

# explore SPACE

**A Cosmic Journey**



# Our Dynamic Star



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Bentonville Public Library  
March 14, 2017

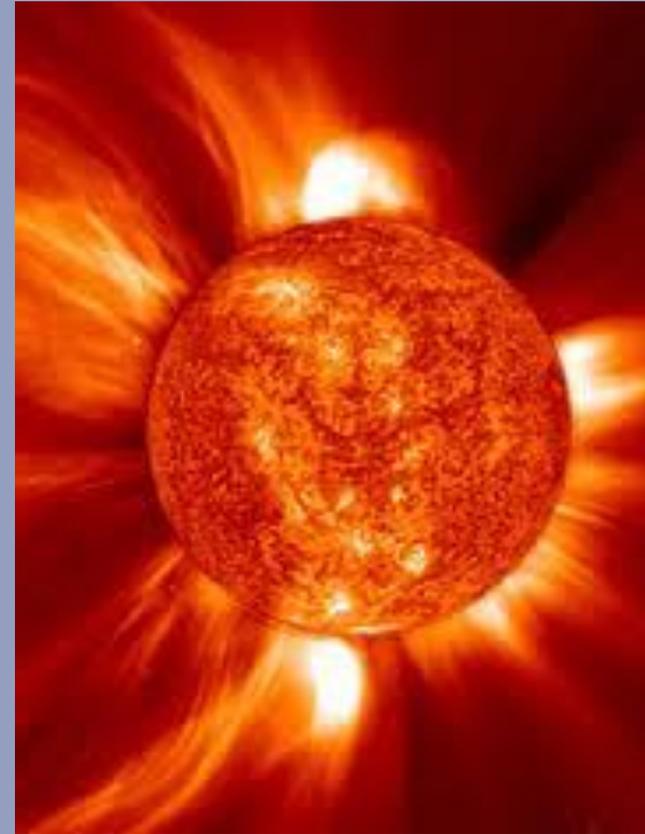


# Overview

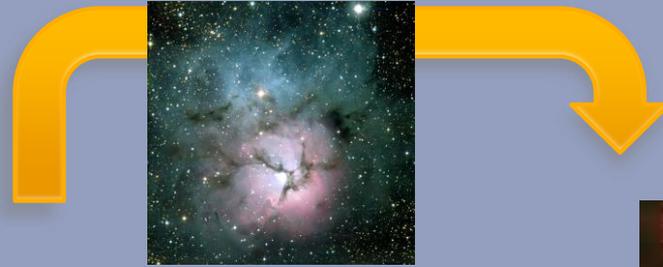
- \* Basics
- \* Energy Source
- \* History
- \* Changes in the Sun
- \* Sunspots
- \* CME
- \* Solar wind
- \* How do We Know?
- \* Changes on Earth
- \* Aurora
- \* Ice Ages
- \* Ocean Currents
- \* Energy production

# The Basics

Hydrogen	91.2	71.0
Helium	8.7	27.1
Oxygen	0.078	0.97
Carbon	0.043	0.40
Nitrogen	0.0088	0.096
Silicon	0.0045	0.099
Magnesium	0.0038	0.076
Neon	0.0035	0.058
Iron	0.030	0.014
Sulfur	0.015	0.040



# Star-Dust-Star cycle



Star nursery

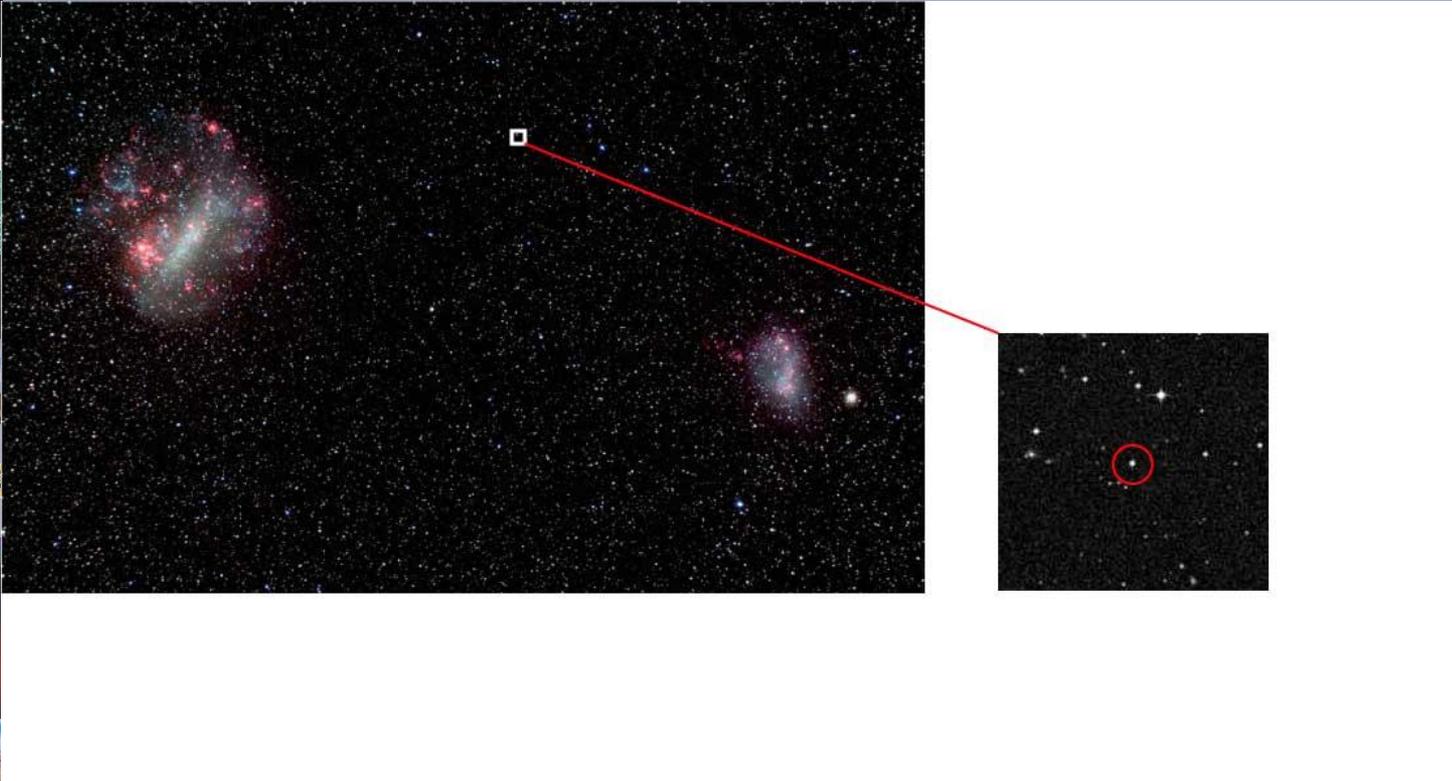


Planetary nebula  
(star death)



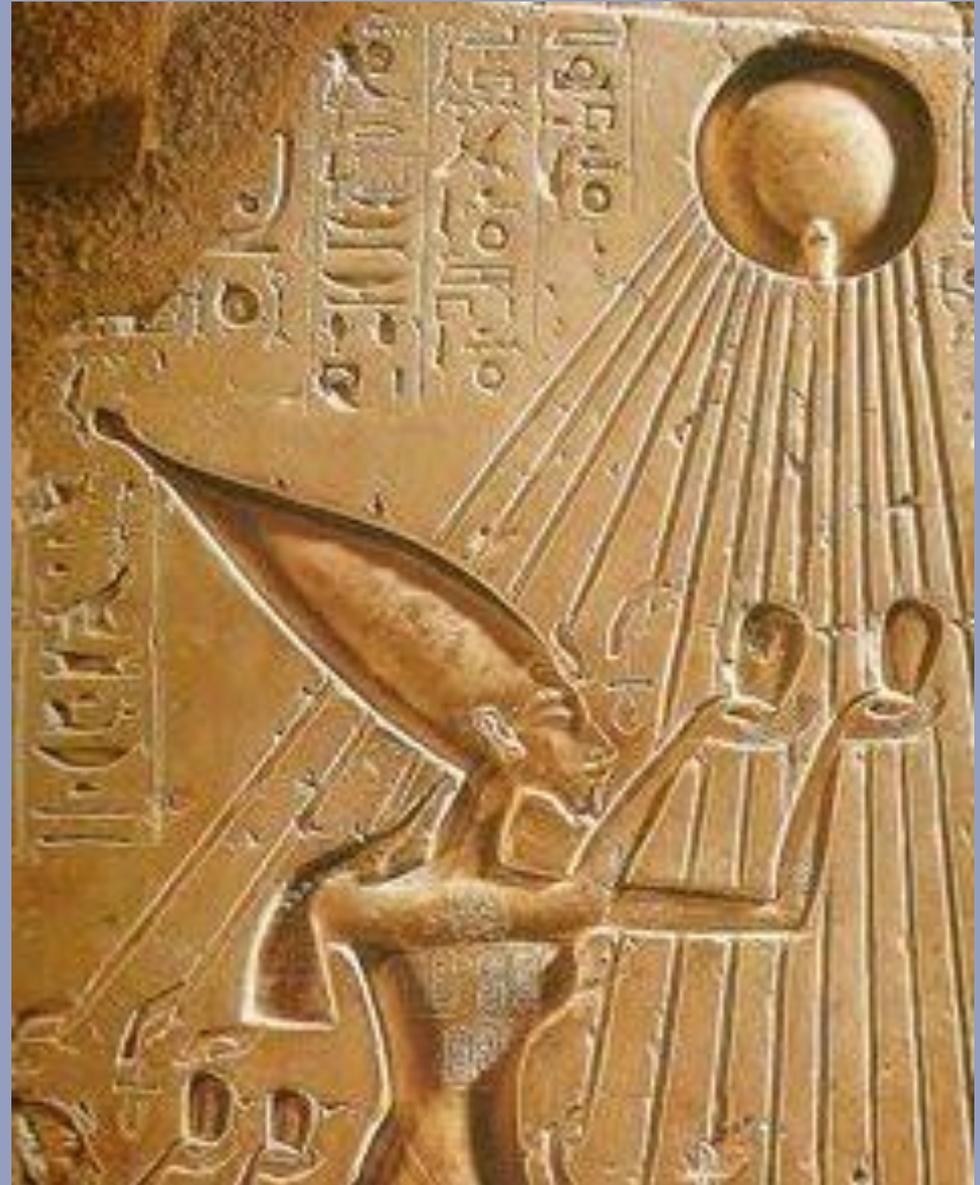
# Keller's Star

\* SMSS J031300.362670839.3



# Our Sun

- \* For centuries humans wondered about, and worshipped, the Sun



# Our Sun

- \* For centuries humans wondered about, and worshipped, the Sun



# Sun Shine?

\* Is sunshine like fire? (a chemical bonding change)

Chemical energy content  
Luminosity

~ 10,000 years

So... No.



# Sun Shine?

\* Is the sun contracting?

$\frac{\text{Gravitational potential energy}}{\text{Luminosity}} \sim 25,000 \text{ million years}$

So... No.



# Sun Shine?

- \* Is sunshine due to nuclear energy? (a chemical bonding change)

Nuclear potential energy  
Luminosity

~ 10,000 billion years

So... Yes!!!



# Sun Shine?

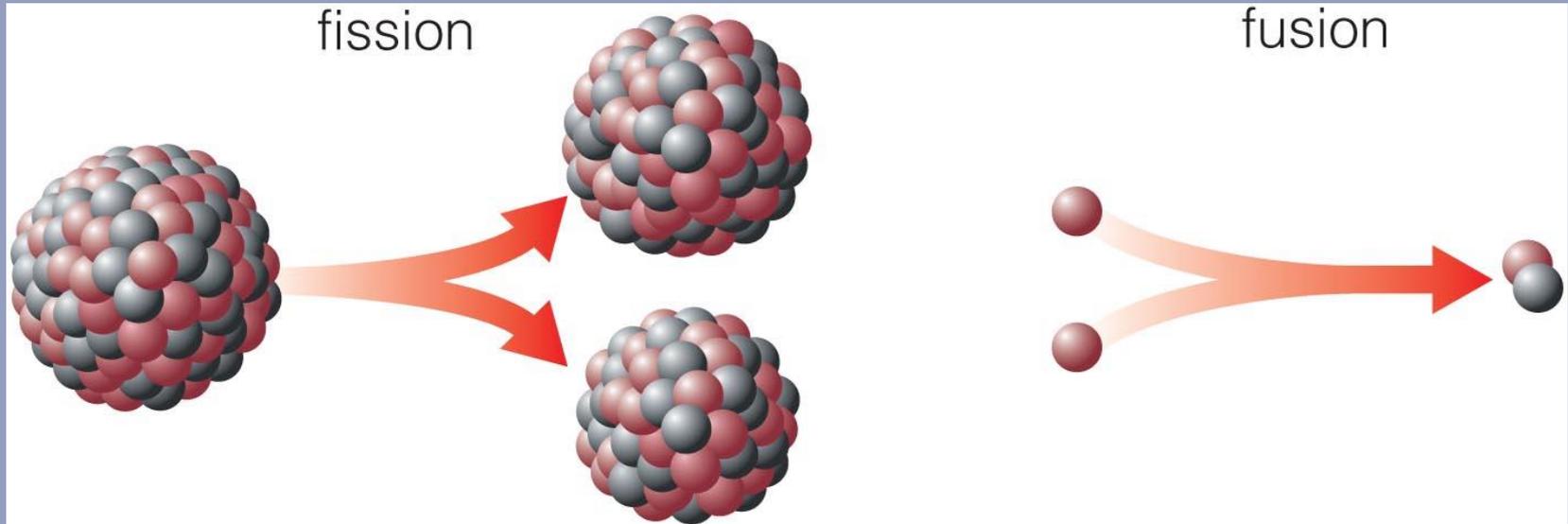
- \* Is sunshine due to nuclear energy? (a chemical bonding change)

Nuclear potential energy  
Luminosity

~ 10,000 billion years

So... Yes!!!





**Big nucleus splits into smaller pieces.  
(Weapons and nuclear reactors)**

**Small nuclei stick together  
to make a bigger one. (Sun,  
stars)**

Fission is the process we use in nuclear power and weaponry.

Fusion is opposite reaction.

# History

\* 150 CE Greek scholar  
Claudius Ptolemy  
writes *Almagest*



\* 1543 Nicolaus  
Copernicus publishes  
*On the Revolutions of  
the Celestial Spheres*



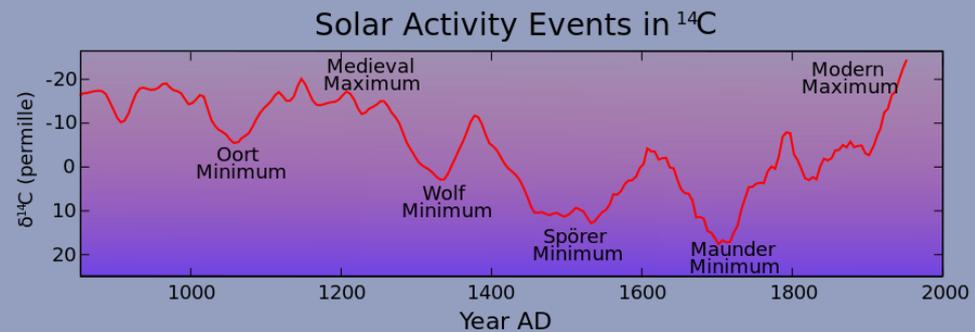
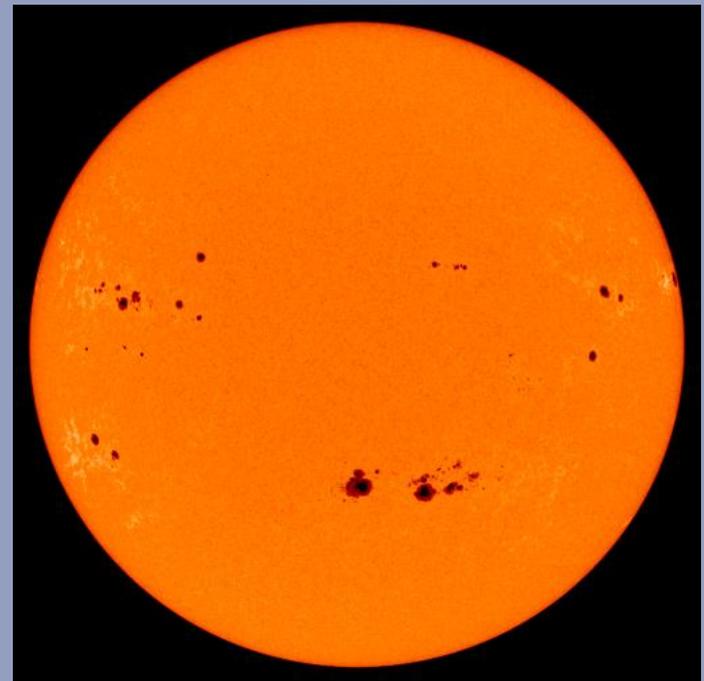


# History

\* 1610 First observations of sunspots through a telescope made independently by both Galileo Galilei and Thomas Harriot

\* 1645-1715 Maunder Minimum Sunspot activity declines to almost zero

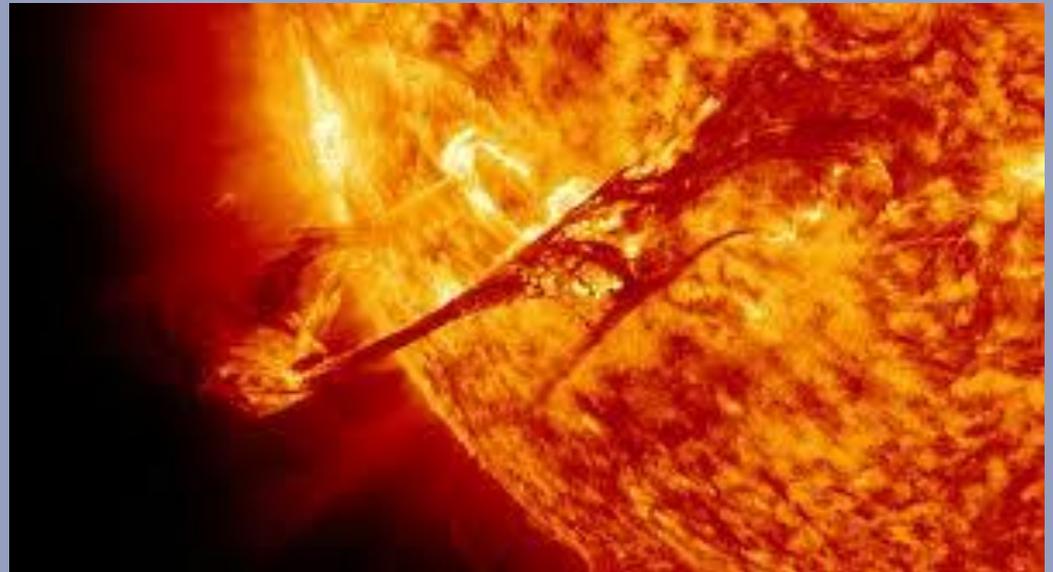
Corresponds with "Little Ice Age"



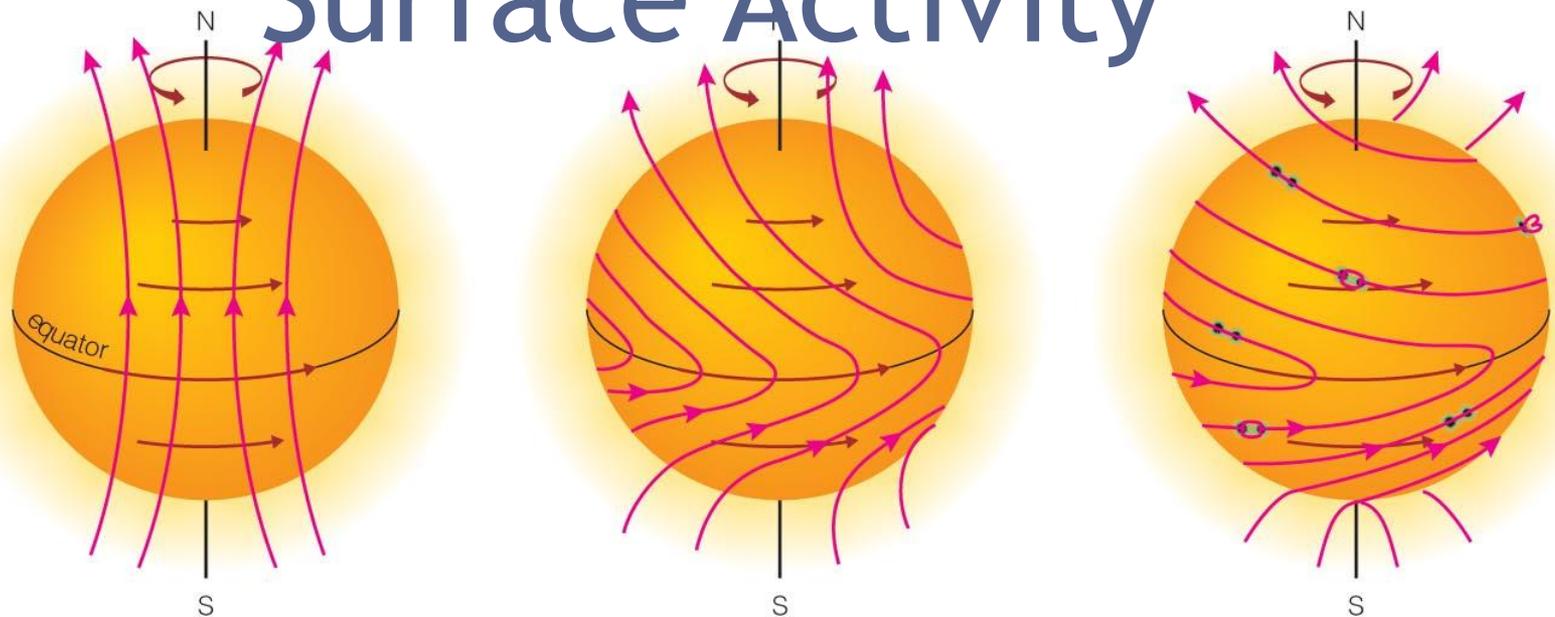


# Changes in the Sun

- \* Neutrinos leave the sun all the time. When there is a solar prominence or CME (coronal mass ejection) there are more.



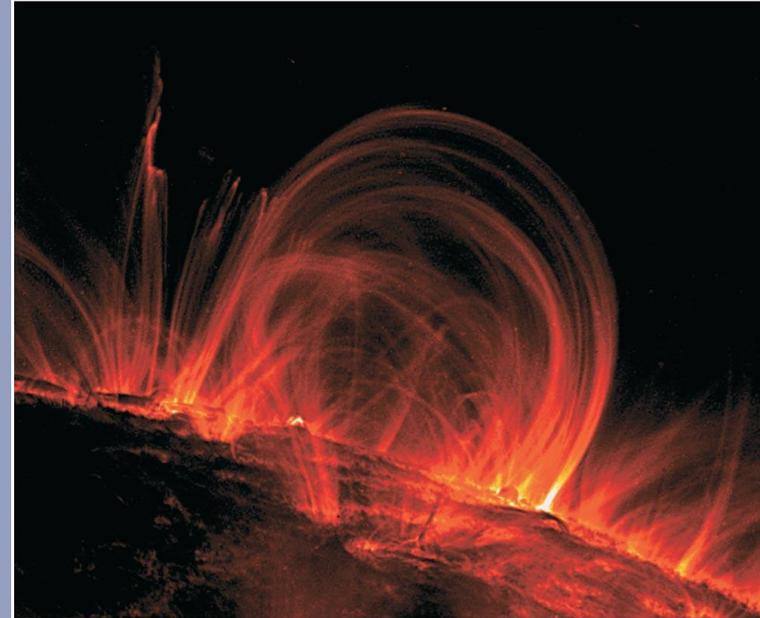
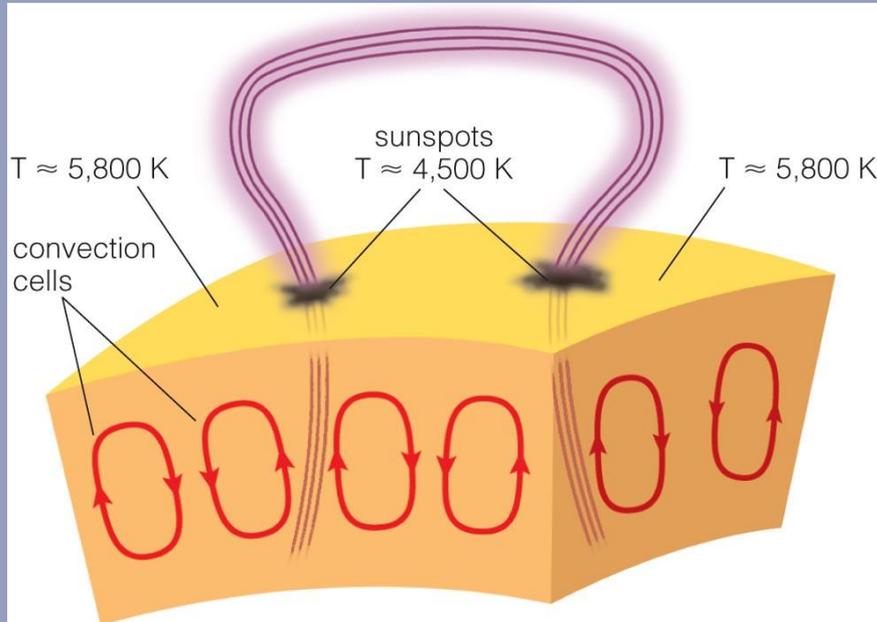
# Surface Activity



The winding and twisting of the Sun's magnetic field causes other (more observable) events.

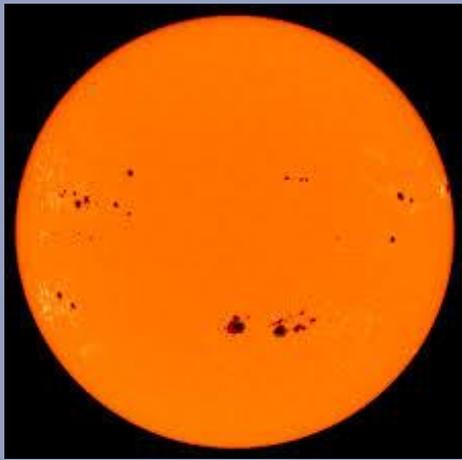


# Field lines escape the Sun



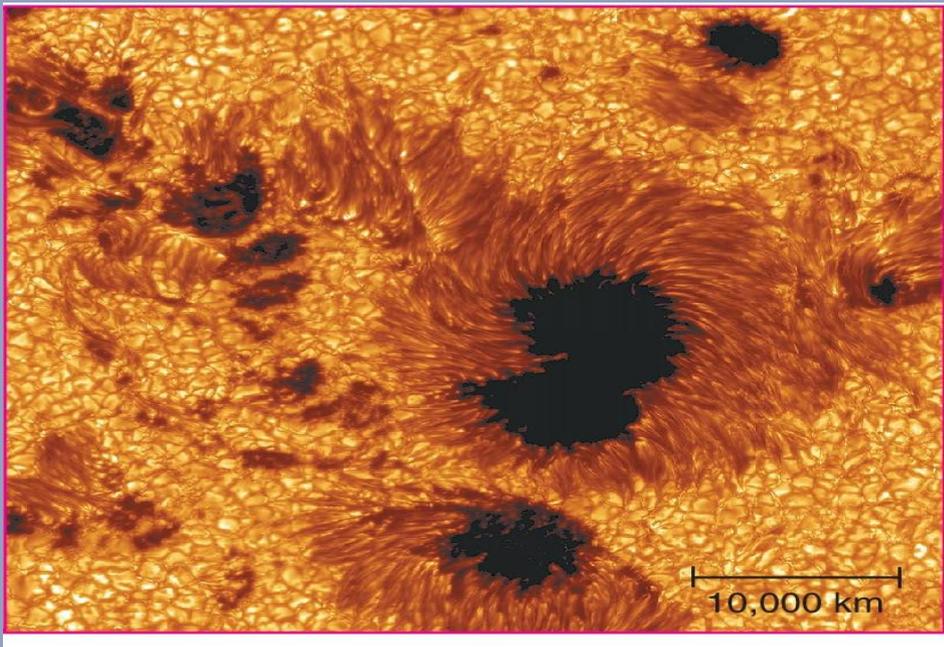
Loops of bright gas often connect sunspot pairs. The glowing plasma is following those magnetic loops.





# Sunspots

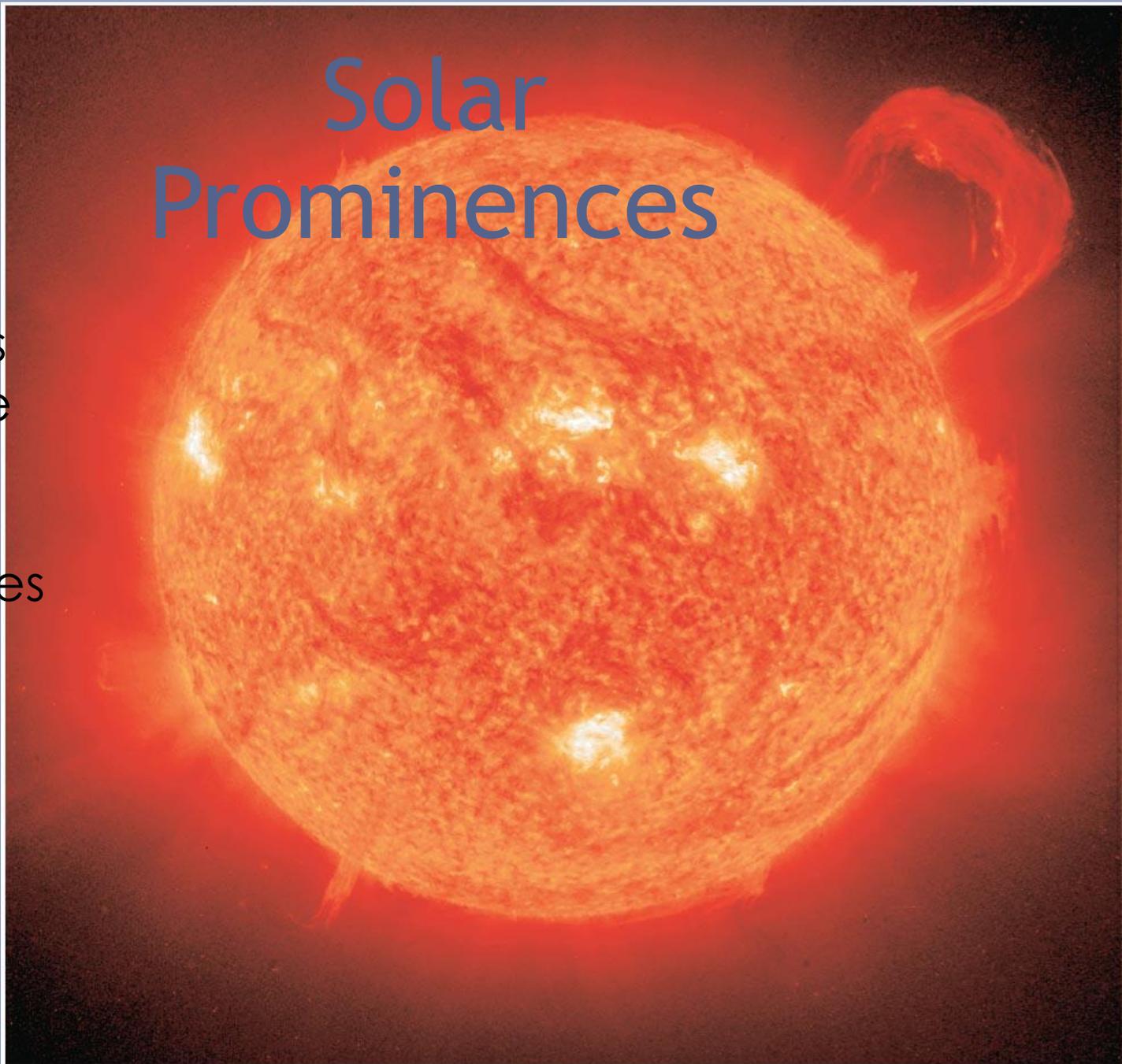
- \* Even sunspots on the surface are large enough to swallow the Earth
- \* The Sun comprises 99.8% of the mass of our solar system.



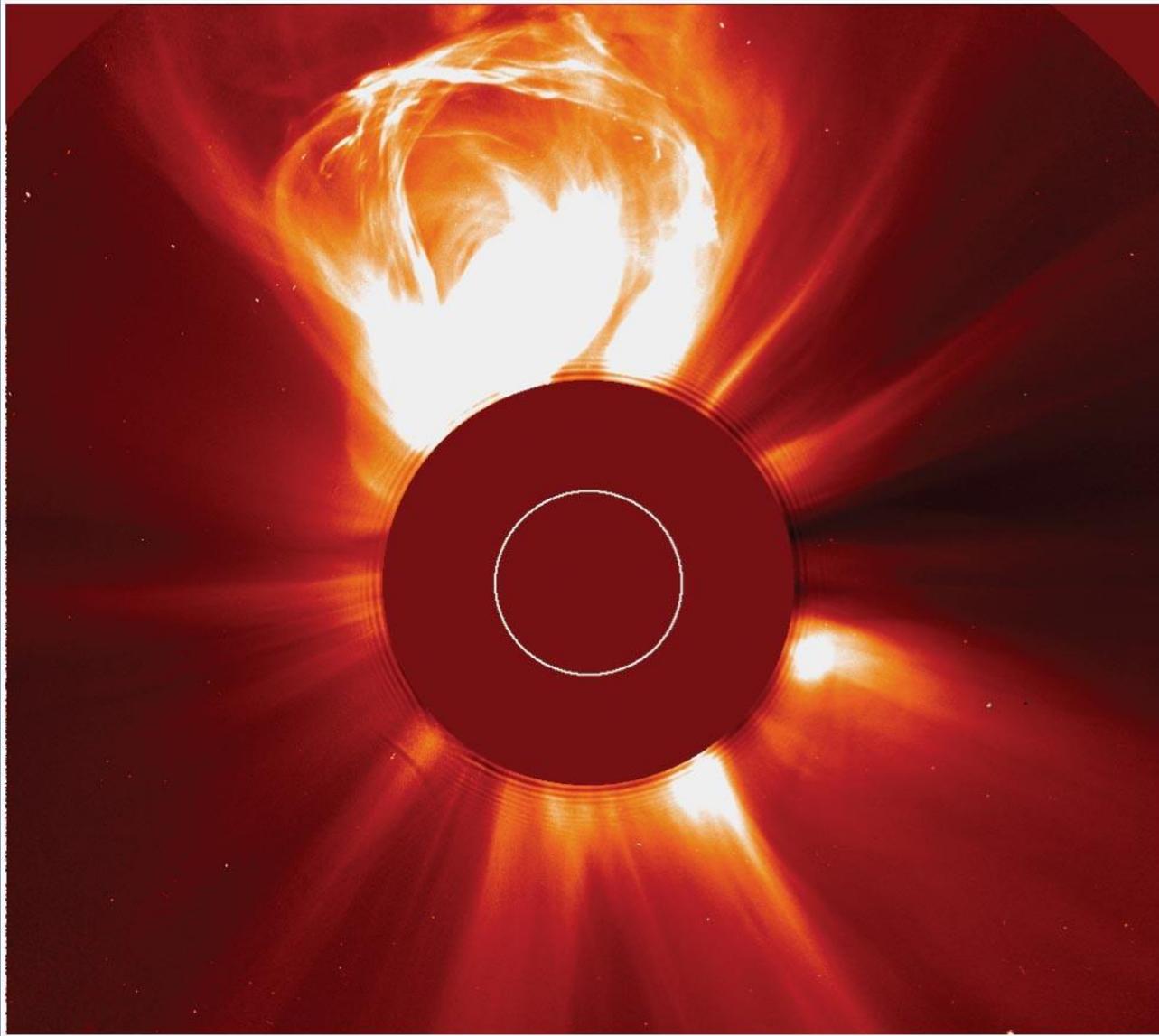


'Plasma' within the sun follows those loops high above the Sun's surface. Prominences are common.

# Solar Prominences

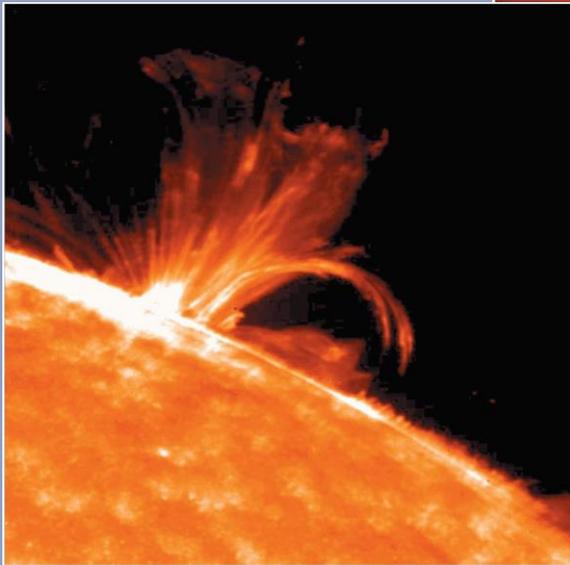
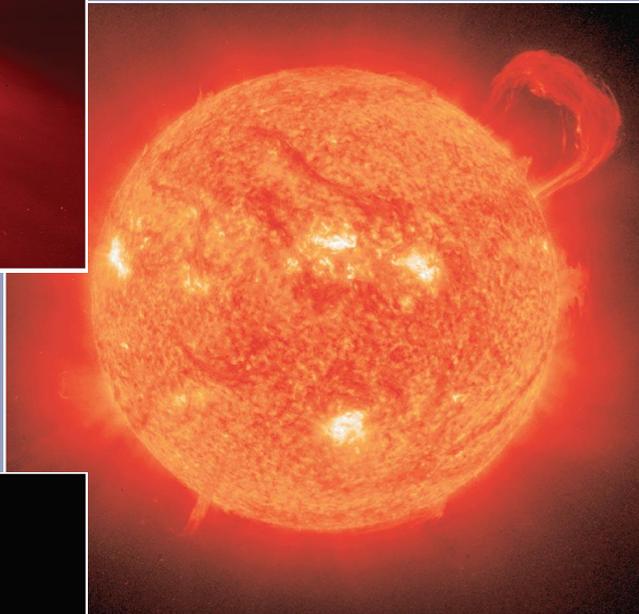
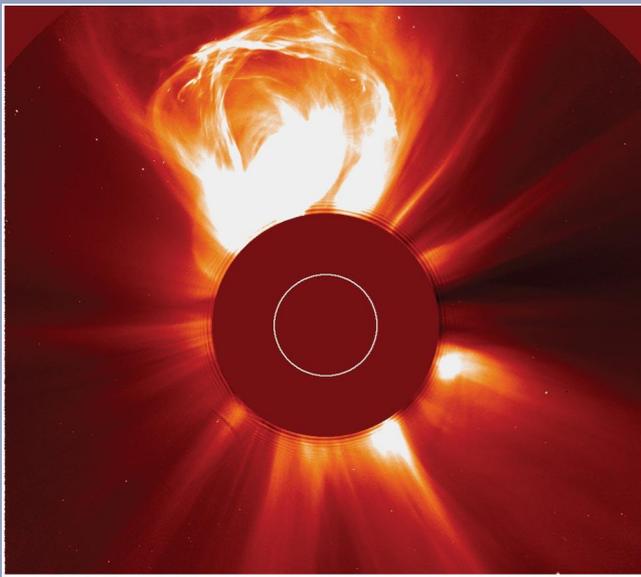


# Coronal Mass Ejection



Billions tons of high-temperature coronal gas are blasted into space at speeds of hundreds of kilometers per second.





Charged particles from any of these can cause increased auroras, damage satellites, interfere with communications, harm anyone in unprotected in space, and can take out power grids on Earth.



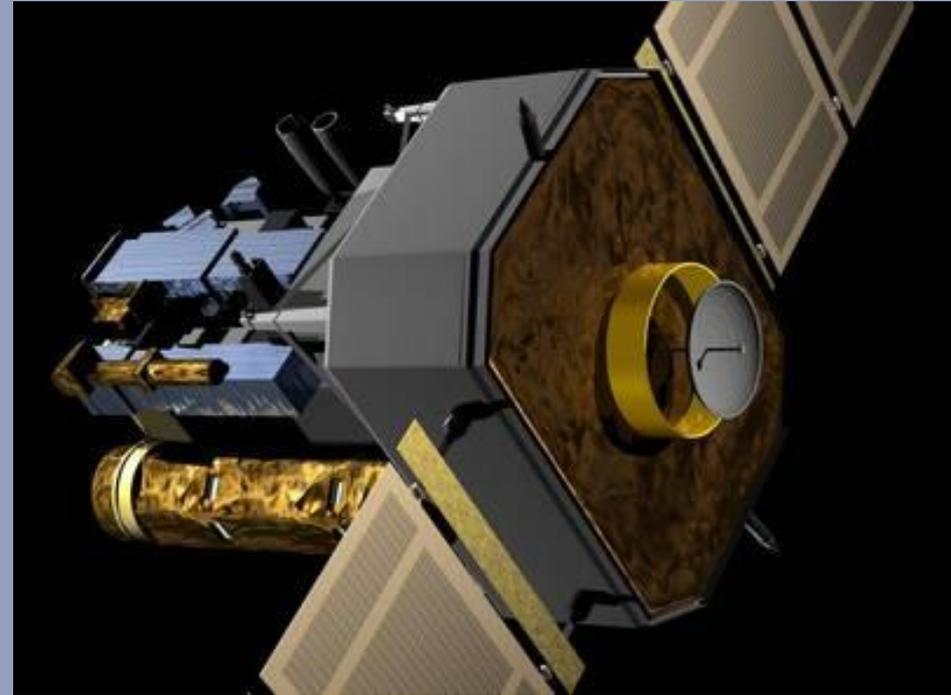
\* Solar and Heliospheric Observatory

\* Study the internal structure of the sun, its extensive outer atmosphere and the origin of the solar wind.

\* Cooperative effort with European Space Agency (ESA)

\* launched on December 2, 1995

# SOHO



[https://www.nasa.gov/mission\\_pages/soho/the-sun-daily/index.html](https://www.nasa.gov/mission_pages/soho/the-sun-daily/index.html)

# Hinode



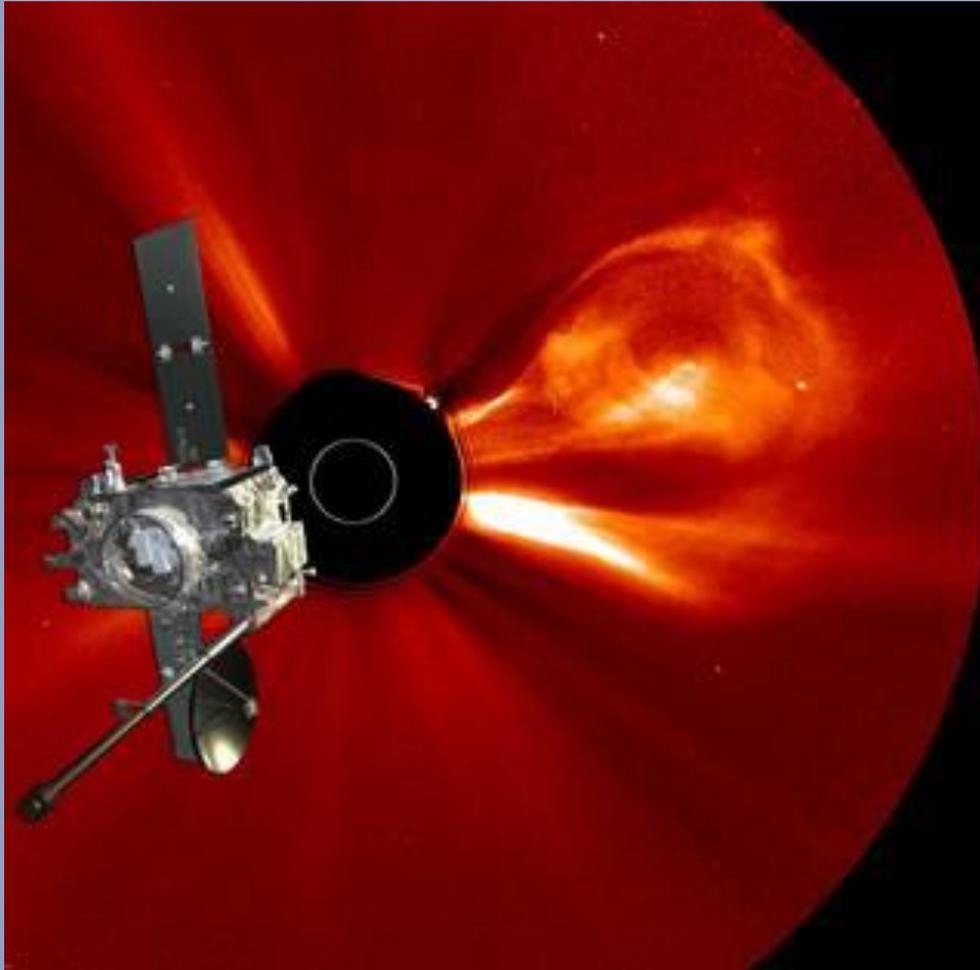
- \* Study the generation, transport, and dissipation of magnetic energy from the photosphere to the corona
- \* Interested in interplanetary space environment
- \* launched in September 22, 2006

\* In cooperation with the Japan Aerospace Exploration Agency (JAXA)





# STEREO

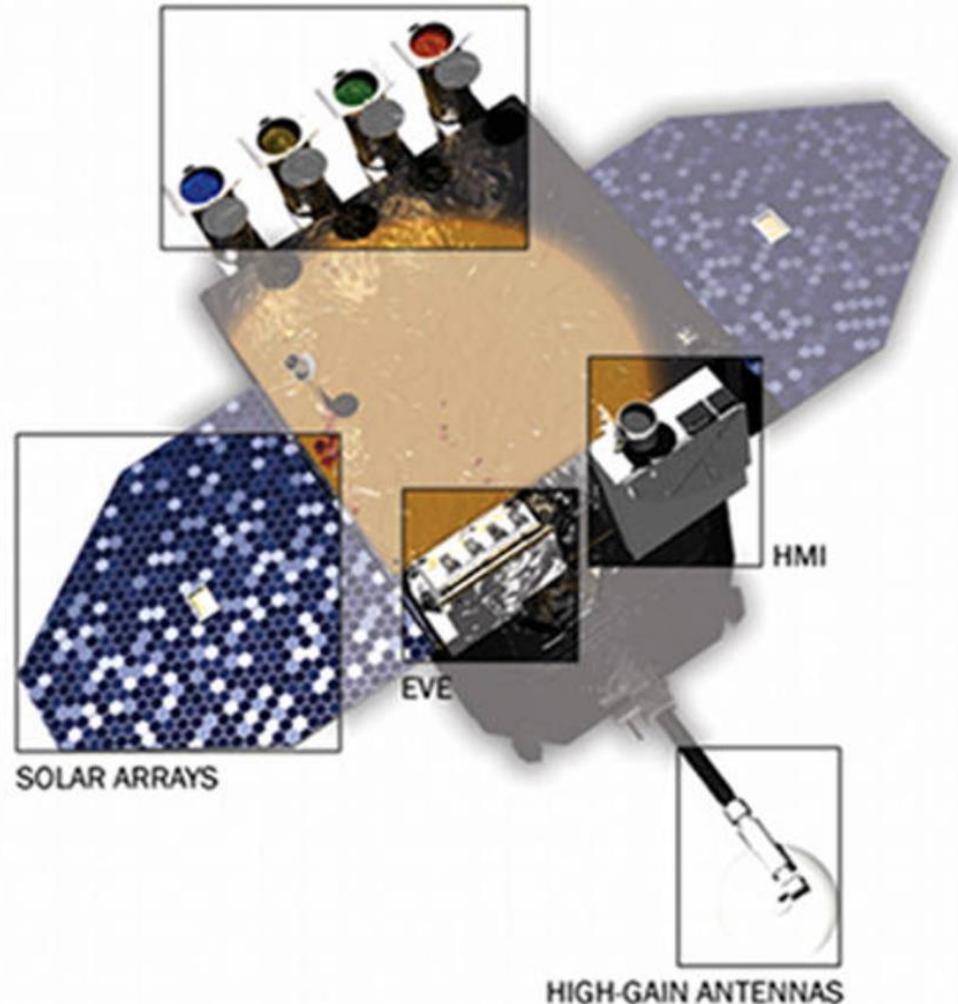


- \* Solar TERrestrial RELations Observatory
- \* launched in October 2006
- \* two nearly identical observatories - one ahead of Earth in its orbit, the other trailing behind

# SDO

- \* Solar Dynamics Observatory
- \* first satellite under the Living with a Star (LWS) program
- \* Launched: Feb. 11, 2010

## The SDO Spacecraft



# Changes on Earth





# Aurora

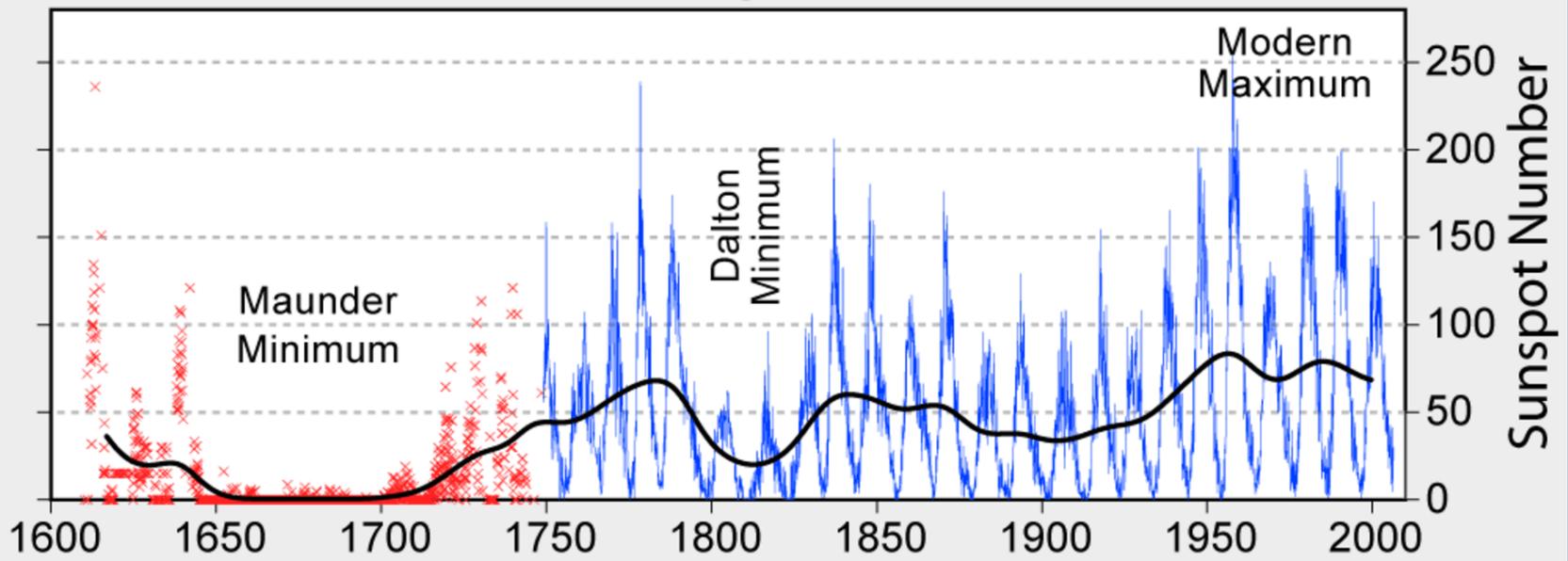


- \* When those neutrinos from the sun interact with atoms in the Earth's atmosphere, the atoms glow...

# Ice Ages

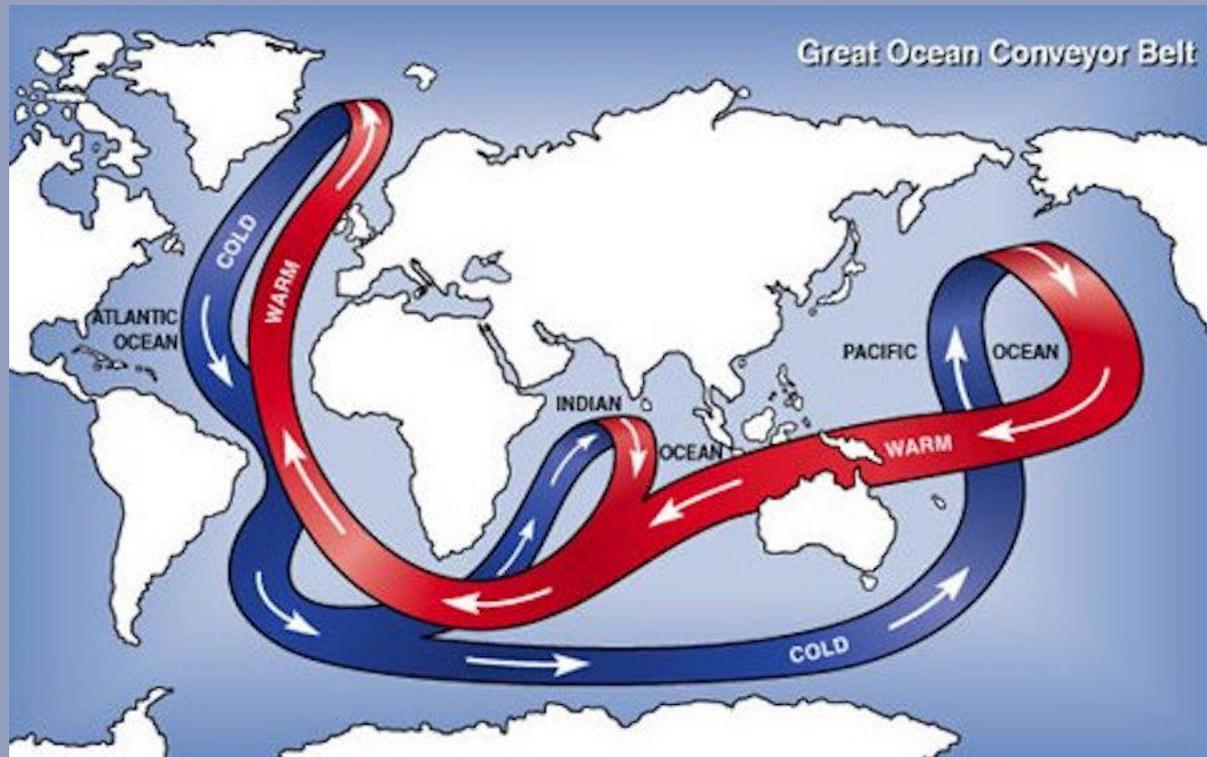
- \* When the Sun has fewer Sunspots, it gives off less energy, less energy makes its way to Earth, and our planet cools down.

## 400 Years of Sunspot Observations



# Ocean Currents

- \* The heat of the sun controls thermohaline circulation, or more simply, the “Global Conveyor Belt”





# Recap

- \* Many ways that our Sun changes through time
- \* Because the Earth is inside the Sun's atmosphere those changes causes changes on Earth
- \* Some are bigger changes... some are smaller

# Questions?

