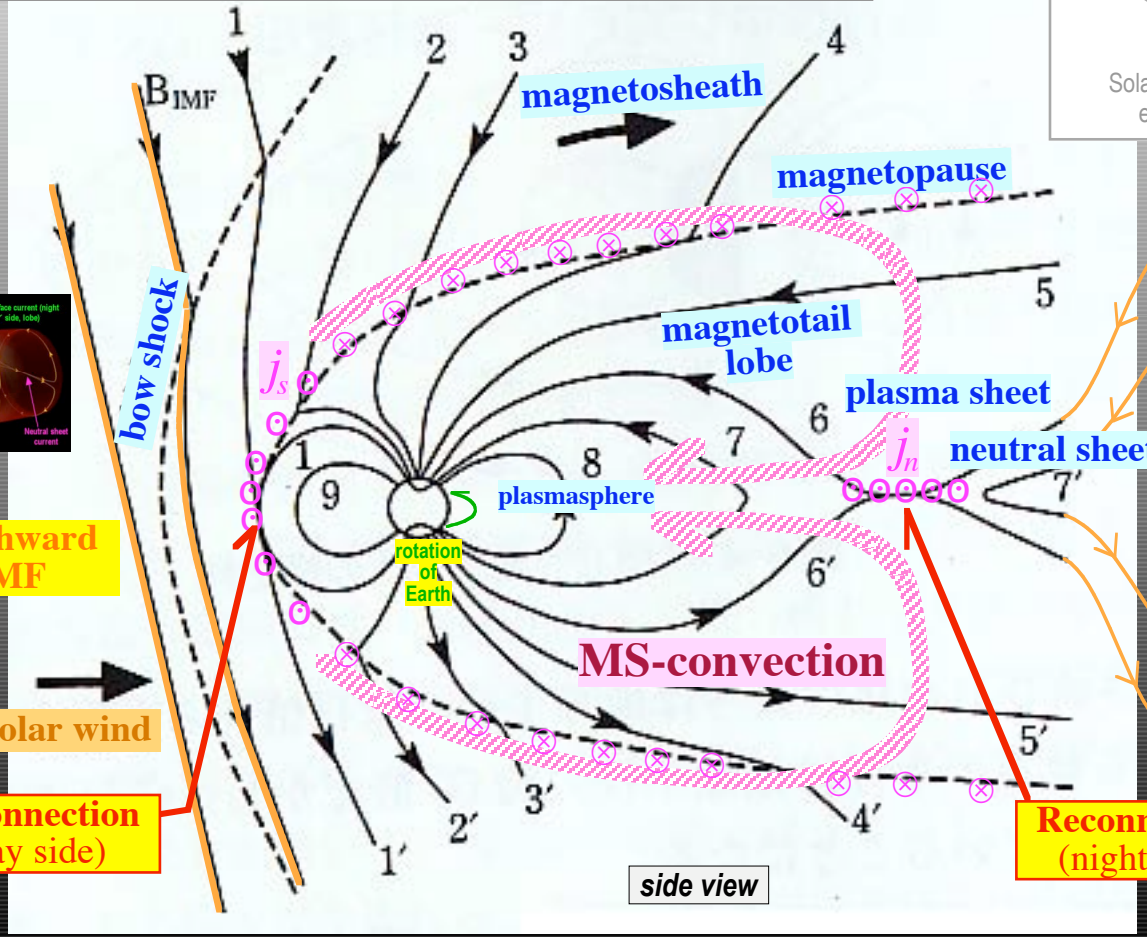
magnetotail lobe | plasma sheet | plasmashpere



Closed model

Solar wind plasma does not enter magnetosphere





Southward IMF