

The background of the slide is a composite image. On the left, there is a large, bright orange and yellow sun with visible solar flares and a glowing corona. On the right, there is a blue and white visualization of a magnetic field or plasma flow, showing concentric, swirling lines. The entire scene is set against a dark space background filled with numerous small white stars.

# Space Weather

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# Outline

- Introduction
- Solar parts
  - Solar wind
  - Solar flare
  - Coronal Mass Ejections
- Magnetosphere
  - Aurora
  - Van Allen belt
- Effects
- Summary

# Solar wind

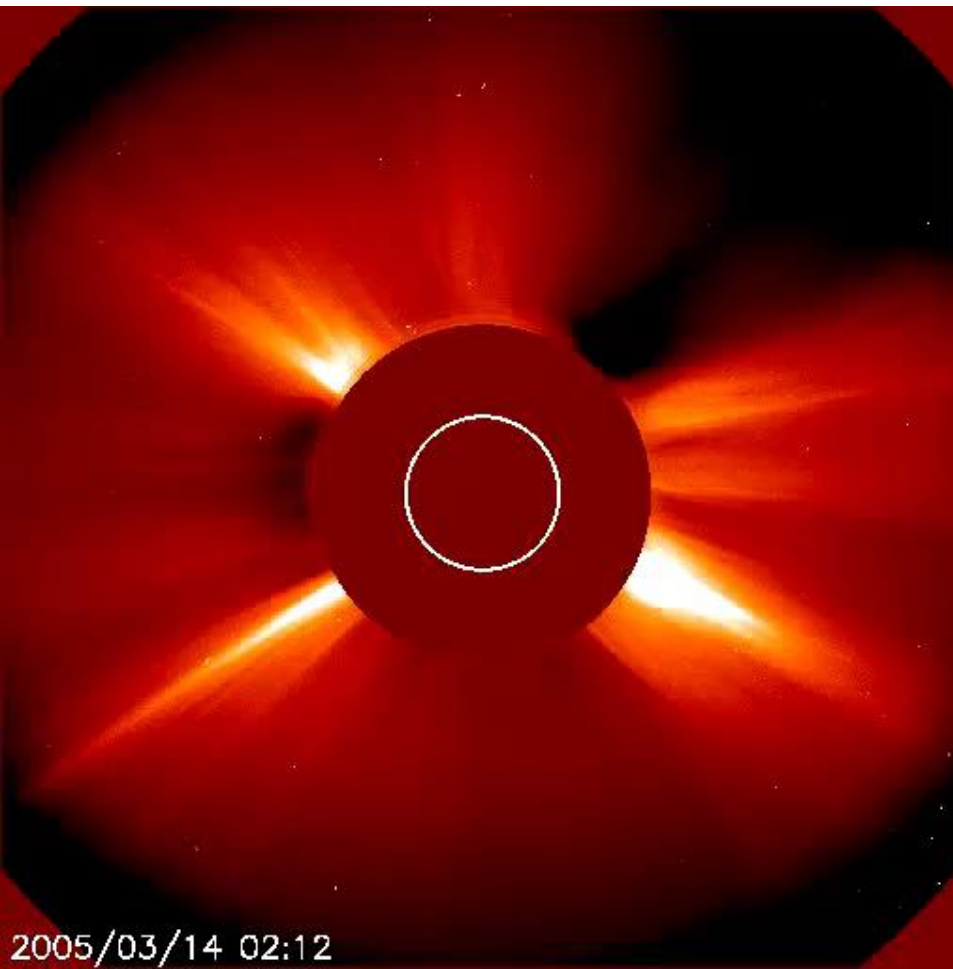


- a stream of charged particles released from the upper atmosphere of the Sun called the corona.

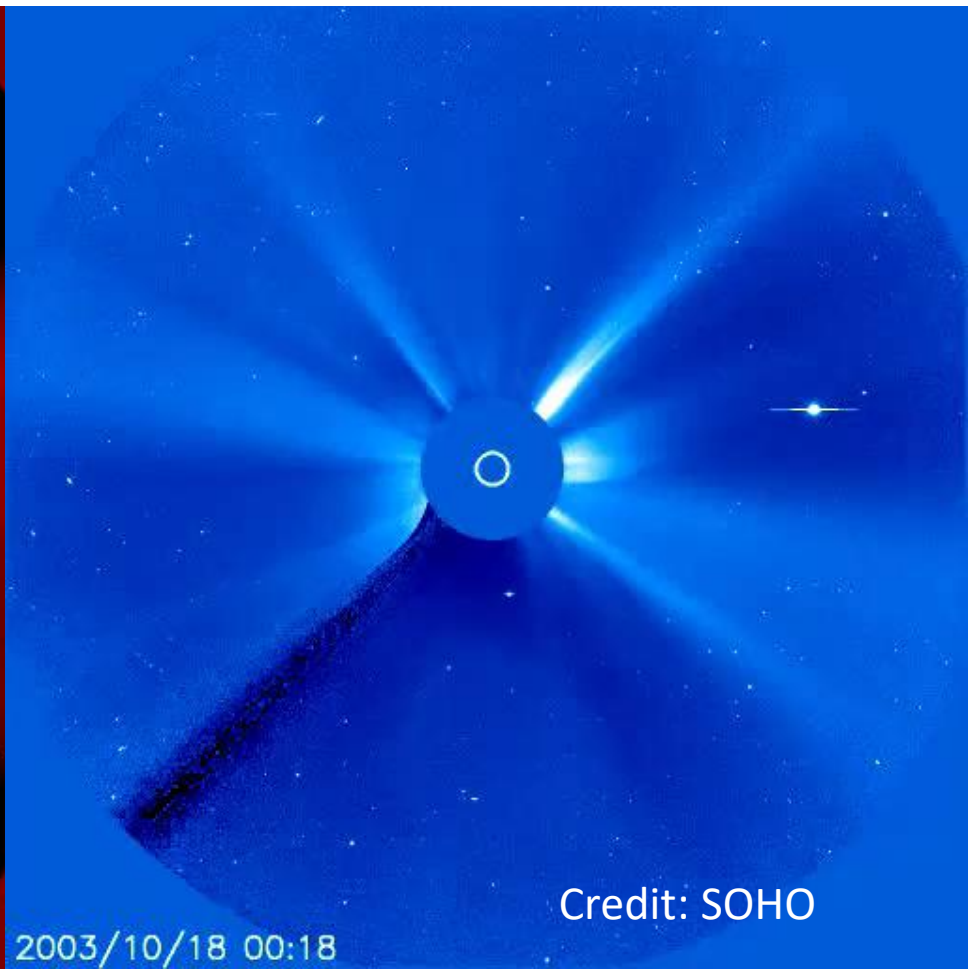
CORONA

SOLAR WIND

- mostly electrons, protons and alpha particles with kinetic energy between 0.5 and 10 keV.
- Carry interplanetary magnetic field (IMF)
- ~400km/s
- Continually



2005/03/14 02:12



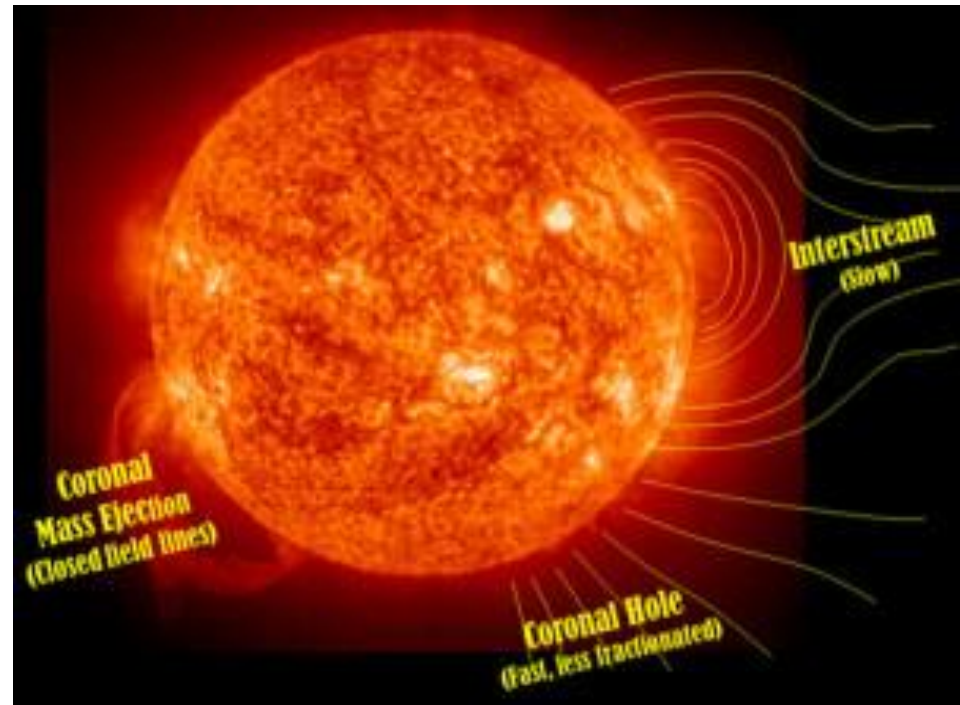
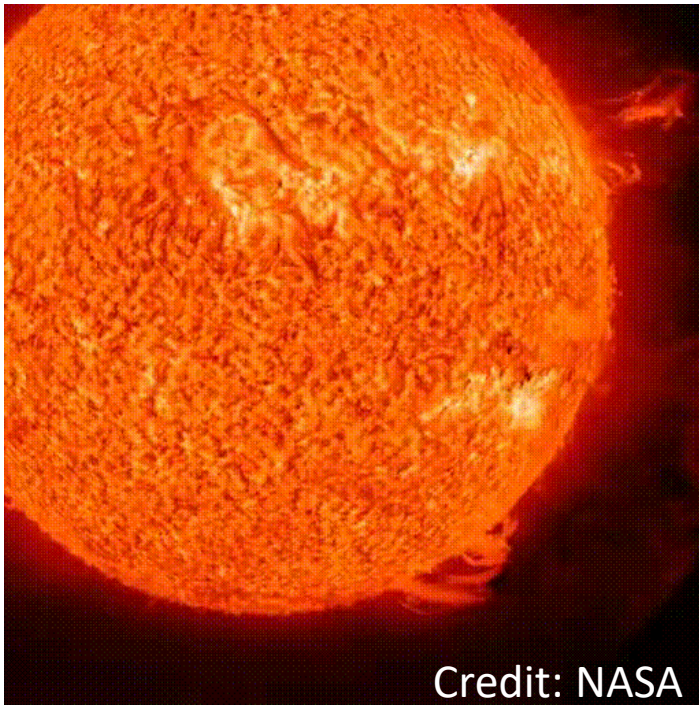
2003/10/18 00:18

Credit: SOHO



# Coronal Mass Ejections (CMEs)

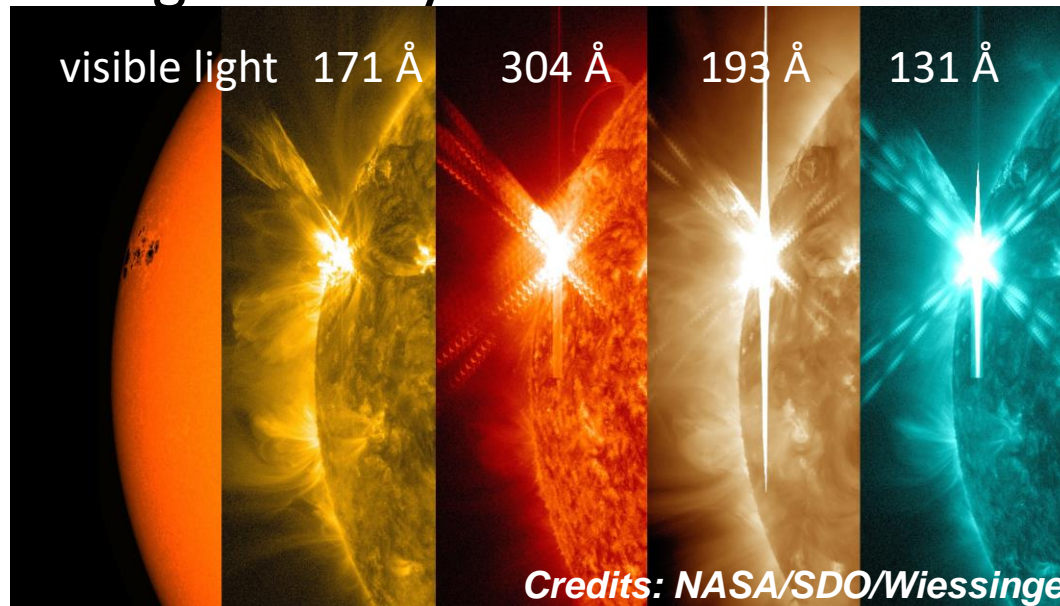
- Definition: an observable change in coronal structure that
  - 1) occurs on a time scale of a few minutes and several hours
  - 2) involves the appearance (and outward motion) of a new, discrete, bright, white light feature in the coronagraph field of view.
- a magnetized plasma consisting primarily of electrons and protons.
- from a few km/s (near the Sun) to nearly 3000 km/s



# Solar Flares

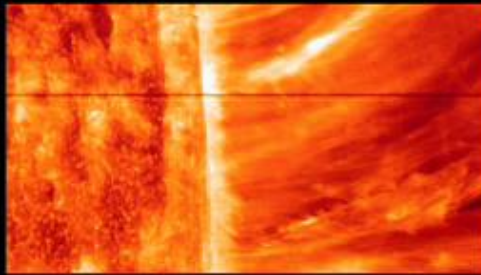
*A sudden flash*

- The flashes of electromagnetic radiation released within seconds to minutes
- thermal soft x-ray flare first
- CME → shock wave → accelerated electrons → bremsstrahlung → X-ray

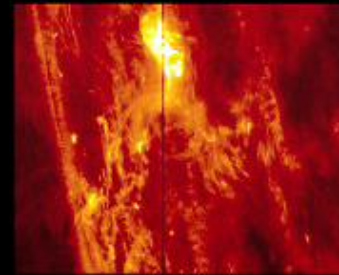


# Solar flares vs CMEs

Flares look like bright flashes of light on the sun. Coronal mass ejections look like clouds zooming out into space.



CME



Flare

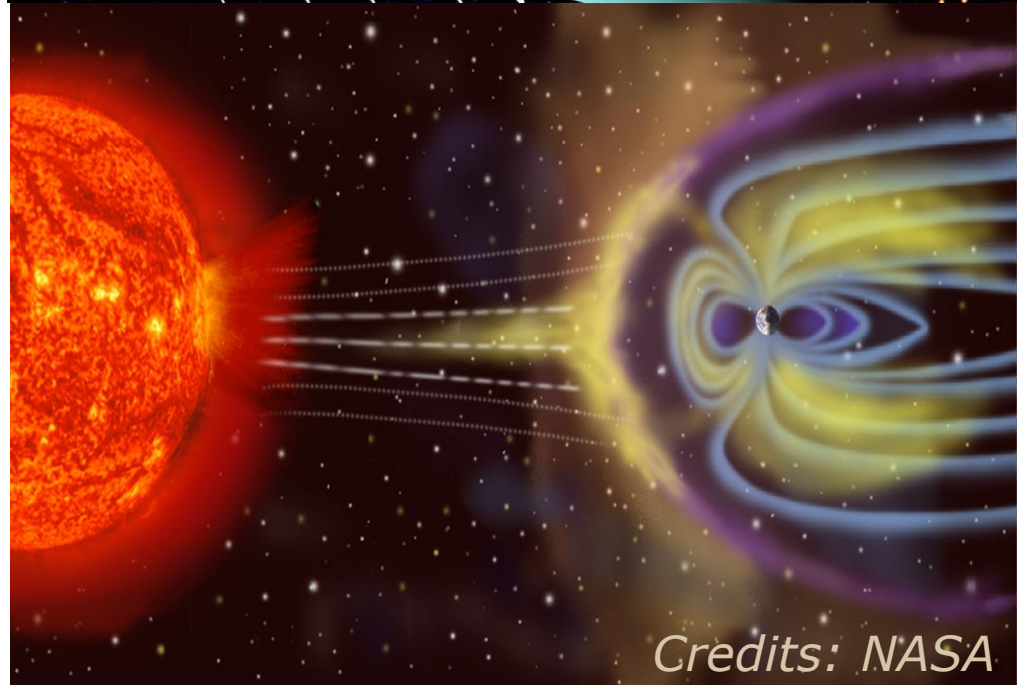
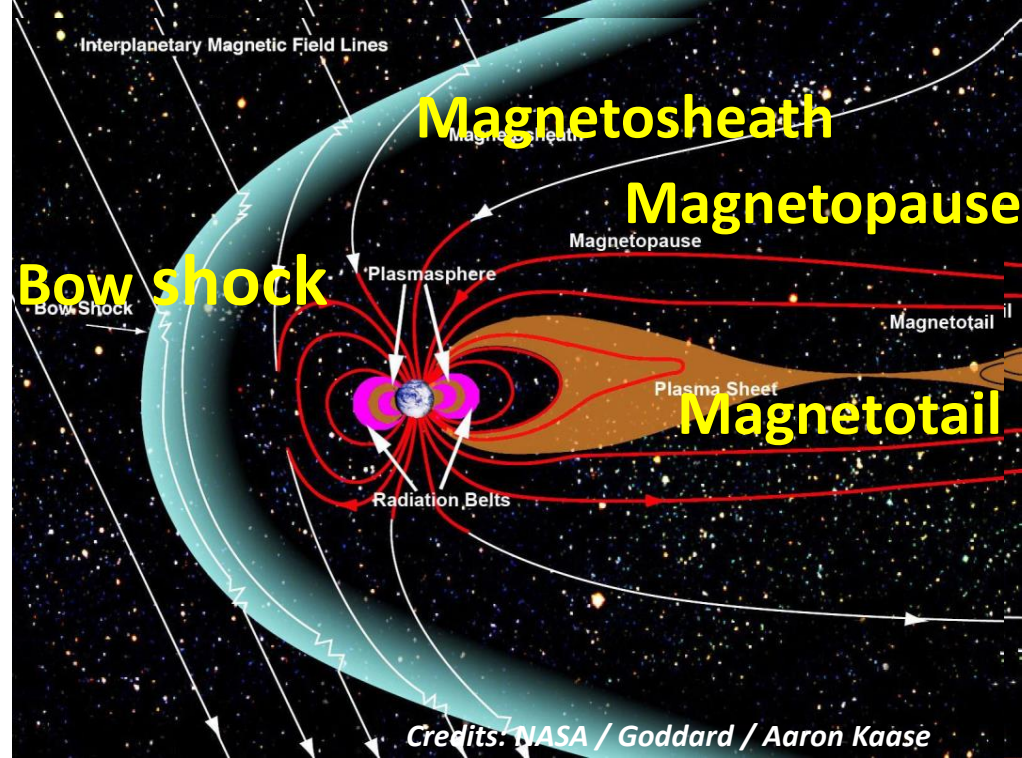
# CMEs interaction with Magnetosphere





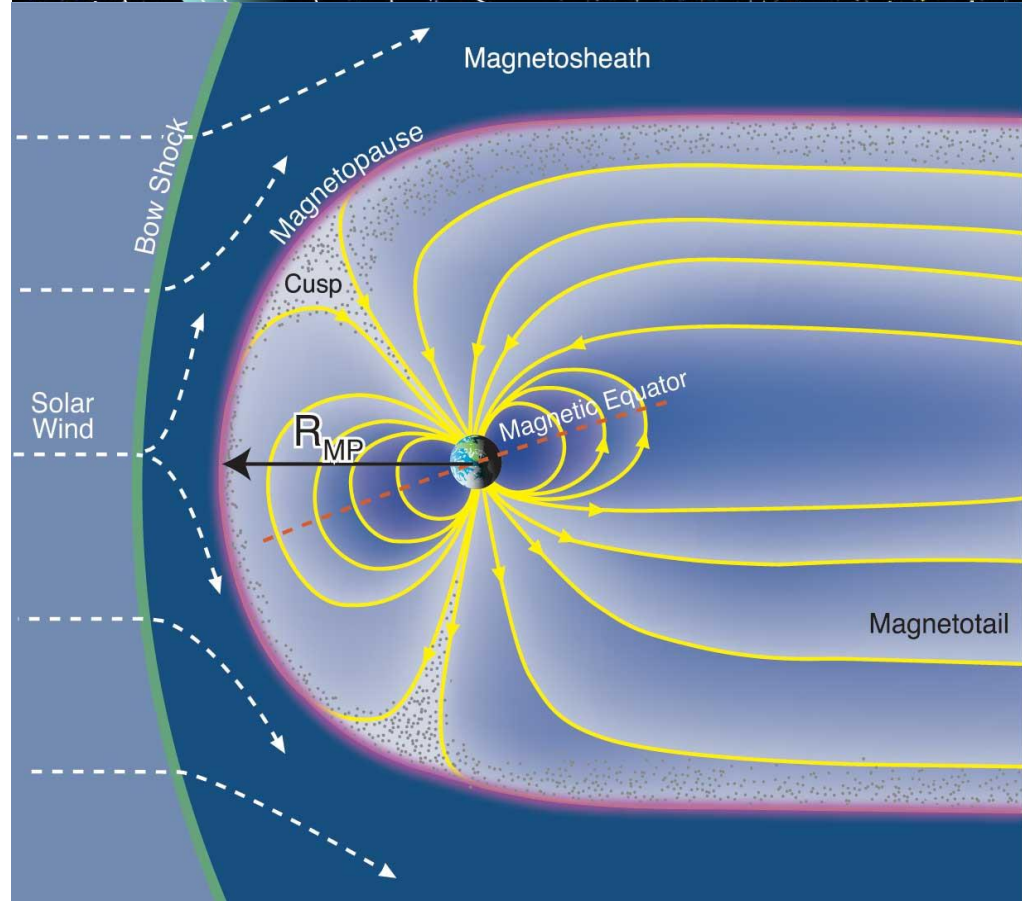
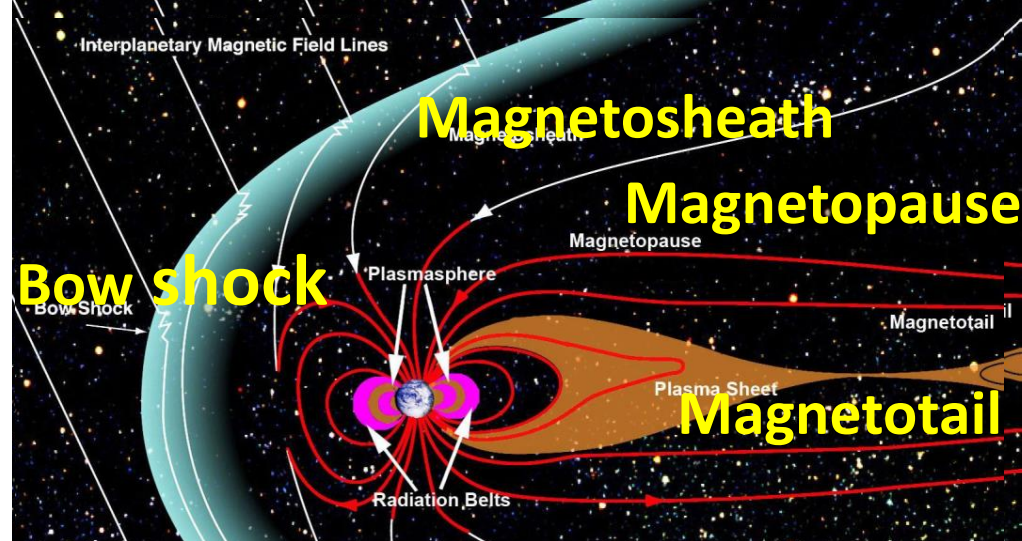
# Magnetosphere

- **Bow shock**
  - outermost layer
- **Magnetosheath**
  - between the bow shock and the magnetopause
  - speed of the solar wind there **decreases**
- **Magnetopause**
- **Magnetotail**



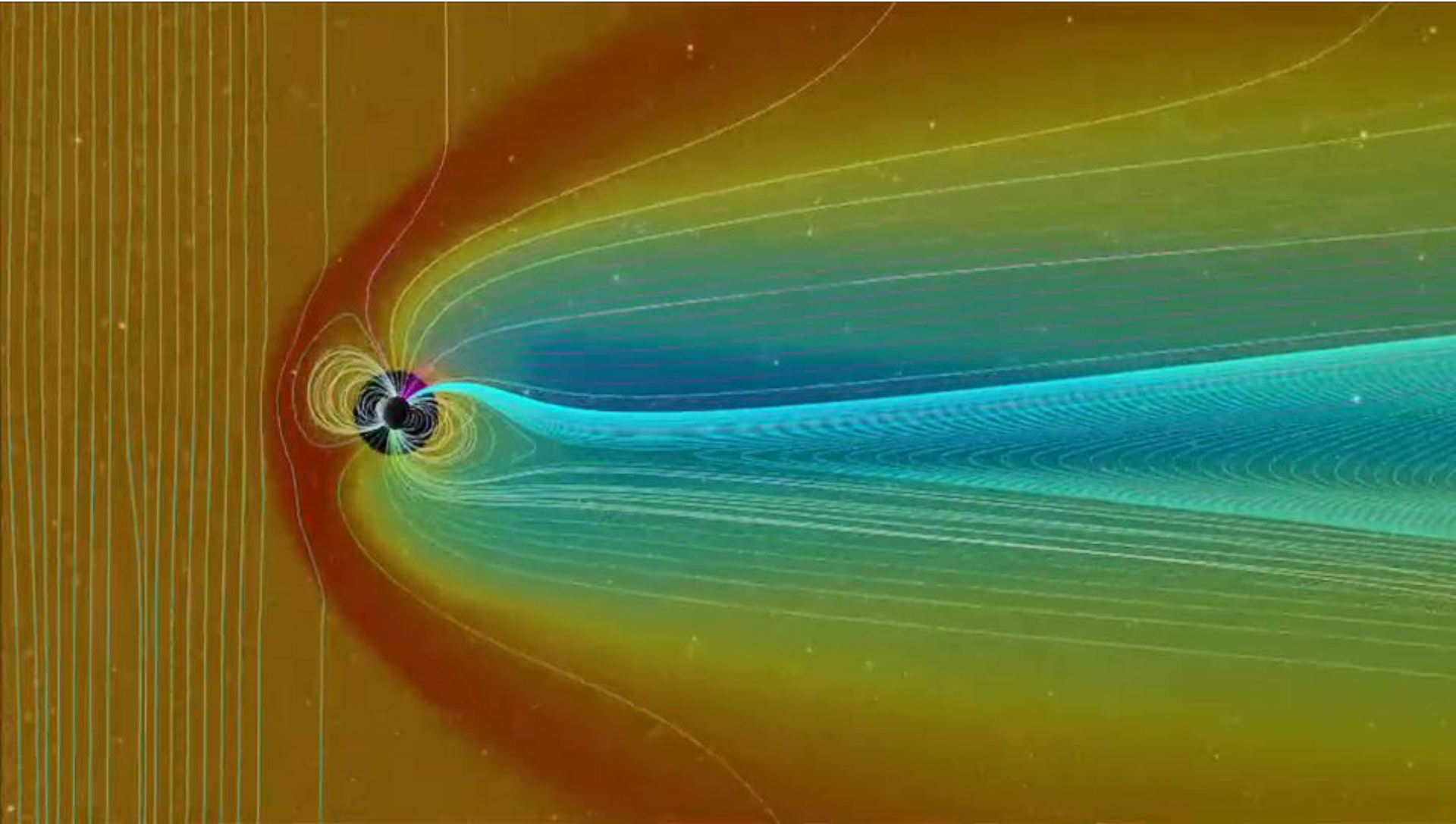
# Magnetosphere

- Bow shock
- Magnetosheath
- Magnetopause
  - pressure from the planetary magnetic field is balanced with the pressure from the solar wind
- Magnetotail
  - Opposite the compressed magnetic field
  - almost empty



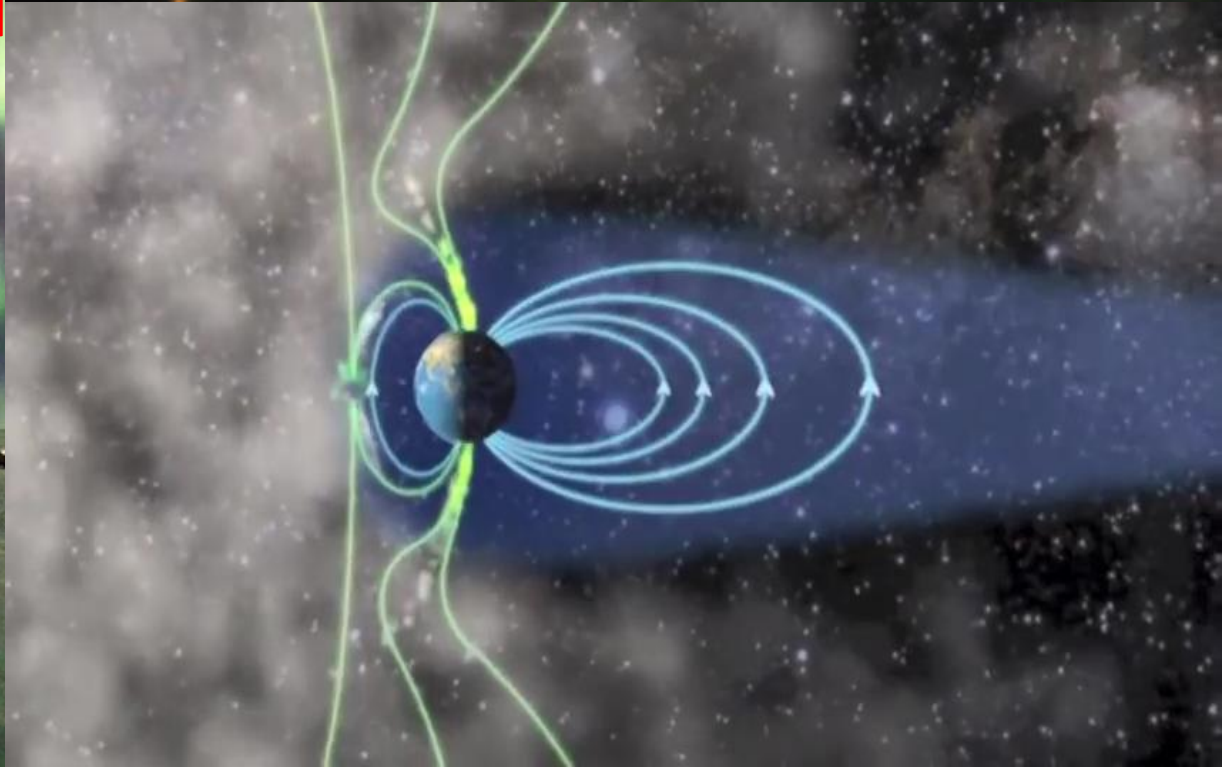


# Magnetosphere



# Aurora

- Auroras are the result of disturbances in the **magnetosphere** caused by **solar wind**
- The resulting **ionization** and **excitation** of atmospheric constituents emits light of varying color and complexity





# Van allen belt

A diagram showing the Earth at the center with magnetic field lines extending outwards. Three distinct belts of charged particles are shown: an inner blue belt, a middle pink belt, and an outer violet belt. The belts are symmetric about the equator and extend to the poles. The background is a dark purple gradient.

Three Van Allen belts, coloured diagram:

- blue: Inner Van Allen belt (**protons**)  
(voltage per particle: **over 10 million volt**)
- pink: New Van Allen belt (**electrons**)  
(voltage per particle: **1 to 5 million volts**)
- violet: Outer Van Allen belt (**electrons**)  
(voltage per particle: **10 to 100 million volt**).

Outer Van Allen Belt  
(Electrons)

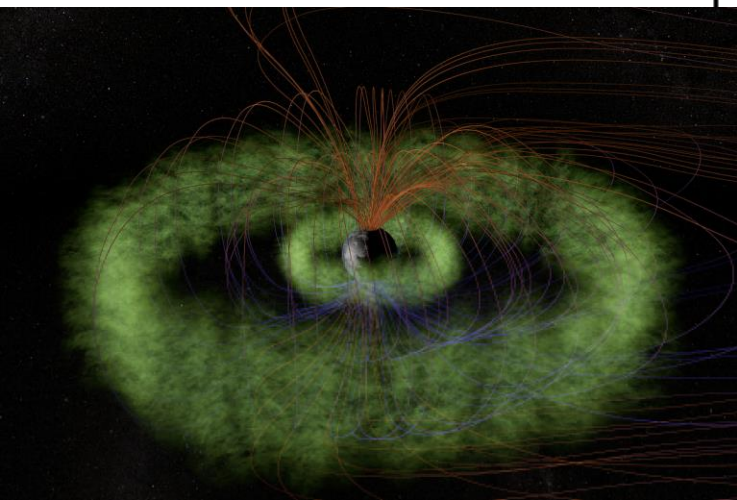
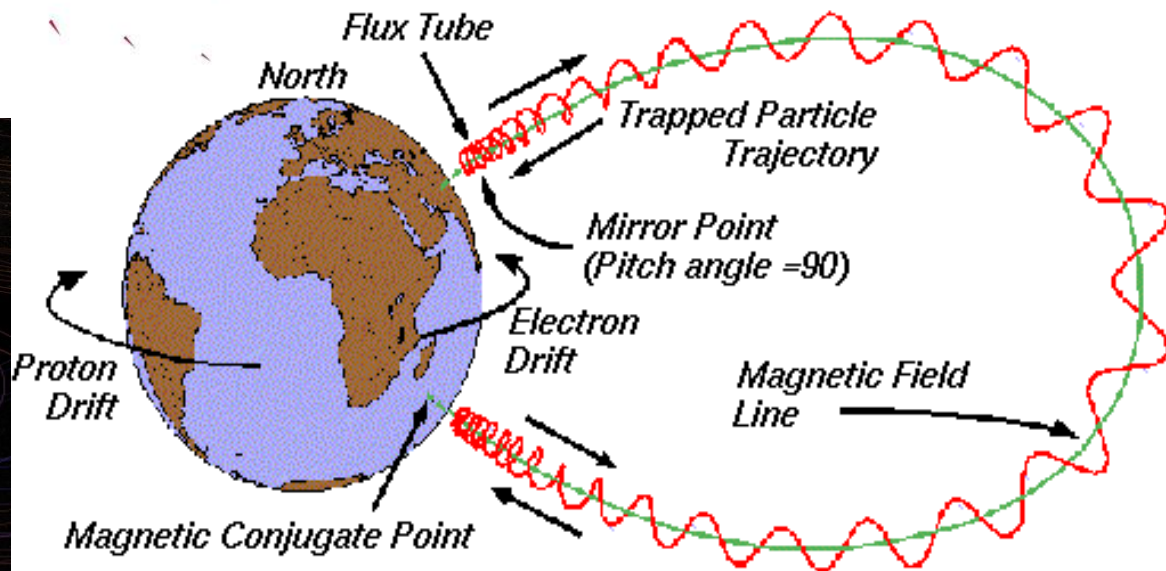
Inner Van Allen Belt  
(Protons)

New Belt  
(Interstellar Matter)



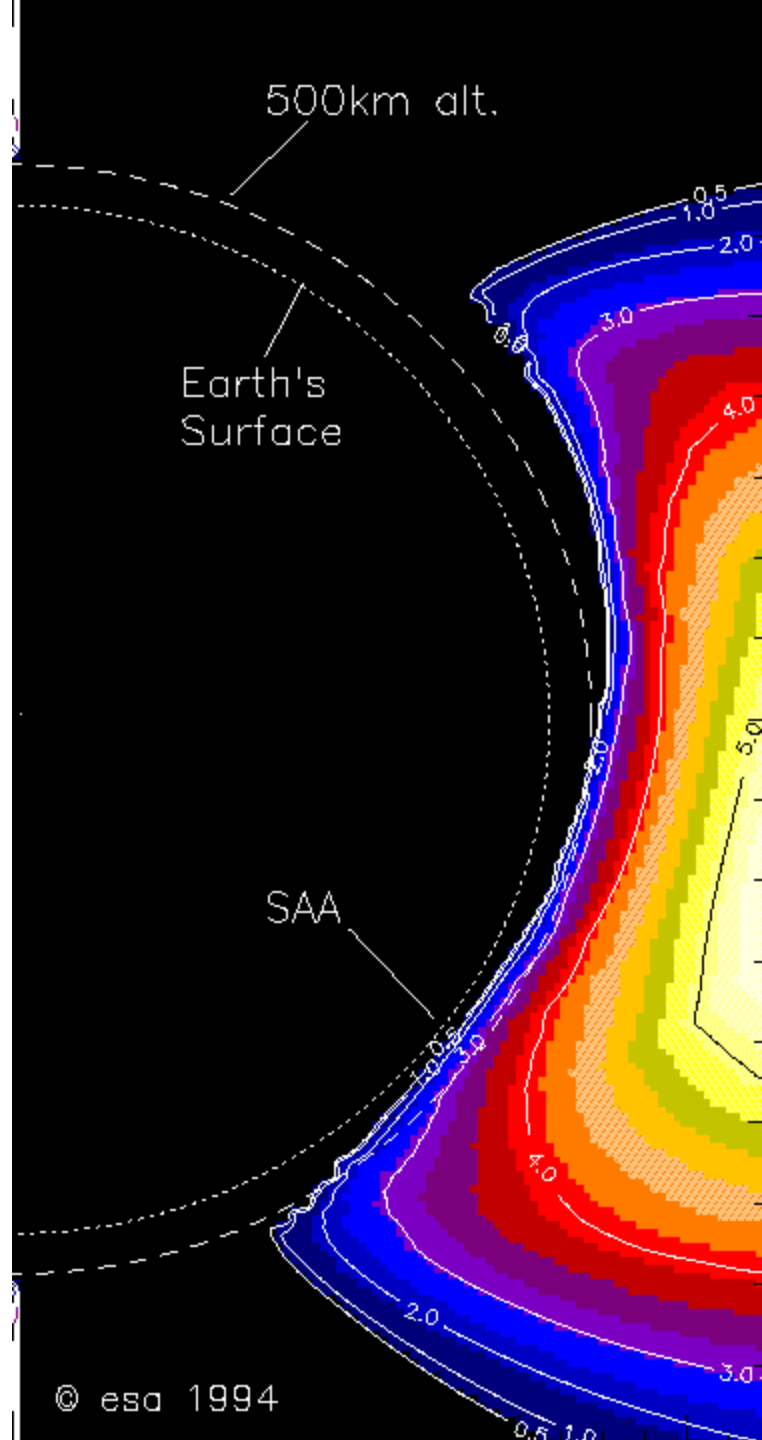
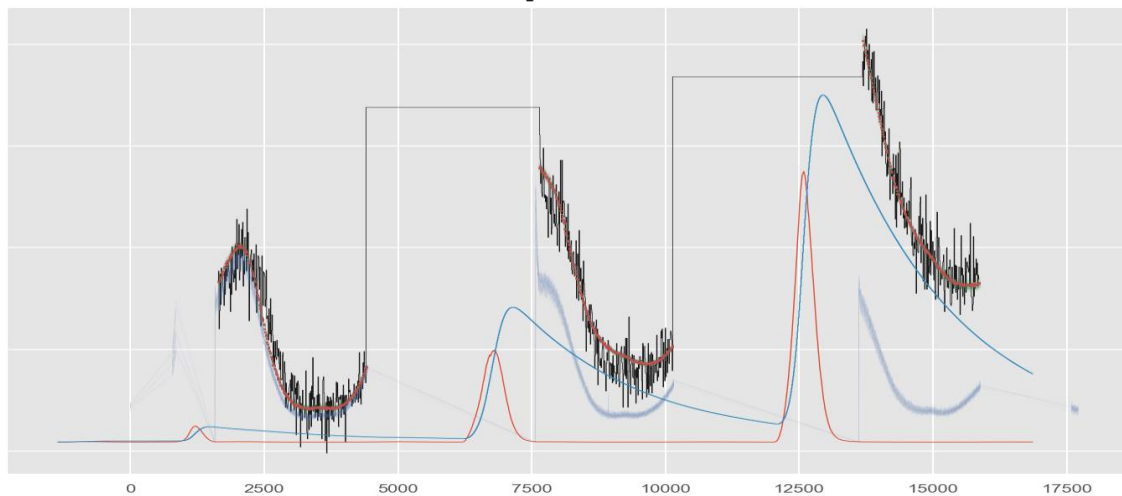
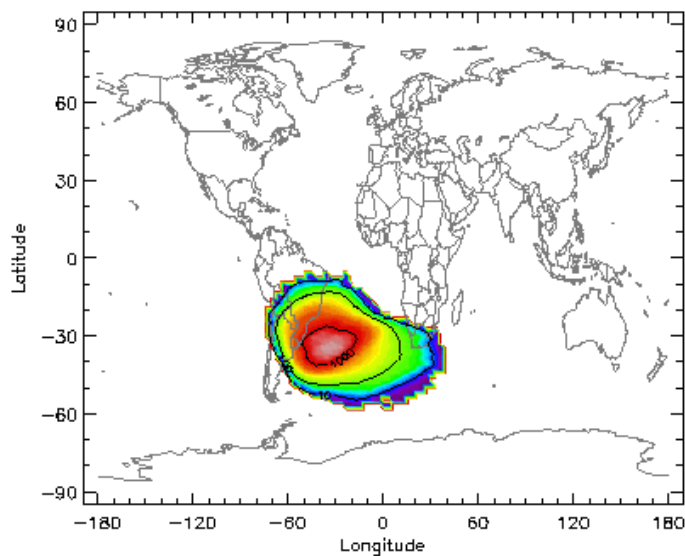
- Diagram of the particle path in the Van Allen radiation belts

Components of Particle Motion: bounce, gyration and drift





# South Atlantic Anomaly (SAA)



# Space Weather Effects

- **Spacecraft electronics**
  - causes an erroneous signal
  - spacecraft activation and charging.
- **Spacecraft orbit changes**
  - instantaneous heating and **expansion** of atmosphere → a sudden drag that lowers satellites' orbits
- **Humans in space**
- **weather; communication; .....**





# Summary

- Solar parts:
  - Solar wind
  - Solar flare
  - Coronal Mass Ejections

- **Magnetosphere:**
  - Bow shock
  - Magnetosheath
  - Magnetopause
  - Magnetotail
- **Aurora**
- **Van allen belt**
- **Influence to human life**