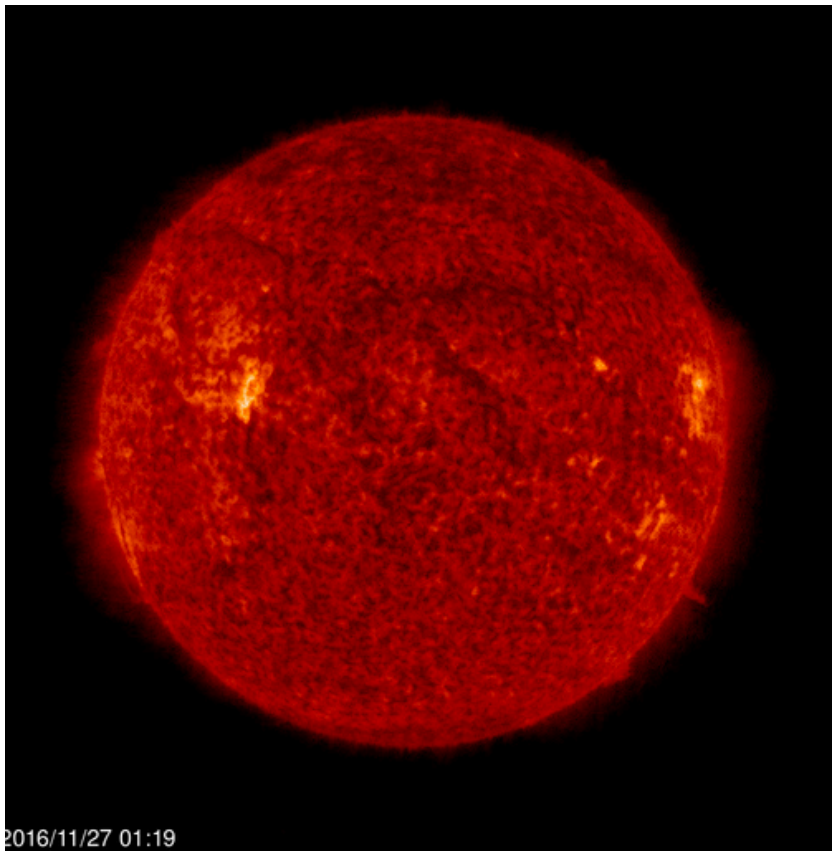
[23] Solar Activity (11/21/17)

Upcoming Items

1. Homework #11 due Nov 30.
2. Read Ch. 5.4 & 13.1–13.2 by next class and do the self-study quizzes.
   Especially read "Mathematical Insight" 13.1 and 13.2 in book

SOHO 11/27/16

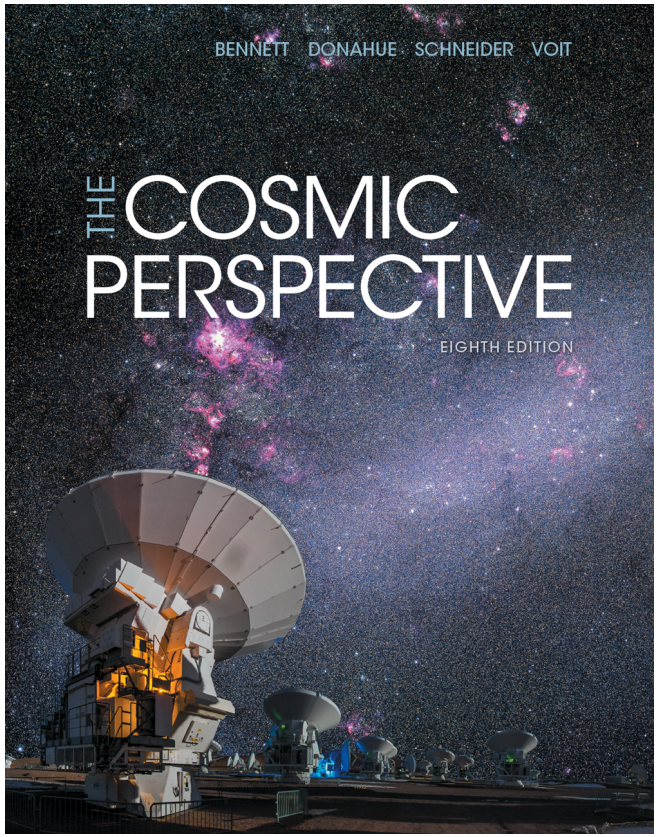


LEARNING GOALS

Ch. 14.3

By the end of this lecture, you should be able to…

- *… provide at least 3 pieces of evidence that solar activity is related to magnetic fields;*
- *… discuss which types of solar activity could affect the Earth, and how;*



Any astro questions?

Consider the following facts about the Sun:

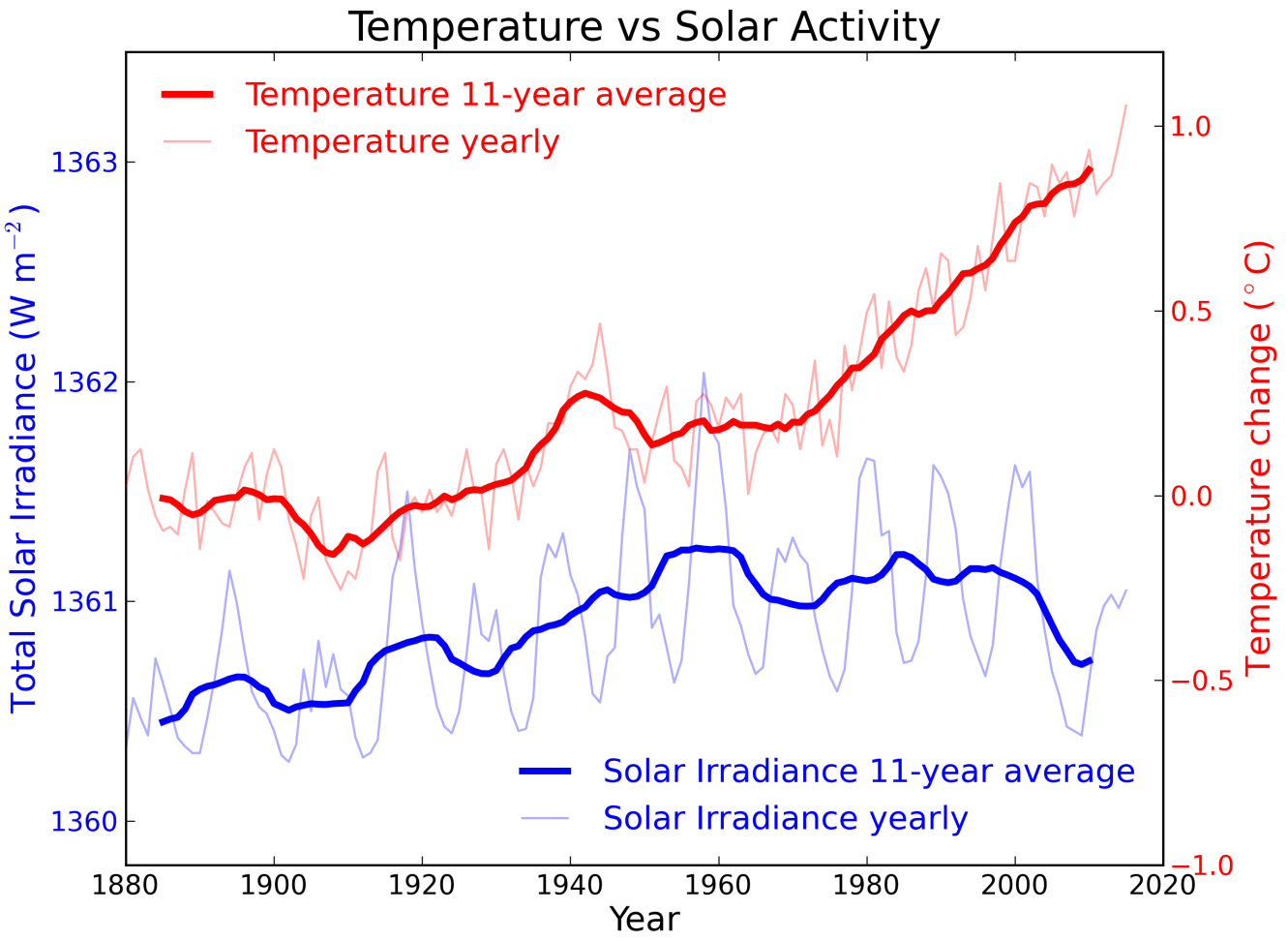
- Spectra of sunspots show the Zeeman effect.
- Solar prominences are arcs of ionized gas.
- Sunspots are cooler than the surrounding photosphere.
- Granules have typical lifetimes of about 10 minutes.
- Solar flares emit bursts of X rays.

How many of these suggest solar activity is related to magnetic fields?

Vote: A = 1, B = 2, C = 3, D = 4, E = 5.

If a CME encounters Earth, all of the following are possible, EXCEPT

A. Especially strong aurorae will be visible to low latitudes.
B. There will be a sharp rise in the neutrino flux detected.
C. Electrical power grids on Earth will be disrupted.
D. Satellites in orbit will be damaged.
E. Astronauts will need to take measures to protect themselves.

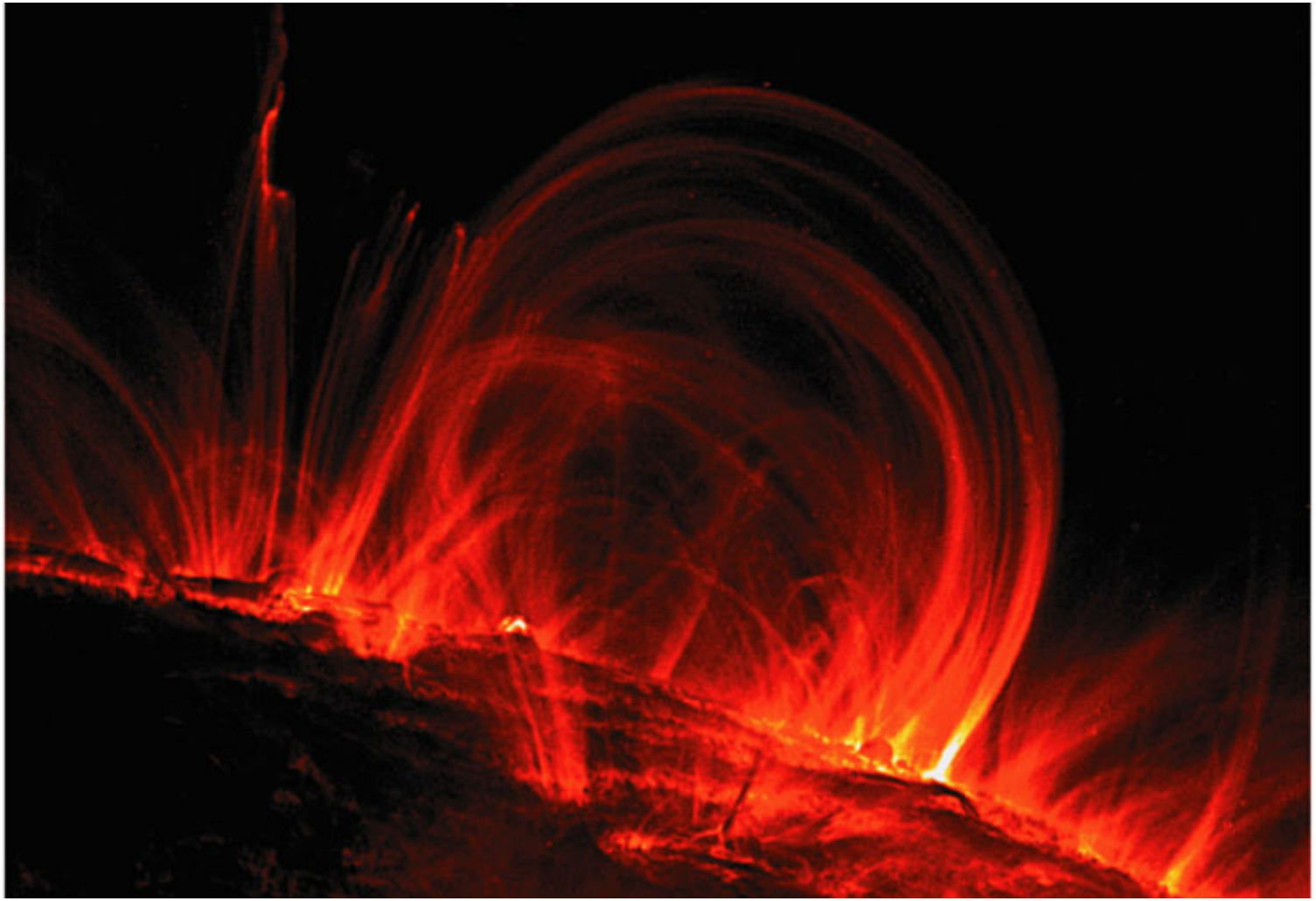


Group discussion: how could you use this data to convince someone that global warming is not due to solar activity?

Solar Activity

- Solar activity includes sunspots, solar prominences, solar flares, and coronal mass ejections (CMEs).
- Flares and CMEs are hazardous to astronauts, spacecraft/satellites, and power grids on Earth.
- Solar activity is related to the Sun's powerful magnetic field. The 11-year solar cycle may be due to the Sun's differential rotation winding up the field lines.

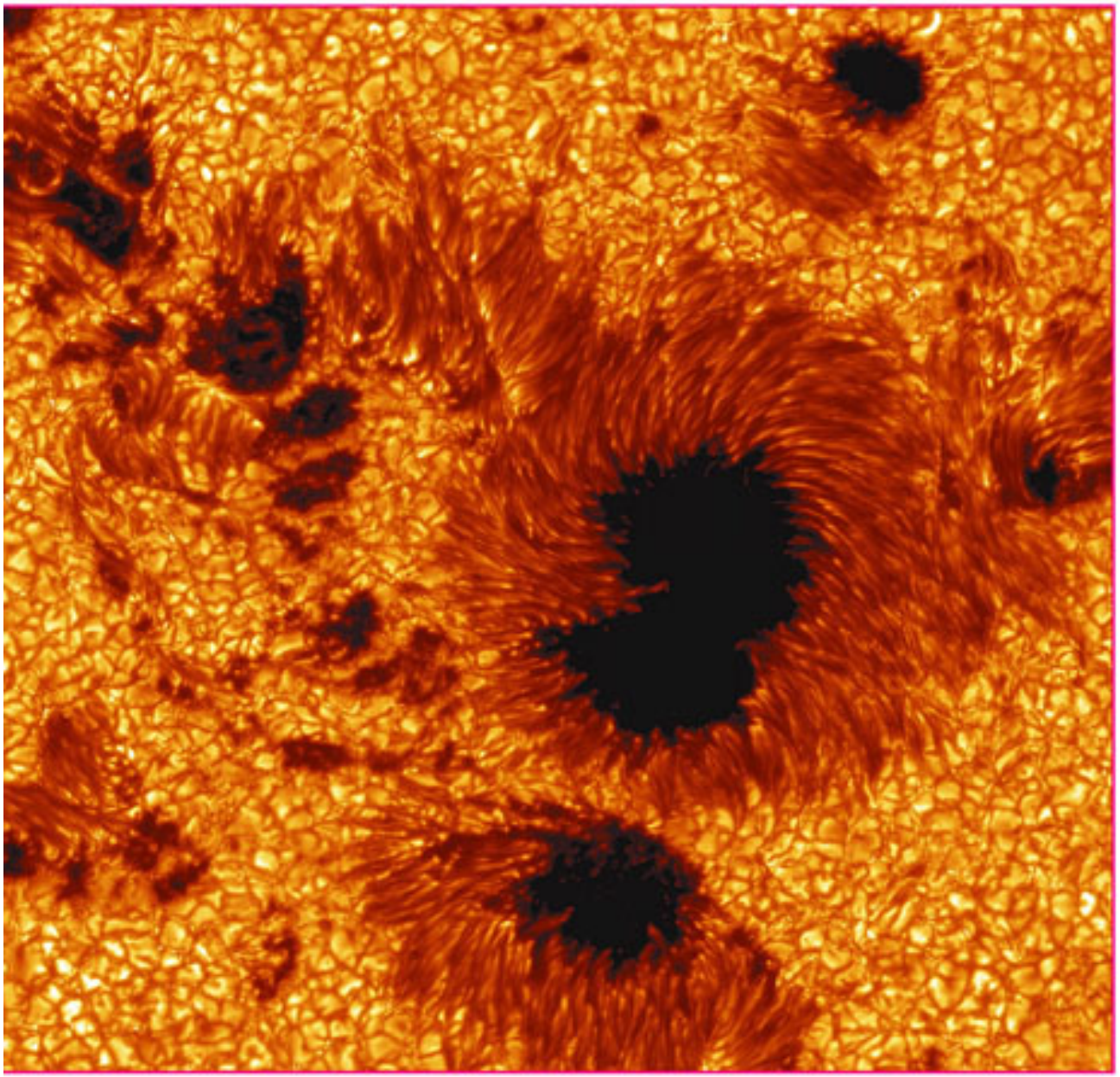
What causes solar activity?



Solar activity is like “weather”…

- Sunspots.
- Solar prominences.
- Solar flares.
- Coronal mass ejections.

All are related to magnetic fields...



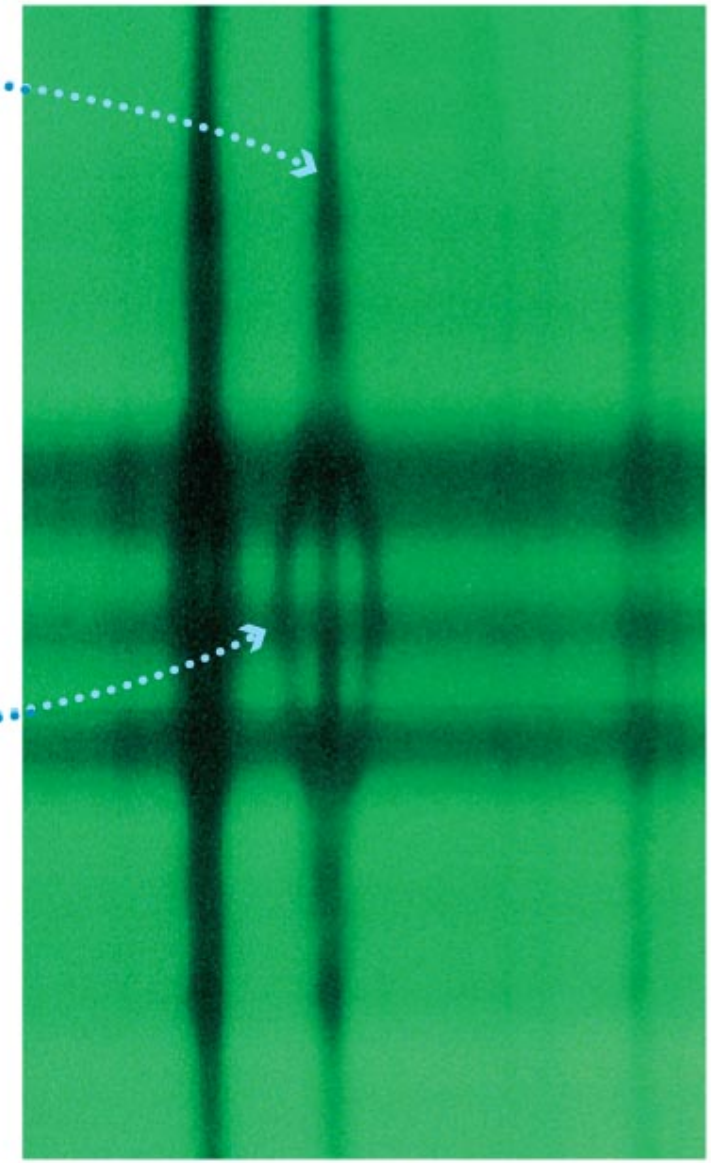
Sunspots:

Cooler than other parts of the Sun's surface (4,000 K).

Regions with strong magnetic fields.

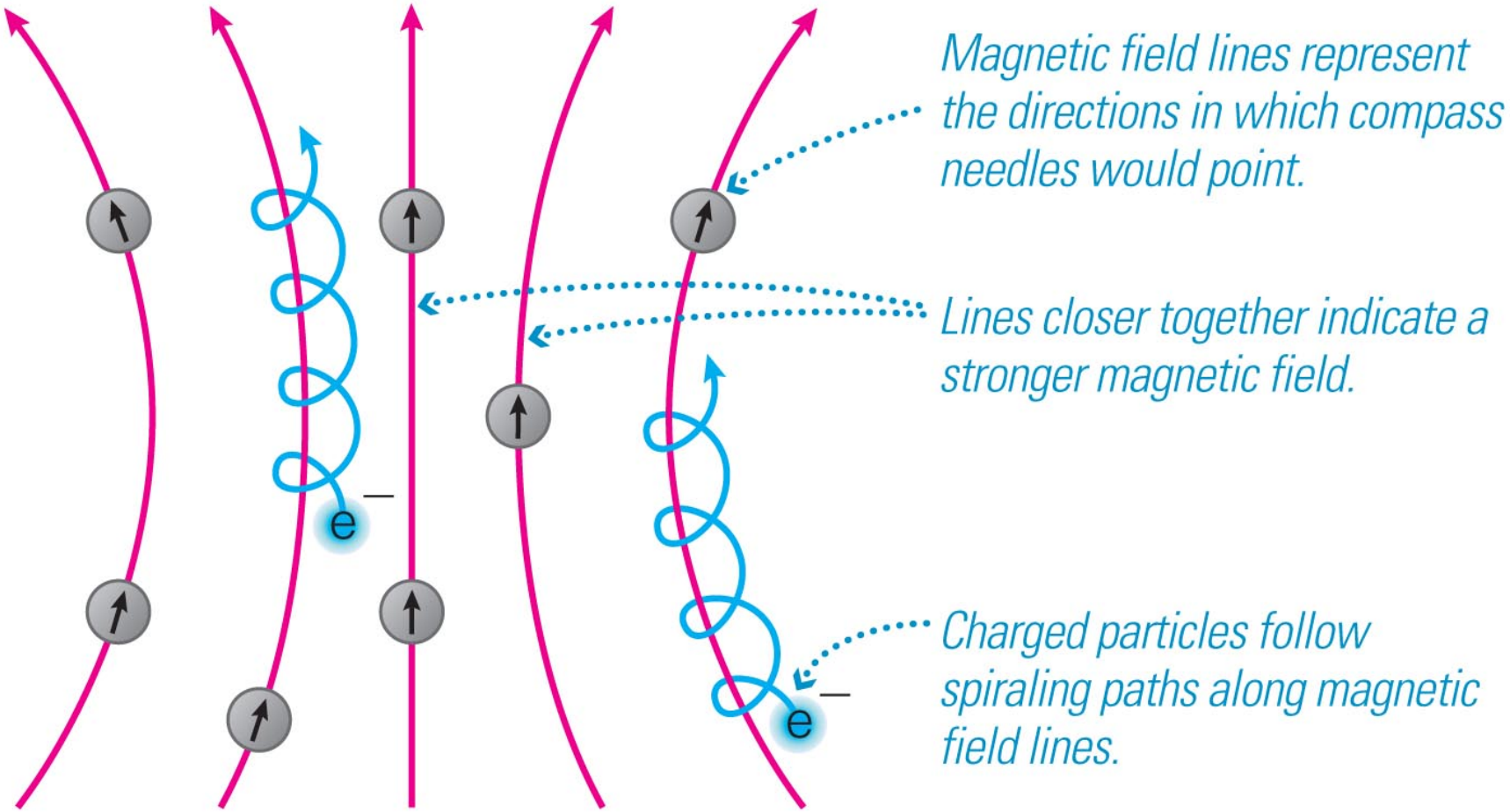
Why are sunspots cool?

- Short answer: they suppress convection by preventing the circulation of gas
  Why would that make sunspots relatively cool?
- How do they do that? In sunspots, the magnetic field strength is large enough to resist gas motion
- In the problem set, you will work out some details

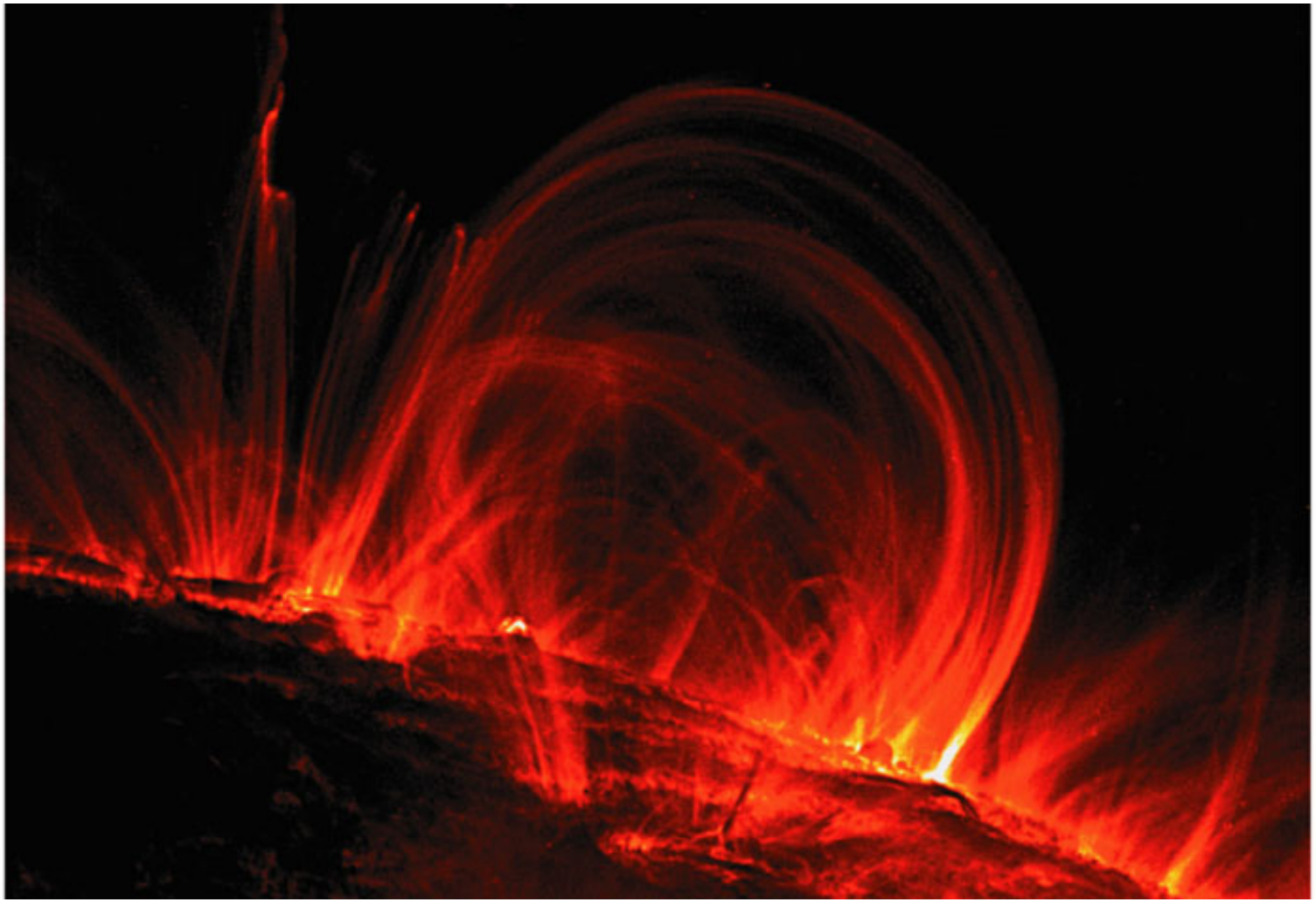


Zeeman Effect:

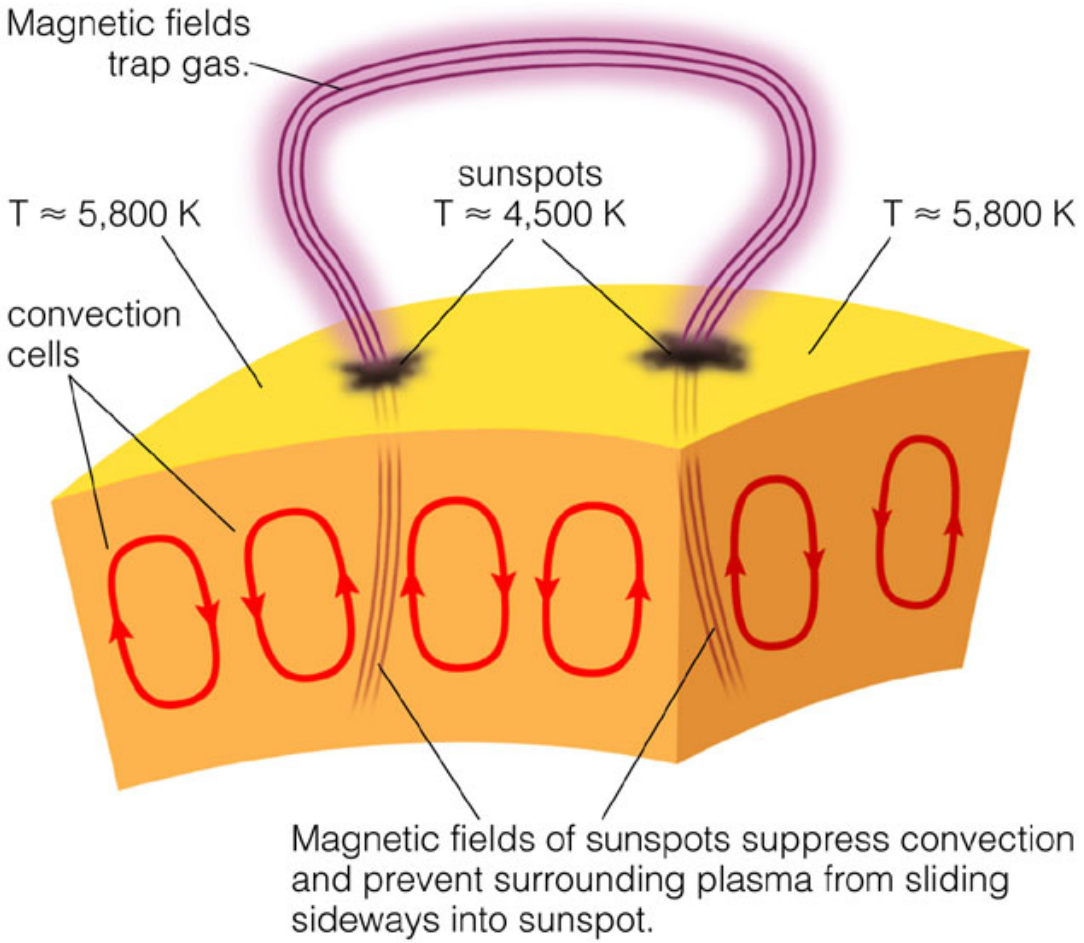
We can measure magnetic fields in sunspots by observing the splitting of spectral lines.



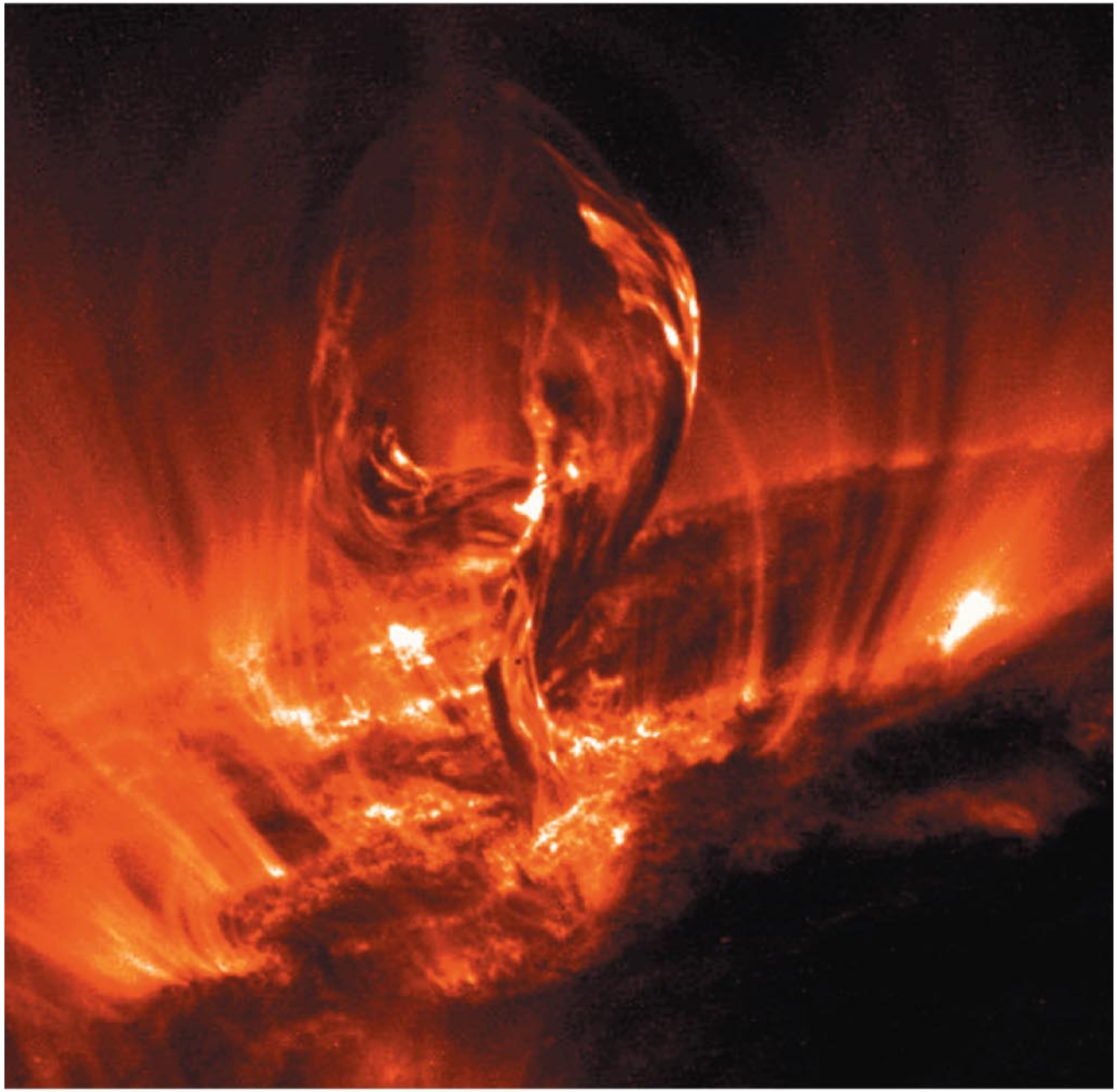
- Charged particles spiral along magnetic field lines.



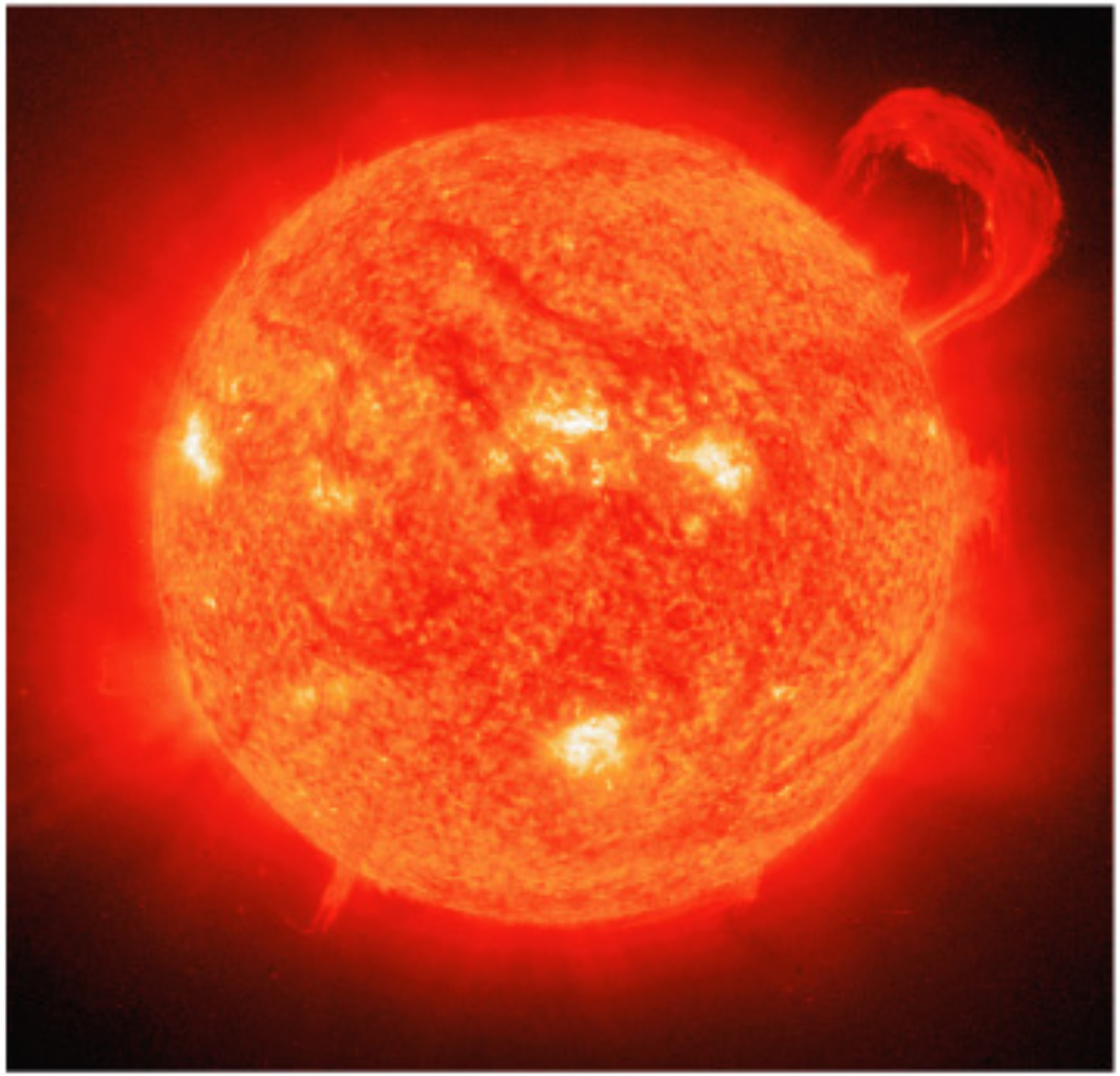
- Loops of bright gas often connect sunspot pairs (***prominence***).



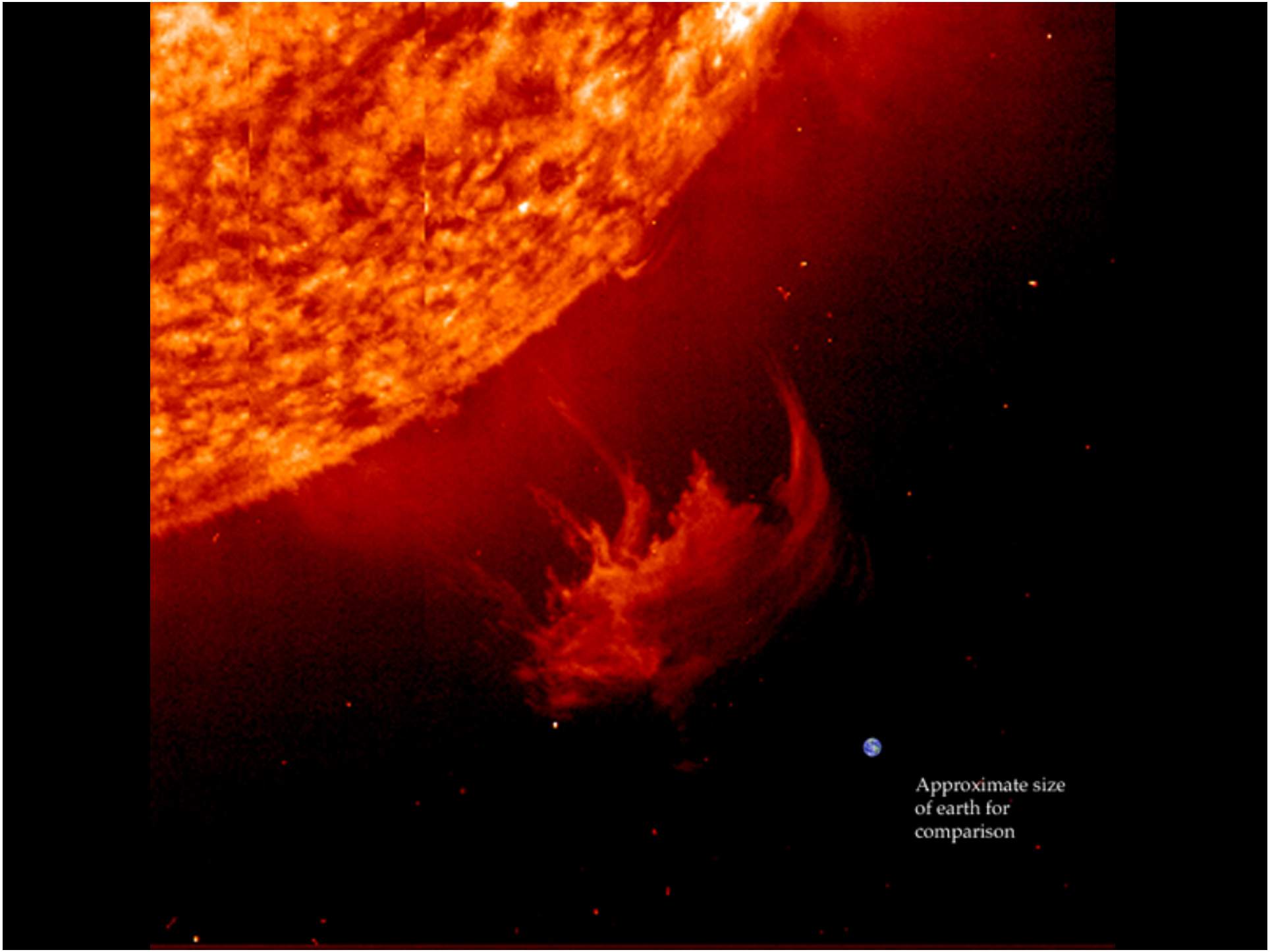
- Loops trace magnetic field lines.

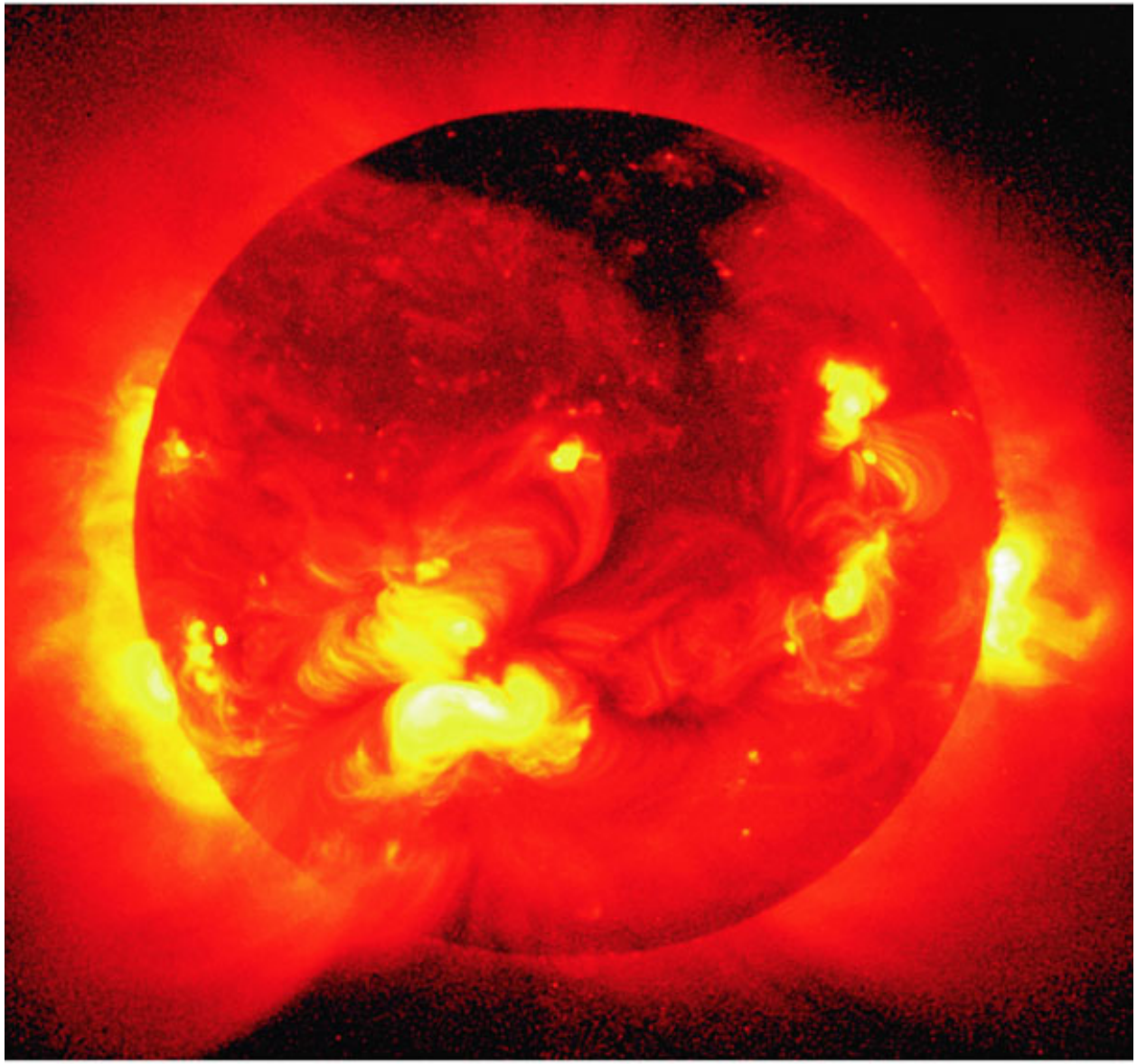


Magnetic activity causes ***solar flares*** that send bursts of X rays and charged particles into space.

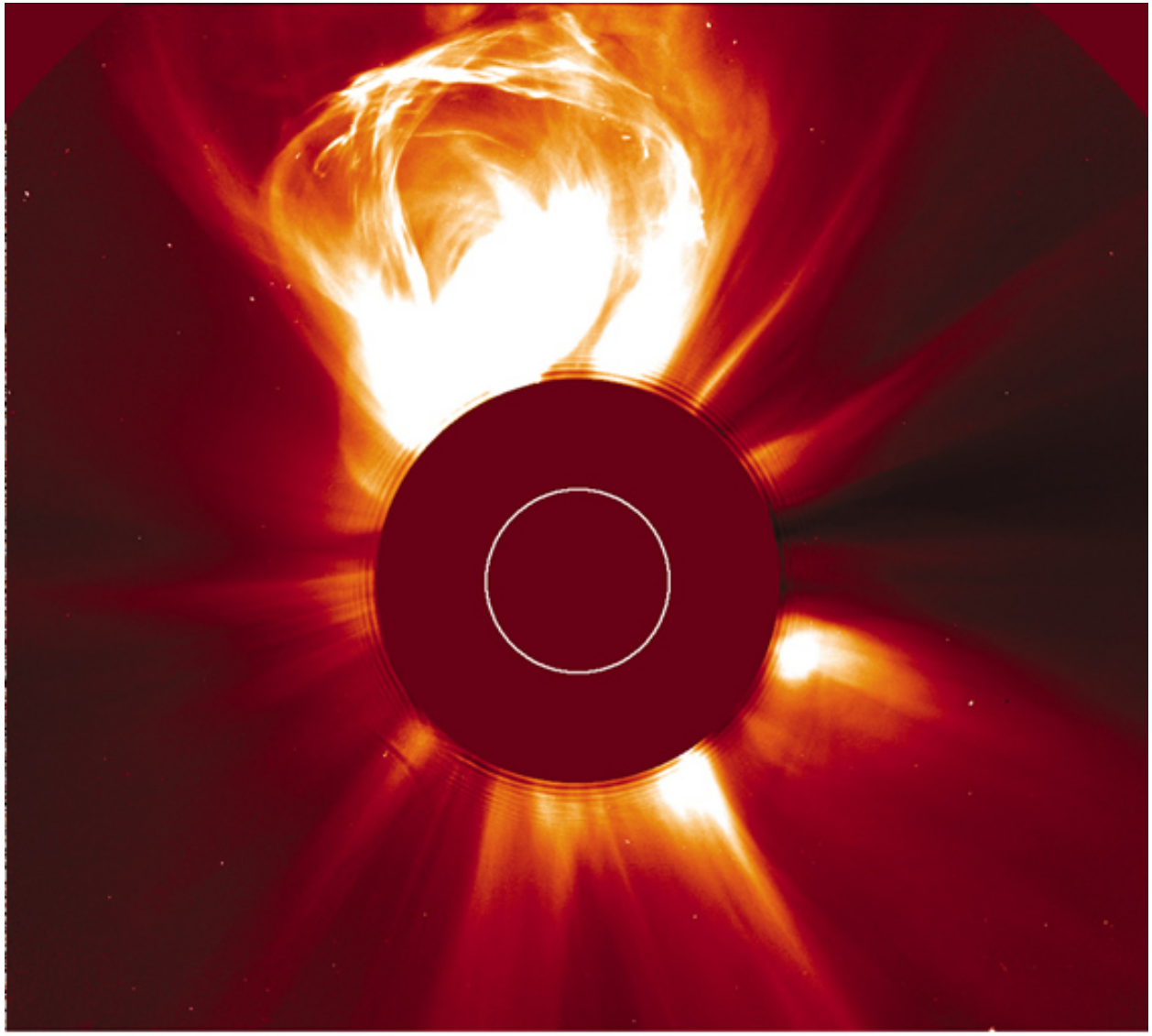


Magnetic activity also causes solar prominences to erupt high above the Sun's surface.


Approximate size
of earth for
comparison

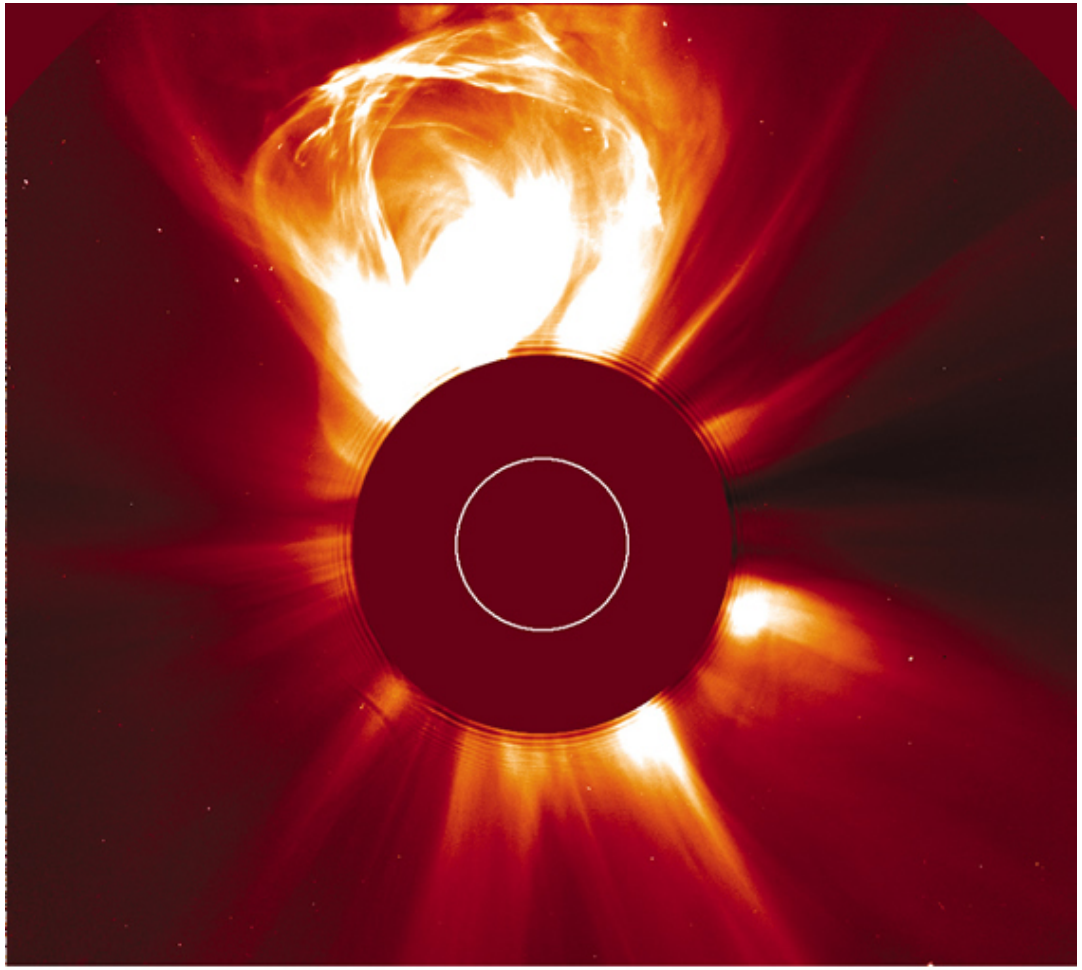


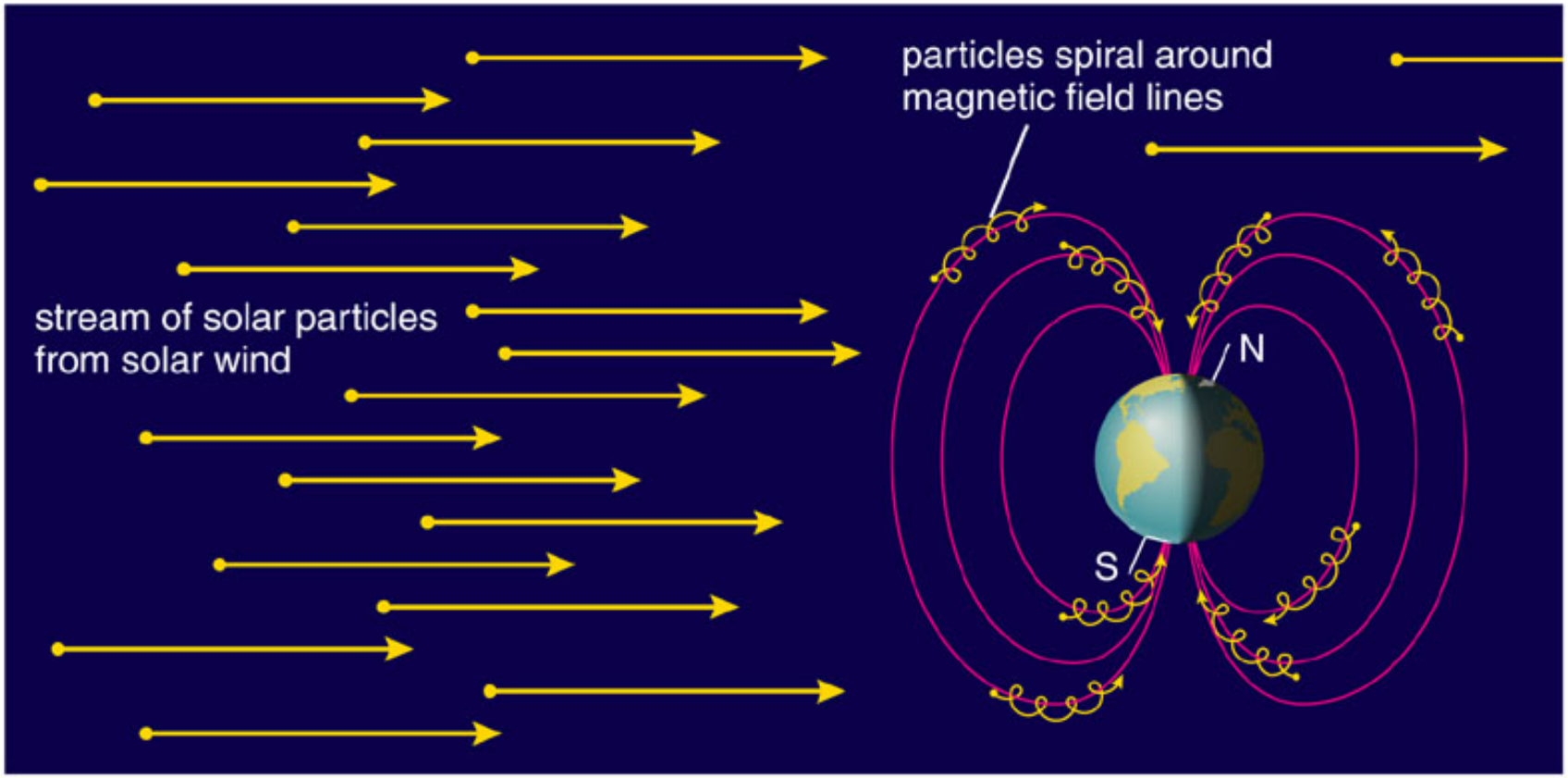
The corona appears bright in X-ray photos in places where magnetic fields trap hot gas.



- ***Coronal mass ejections*** send bursts of energetic charged particles out through the solar system.

How does solar activity affect humans?

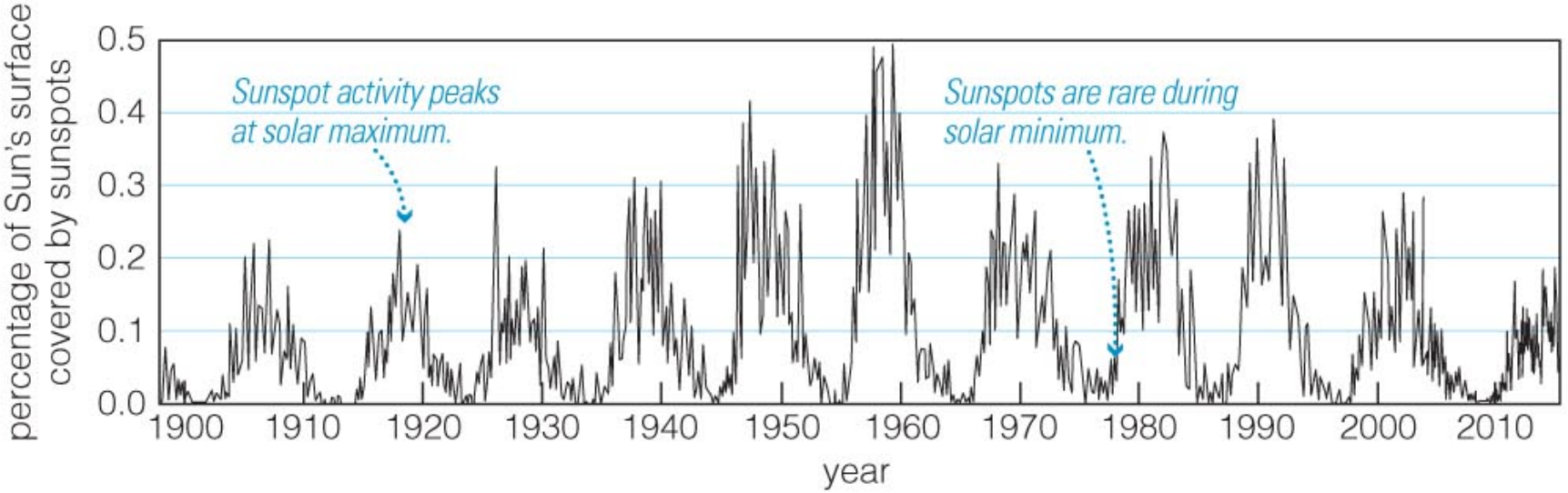




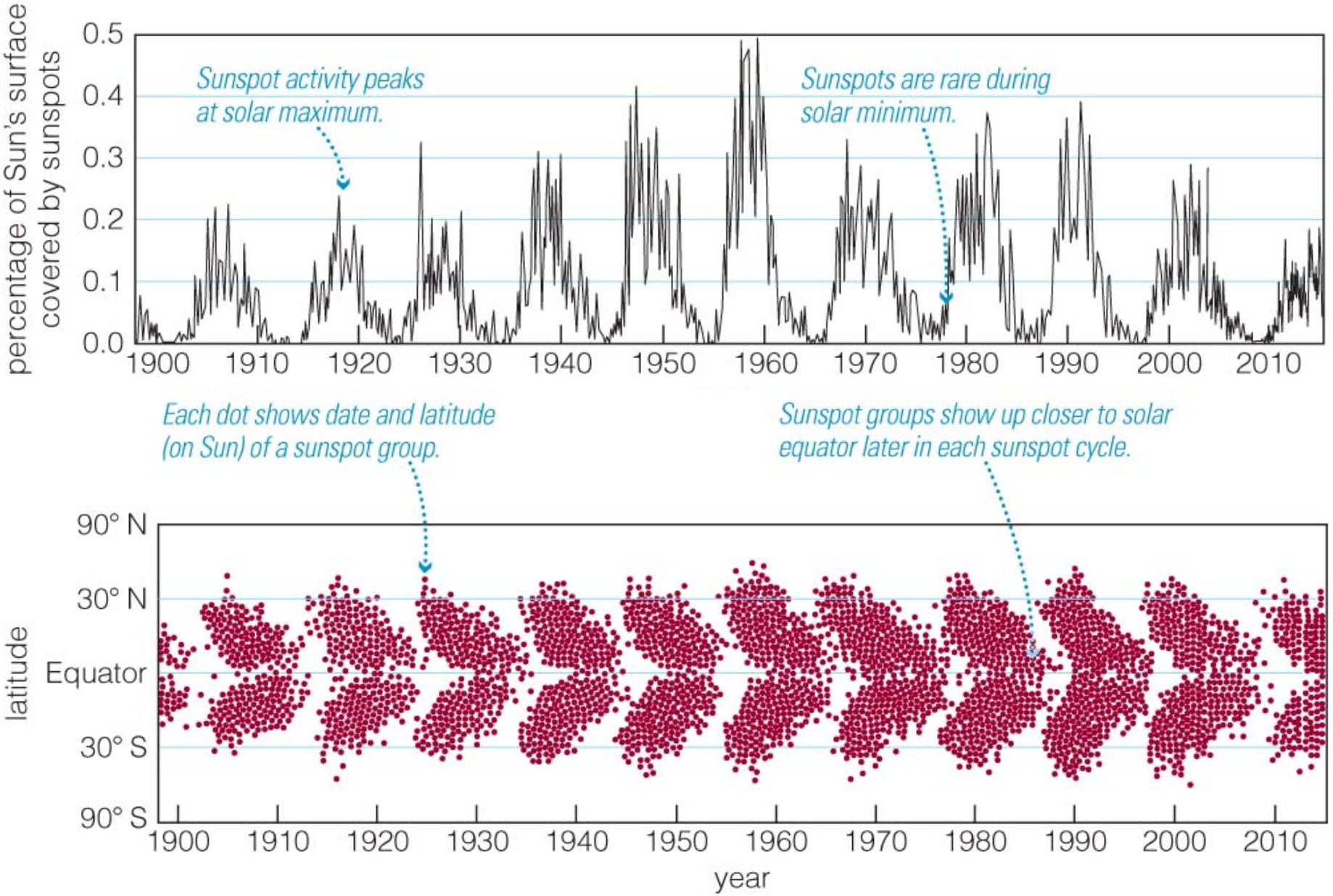
- Charged particles streaming from the Sun can disrupt electrical power grids and disable communications satellites.

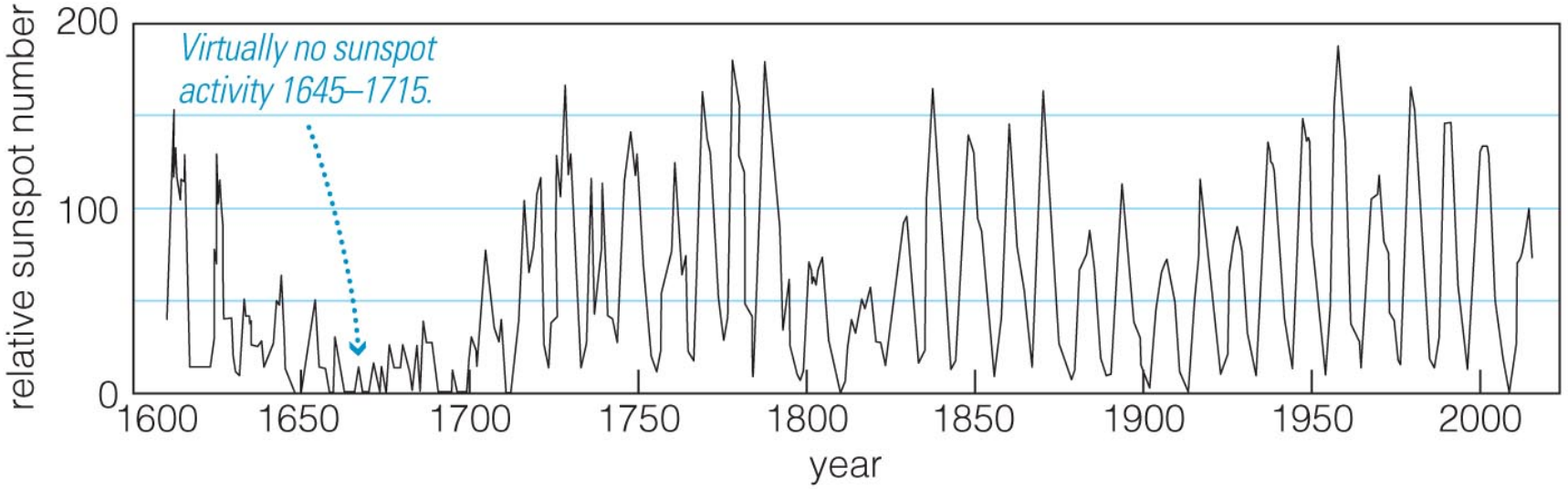
- Energetic particles high in Earth's atmosphere cause aurorae (e.g., Northern Lights).
- Energetic particles from solar flares can damage unprotected organic tissue.

How does solar activity vary with time?

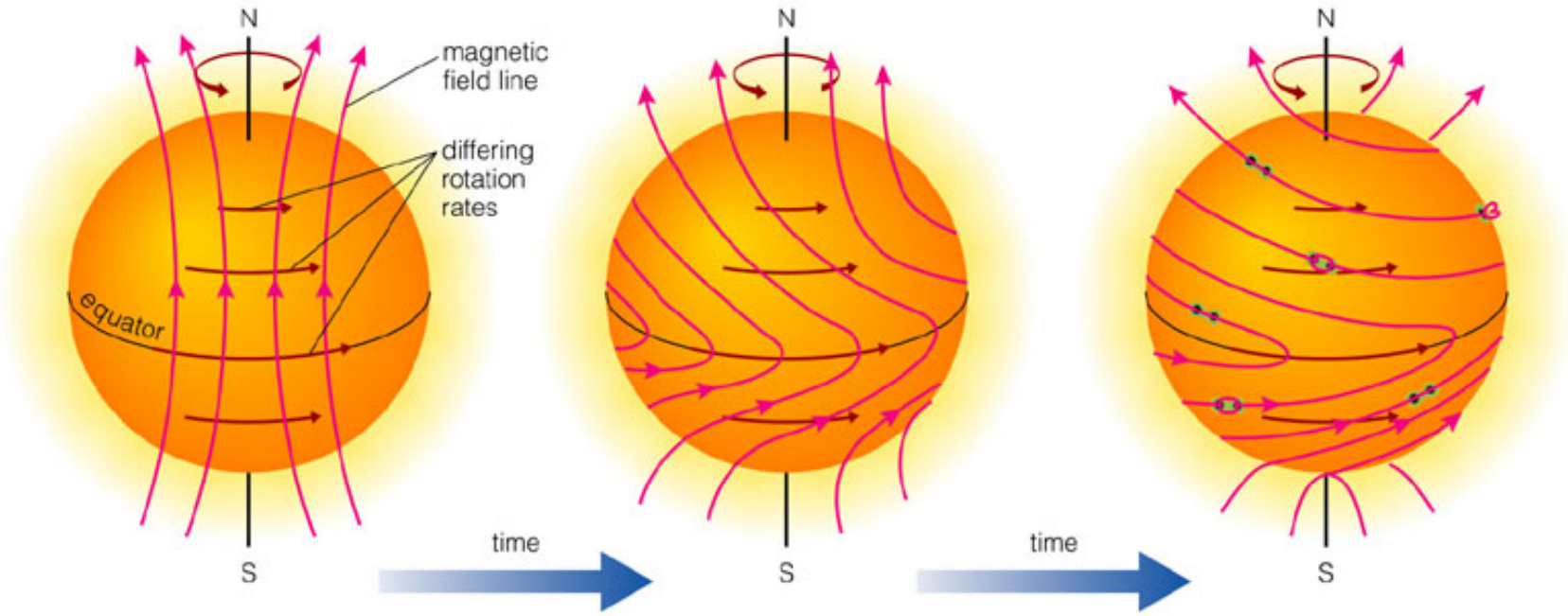


Number of sunspots rises and falls in 11-year cycle.



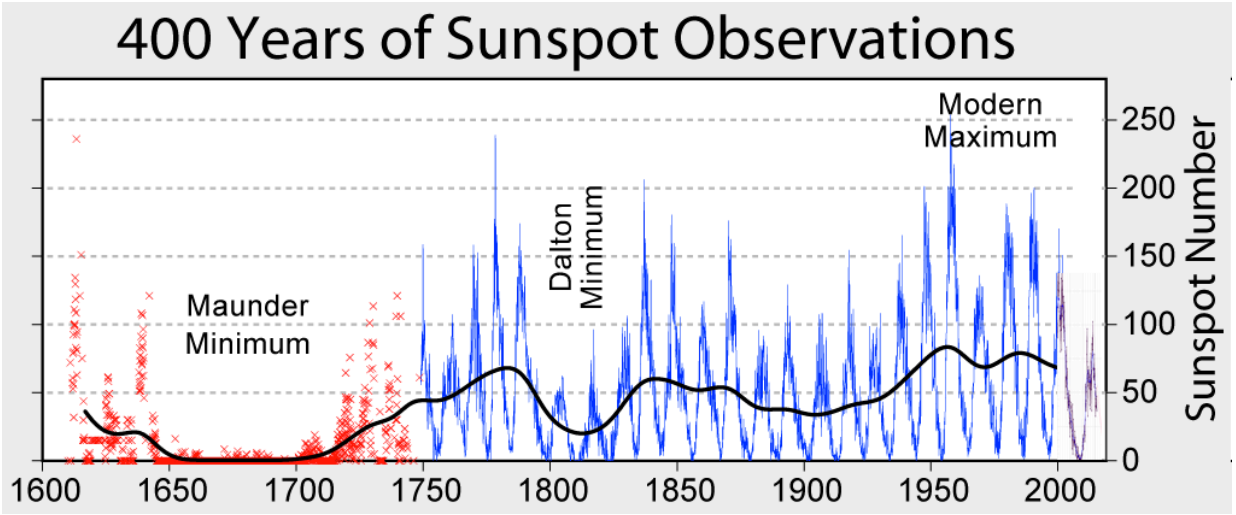


- There are additional variances over longer periods.



- Sunspot cycle believed to be related to winding and twisting of Sun's magnetic field.

Predicting Solar Activity



- Last solar maximum was in 2014, weakest in about a century, but also featured largest sunspot in 24 years!
- NASA previously predicted this max to be in 2010–2011. Also predicted to be *strongest* since 1958!
  - In 1958, northern lights could be seen as far south as Rome, latitude ~42°N.