Solar Flares and Space Weather

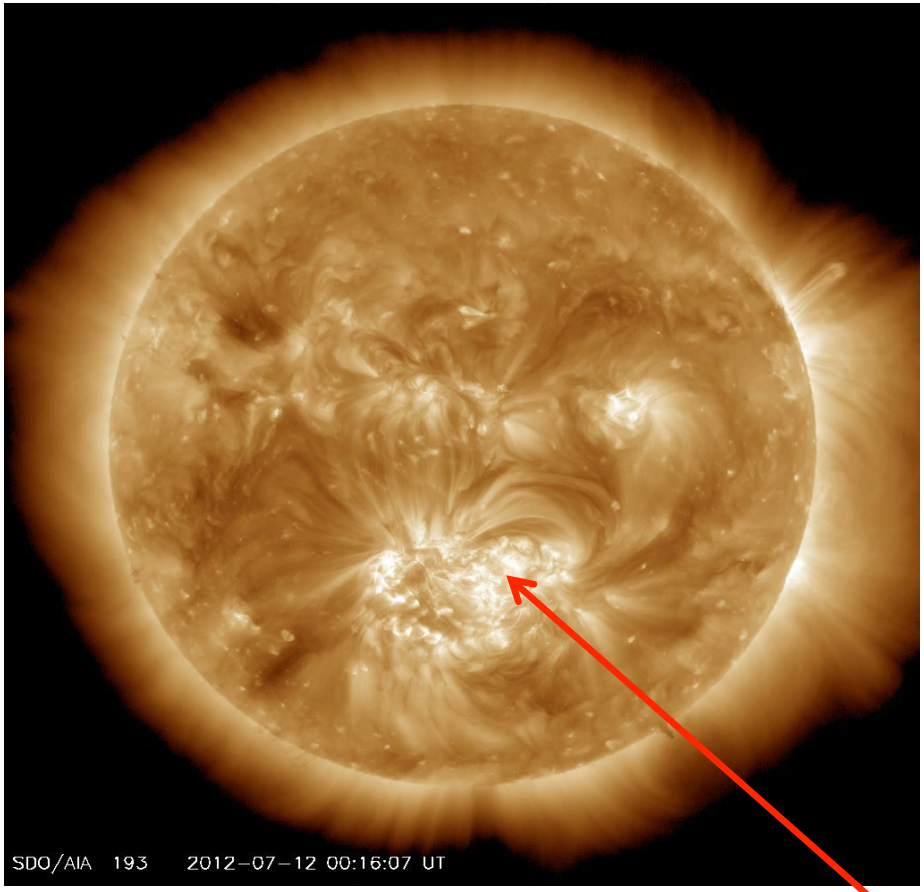
A. Taktakishvili

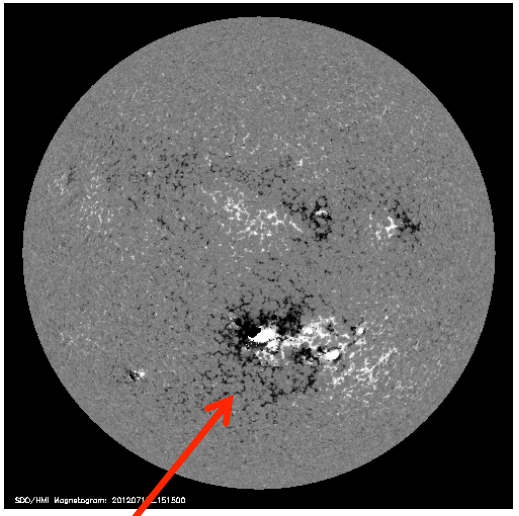
CCMC

NASA Goddard Space Flight Center

Solar Flare

2012, July 12 X1.4 class flare



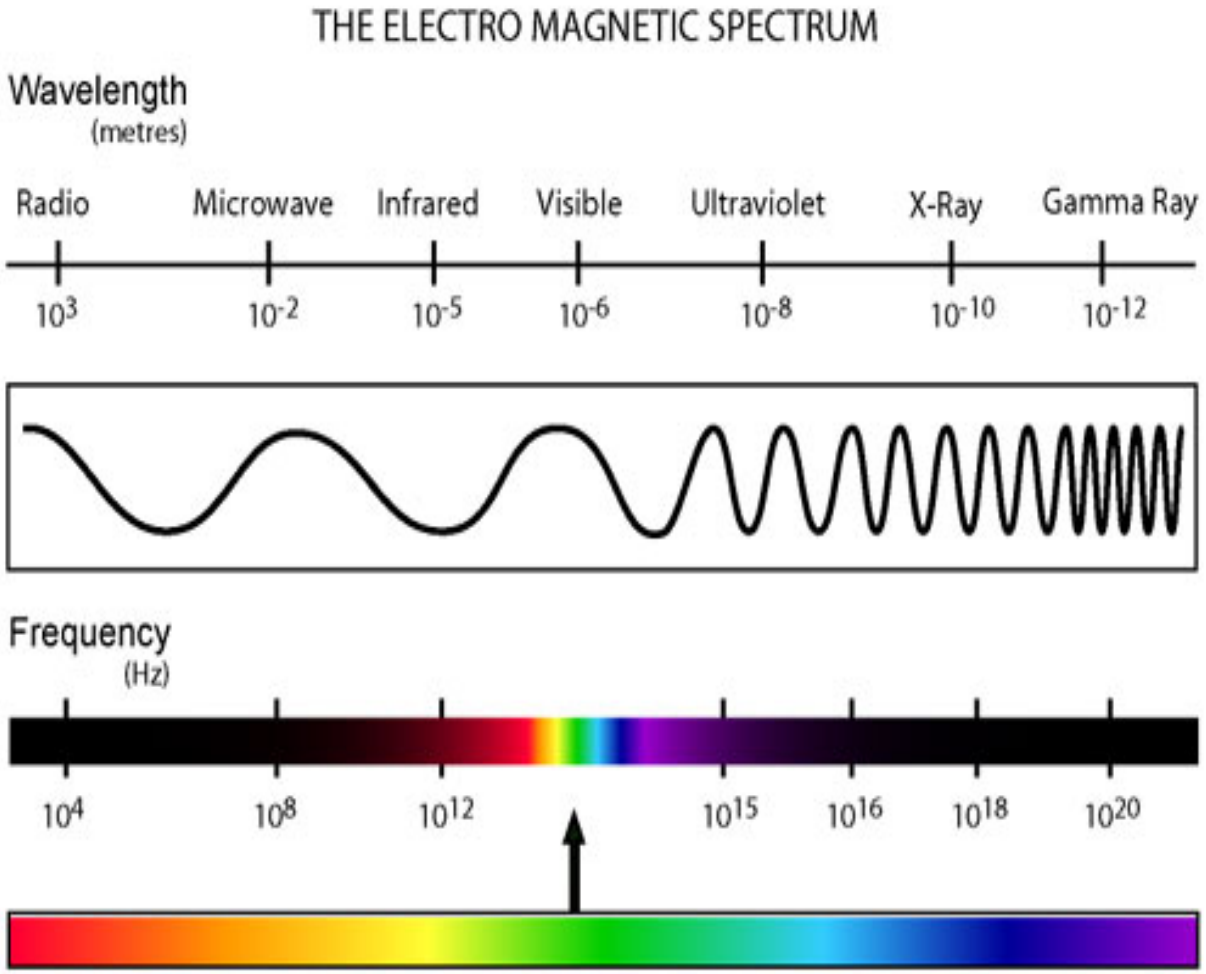


Magnetogram - magnetic map of the solar surface

EUV 19.3 nm

Active Region (AR)

A powerful solar flare radiates across the whole electromagnetic spectrum

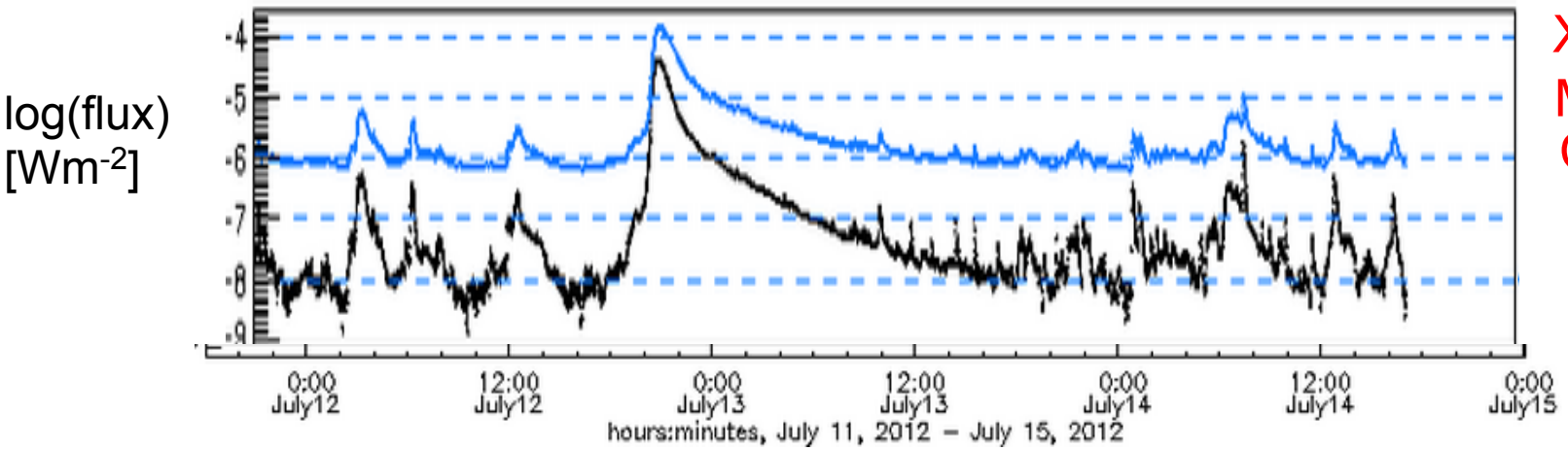


Solar Flare Class

0.1-0.8 nm

0.05-0.4 nm

2012 July 12 X1.4 class flare



X1.4 class: flux(0.1-0.8nm)[Wm^{-2}] = $1.4*10^{-4}$

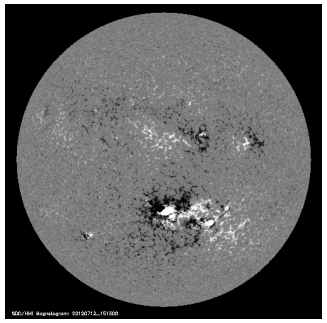
Quick quiz

What is the flare class if

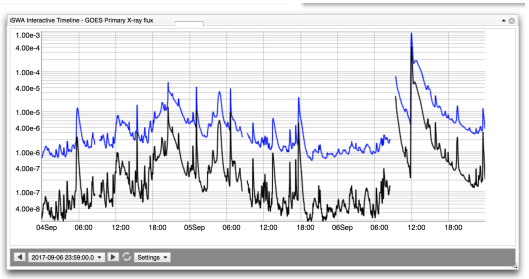
flux(0.1-0.8nm) = $7.8*10^{-5}$ Wm^{-2} ?

Flare Characteristics

- The solar flares occur in active regions, with the strong magnetic field concentration.



- Time scales: few minutes to few hours.



- Energy released ~ 10^{25} J

Annual World energy consumption ~ 10^{20} J

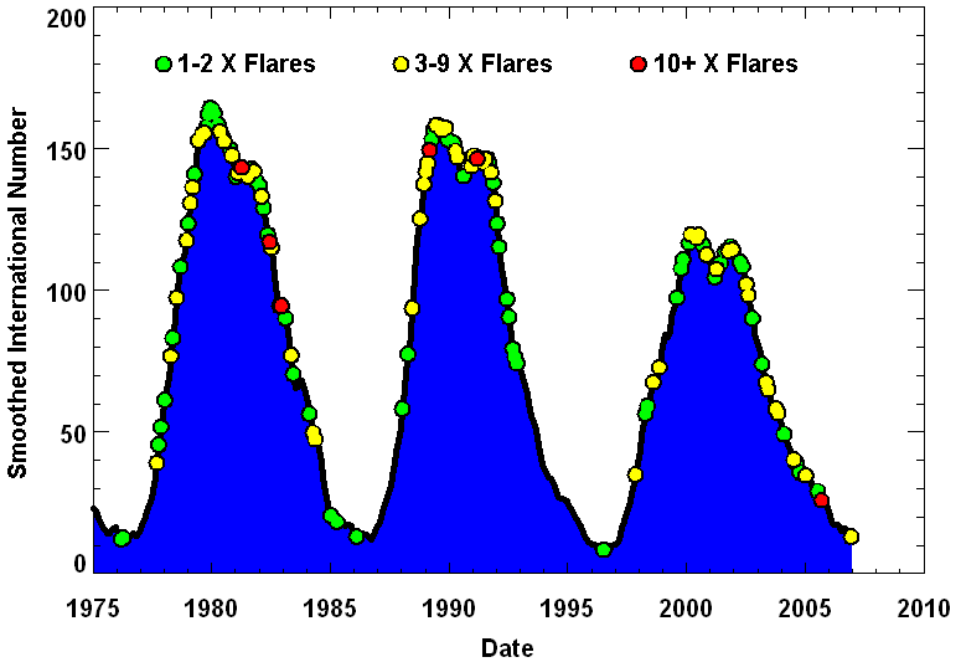
Flare Characteristics

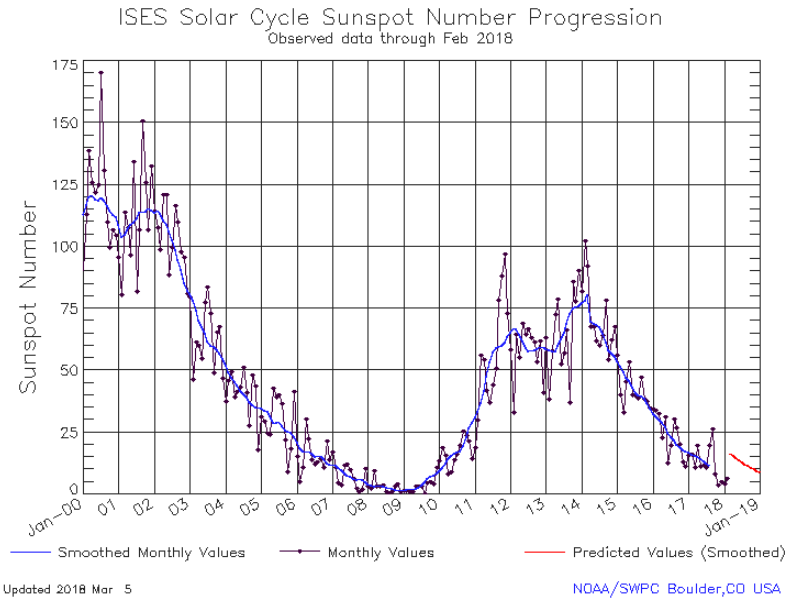
- Flares tend to occur in isolation, localized in space and time but with strong correlations.

- Typically one active region will produce dozens of flares, especially during periods of magnetic flux emergence (often near the beginning of the lifetime of a given region, but not always).

Flares over the Solar cycle

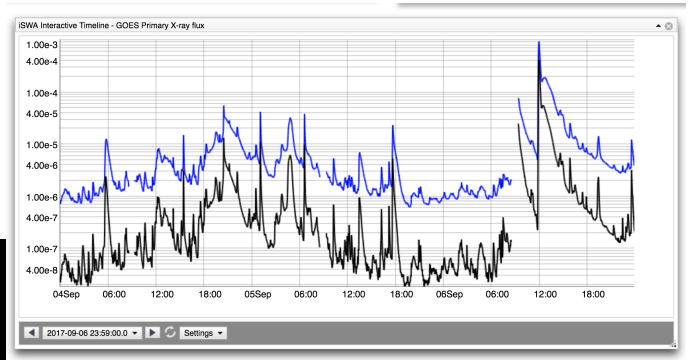
Solar flares have been monitored by x-ray detectors on GOES satellites since 1976. The number of X-Class flares per month increases with the number of sunspots but **big flares can occur anytime sunspots are present**.





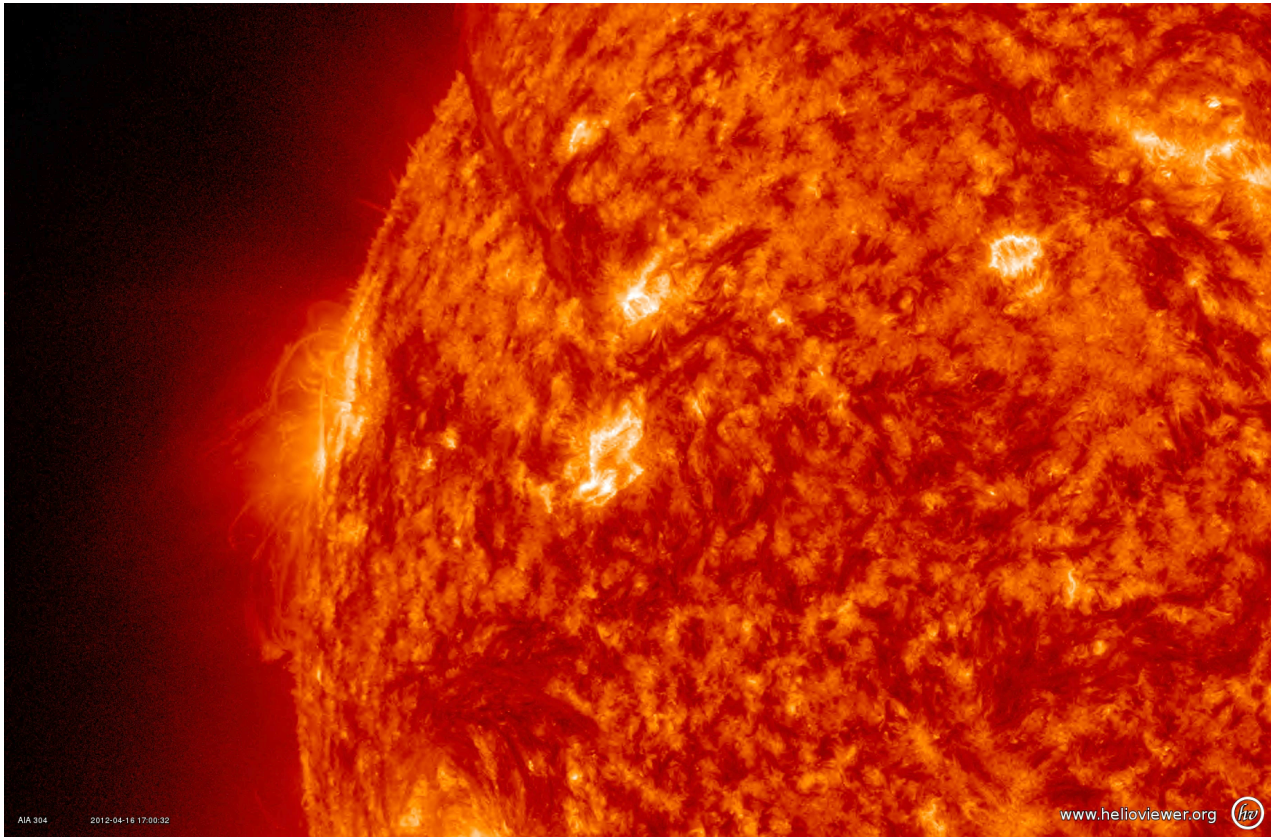
September 4 – 6, 2017 flares

13.1 and 19.3 nm



Flares and Coronal Mass Ejections

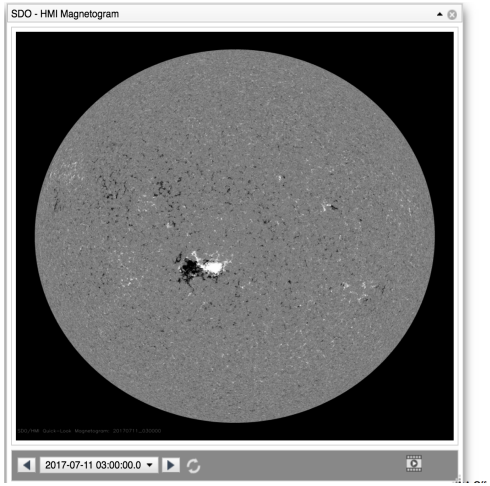
Powerful flares are often accompanied by CMEs in the active regions.



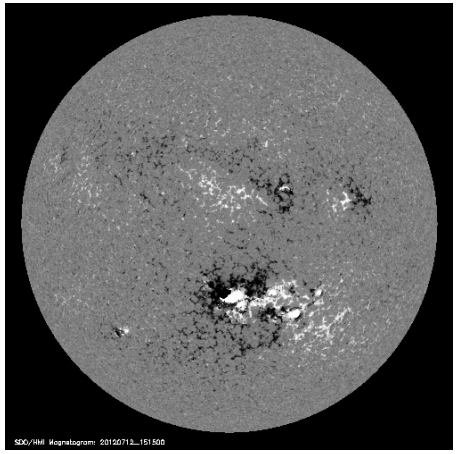
Quick quiz

What do you think is causing solar flare?

Physical Mechanism behind the Solar Flares

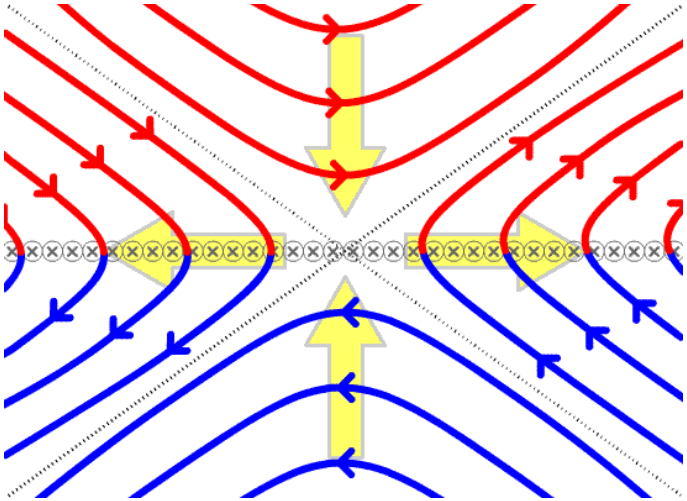


Active Region with simple magnetic configuration



Active Region with complex magnetic configuration

Magnetic Reconnection – the release of free magnetic energy, transformed to heat and particle acceleration



Flare: Space Weather impacts

Affect radio communications, GPS, directly by its radio noises at different wavelengths

Flare: Space Weather impacts - cont.

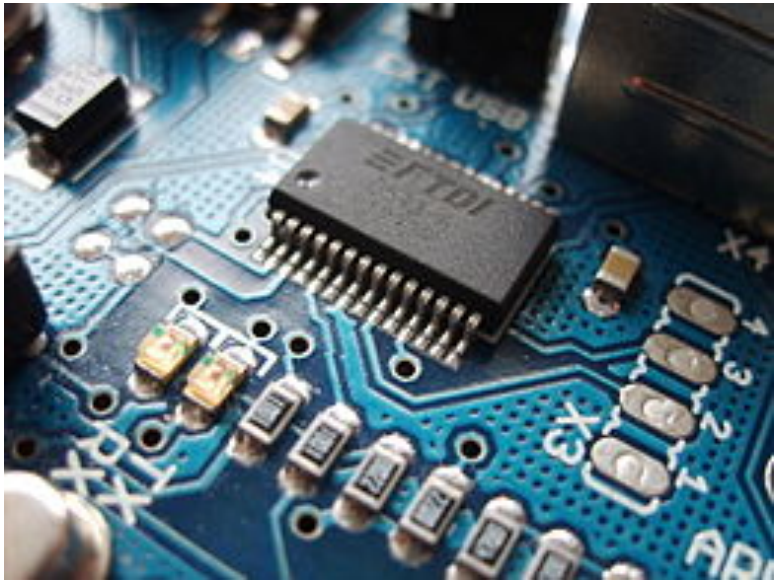
- Cause disruptions/radio blackout through changing the structures/composition of the ionosphere (sudden ionospheric disturbances) – X- ray and EUV emissions

Flare: Space Weather impacts - cont.

X-ray and EUV energy deposition would cause heating of the atmosphere and it's expansion enhancing drag forces to low orbit satellites – ISS descends more than ~ 300 m/day when this happens

Flare: Space Weather impacts - cont.

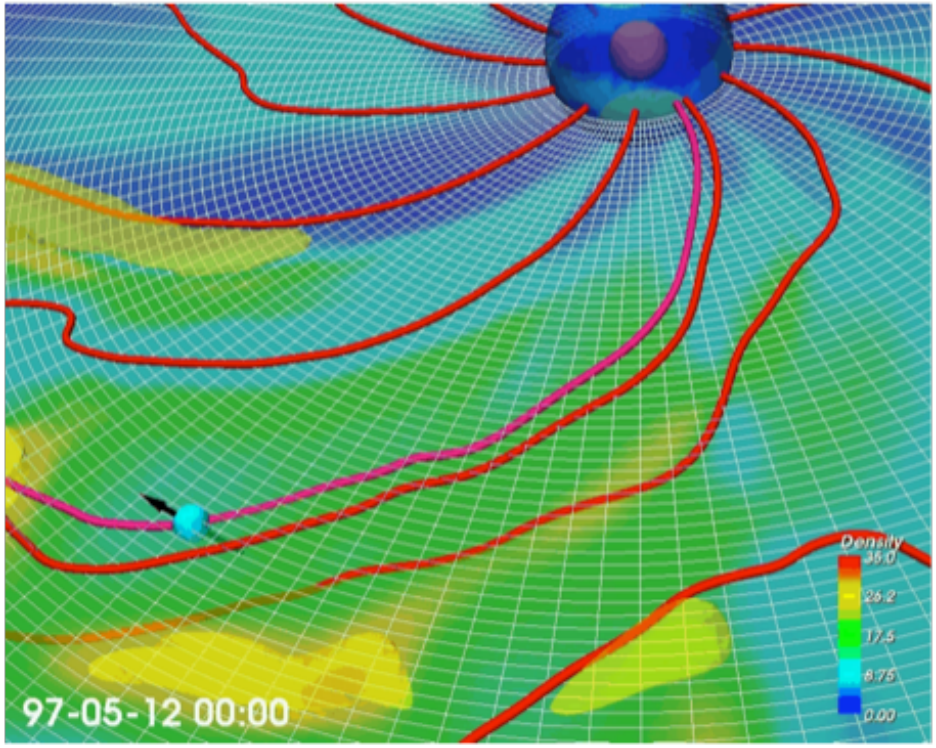
Energy in the form of hard x-rays can be damaging to spacecraft electronics



Flare: Space Weather impacts - cont.

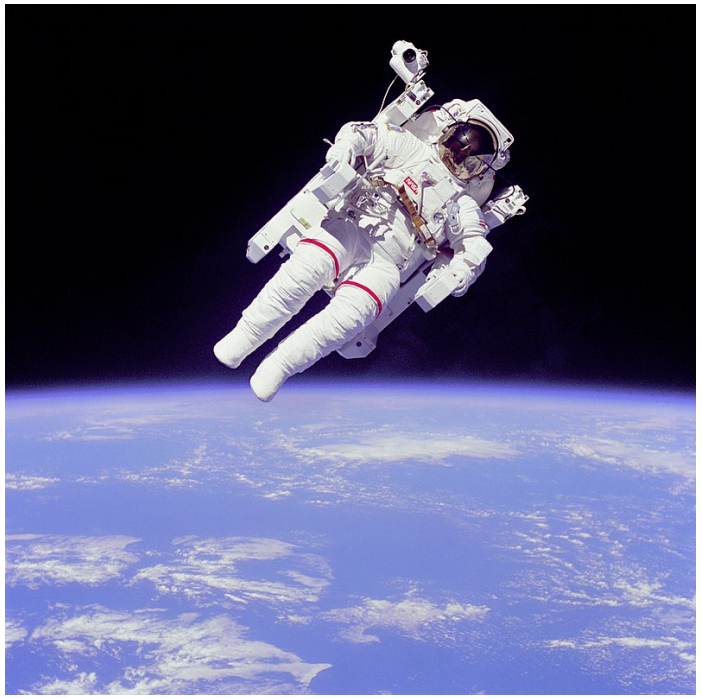
Contribute to Solar Energetic Particles (SEP) – proton radiation

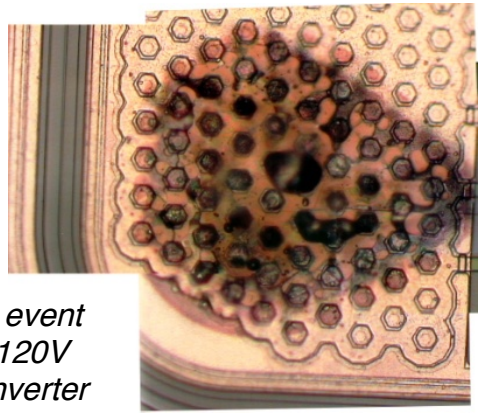
The interplanetary space permeated with Sun's magnetic field. Accelerated charged particles move along the interplanetary magnetic field lines and can reach planet or satellite if the active region is properly connected



Flare: Space Weather impacts - cont.

SEPs can impact the Earth's magnetosphere and present radiation hazards for astronauts and spacecraft.





Destructive event in a COTS 120V DC-DC Converter

A measureable effect in a circuit caused by single incident ion with E > 10 MeV

The END.