

The Magnetic Sun

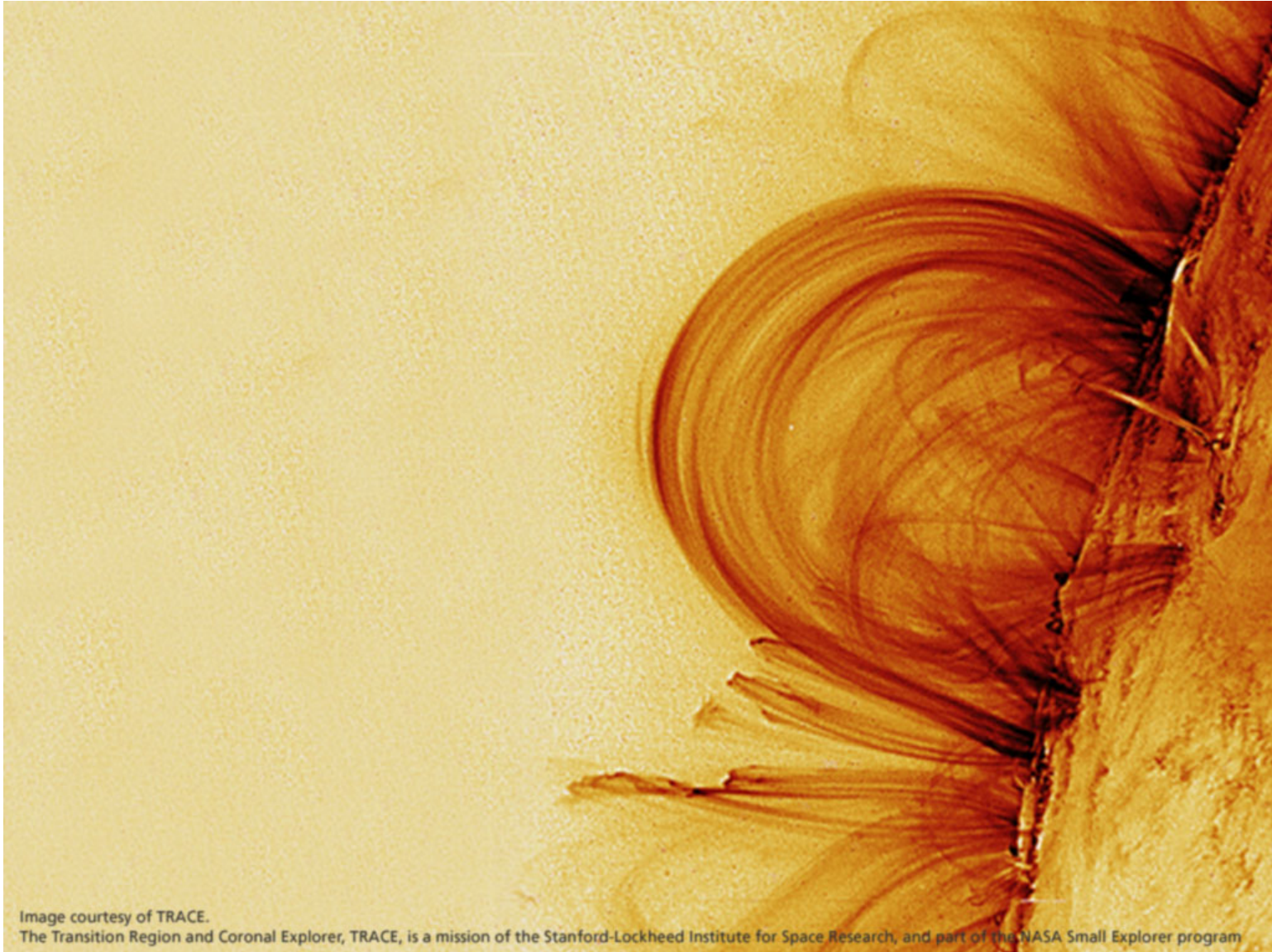


Image courtesy of TRACE.

The Transition Region and Coronal Explorer, TRACE, is a mission of the Stanford-Lockheed Institute for Space Research, and part of the NASA Small Explorer program

What is the Sun?



The Sun is a Star, but seen close-up.

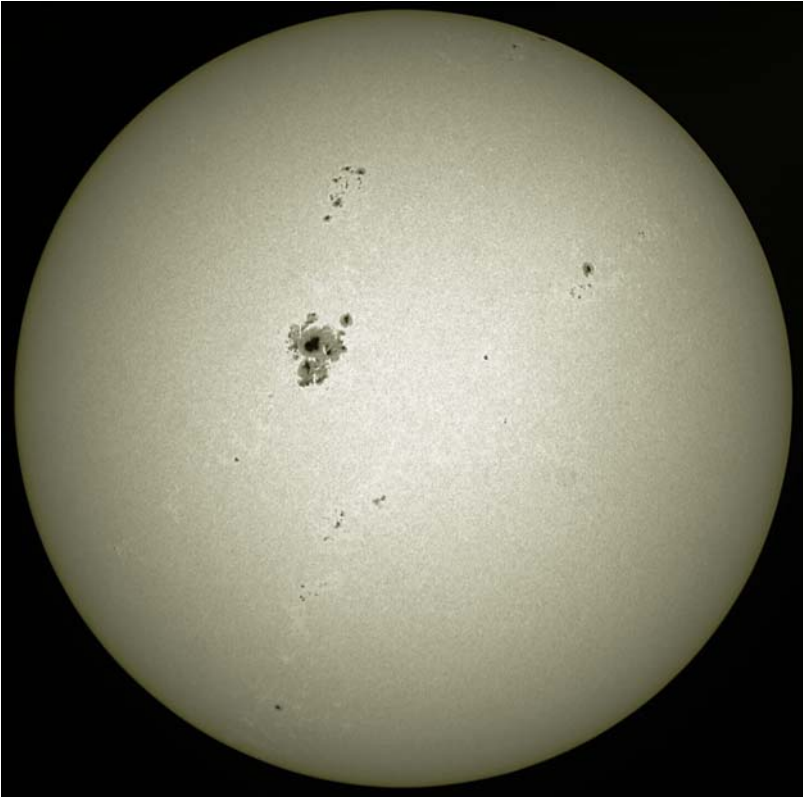
The Stars are other Suns but very far away.



What is the Sun?

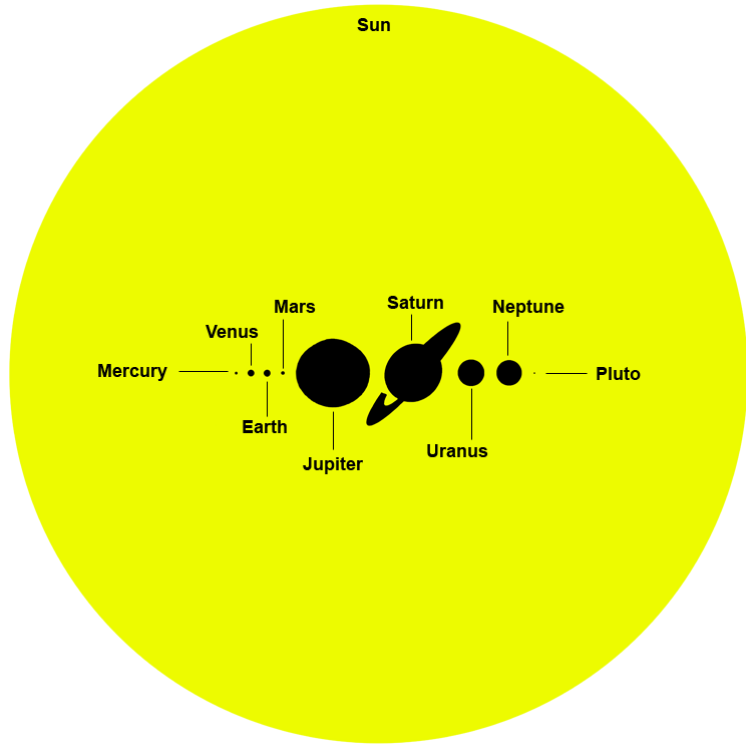
The Sun is giant ball of very hot, mostly ionized gas that shines under its own power.

Solar Data

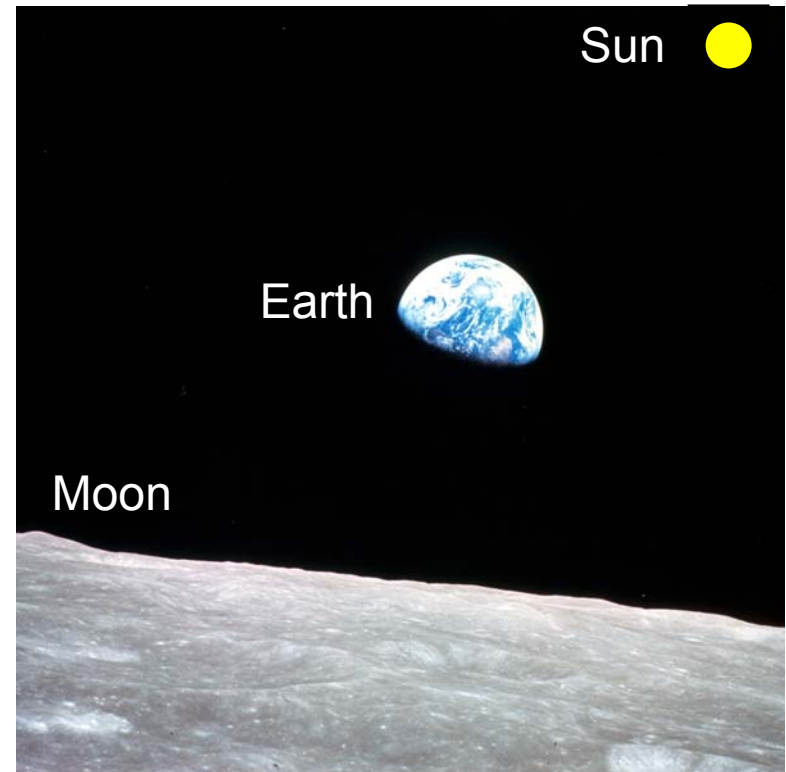


Radius	696,000 km (109 times Earth's radius)
Rotation Rate	27 days (equator) to 31 days (poles)
Luminosity (Power Output)	3.8×10^{26} watts (10 trillion times the power consumption of all Earth's nations combined)
Surface Temperature	5,800 K (average)
Mass	2×10^{30} kg (300,000 times Earth's mass)
Composition (by percentage of mass)	70% Hydrogen, 28% Helium, 2% heavier elements
Core Temperature	15 million K
Age	5 Billion Years (expected to live another 5 Billion)

Size and Distance of the Sun



- The Sun is 109 times the diameter of Earth (10 times the diameter of Jupiter).
- Over 1,000,000 Earths could fit inside the Sun.



- The Sun is 150 million kilometers away from Earth. 390 times farther away than the Moon.
- You would need to line up 11,700 Earths side by side to cover the distance between Earth and Sun.
- It takes light 8 minutes to travel to Earth from the Sun.

The Different Parts of the Sun

Core

- Nuclear Fusion $H \rightarrow He$
- $T = 15,000,000\text{ K}$

Radiative Zone

- Energy transported by light
- $T = 10,000,000\text{ K}$

Convective Zone

- Energy transported by convection

Photosphere

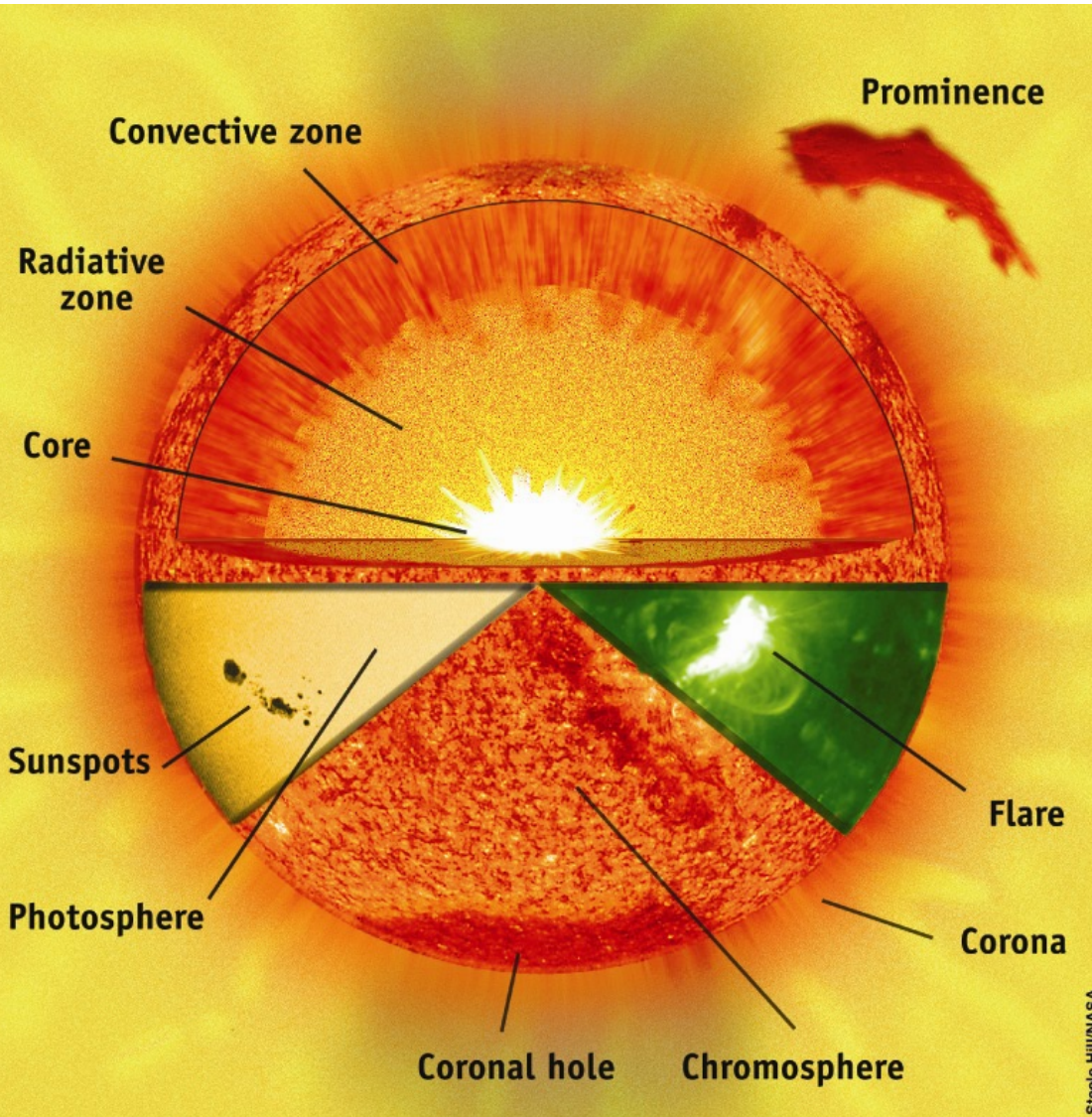
- Visible surface
- Far less dense than Earth's atmosphere
- $T = 5,800\text{ K}$
- Sunspots: $T = 4,000\text{ K}$

Chromosphere

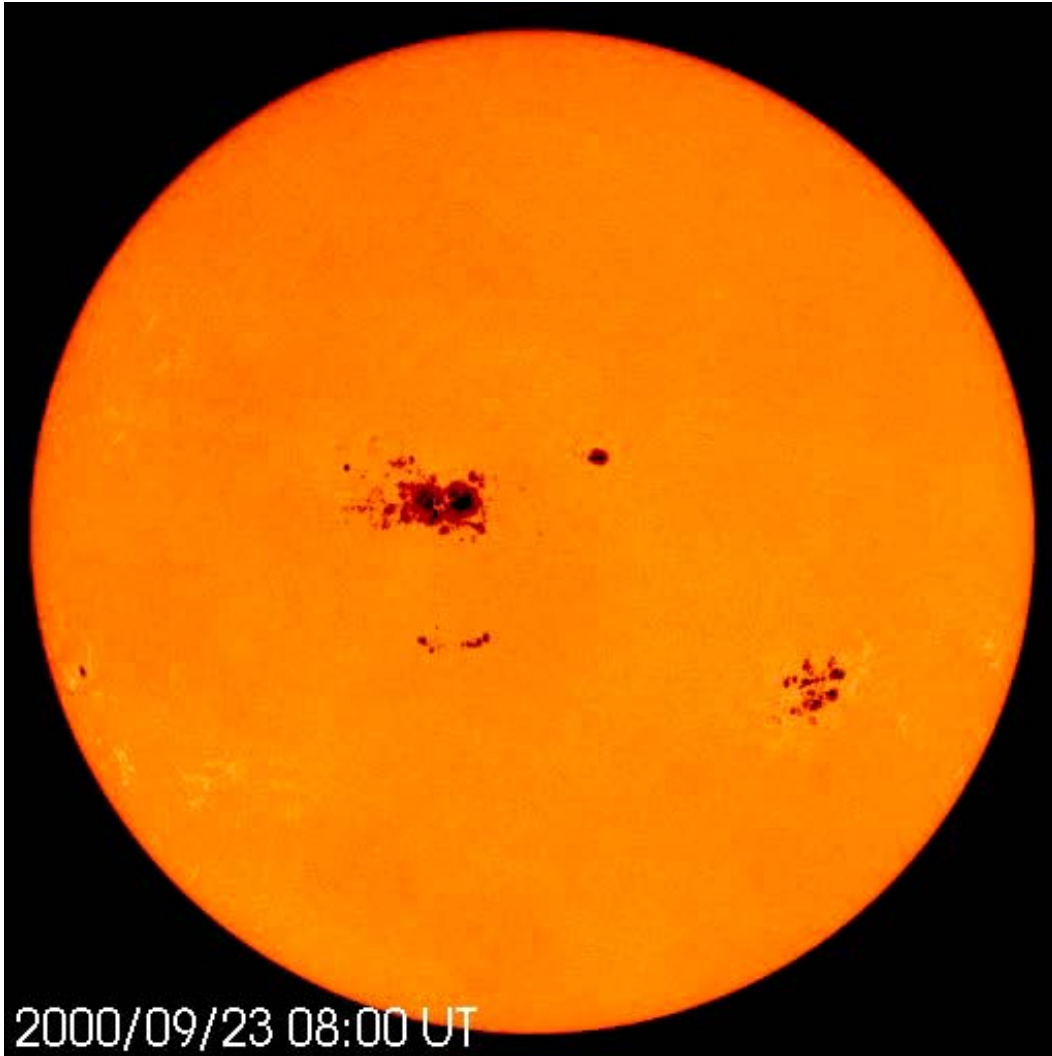
- Thin layer above photosphere
- Produces most of Sun's UV light
- $T = 10,000\text{ K}$

Corona

- Tenuous, extends out millions of kilometers
- Emits X-rays
- $T = 1,000,000\text{ K}$



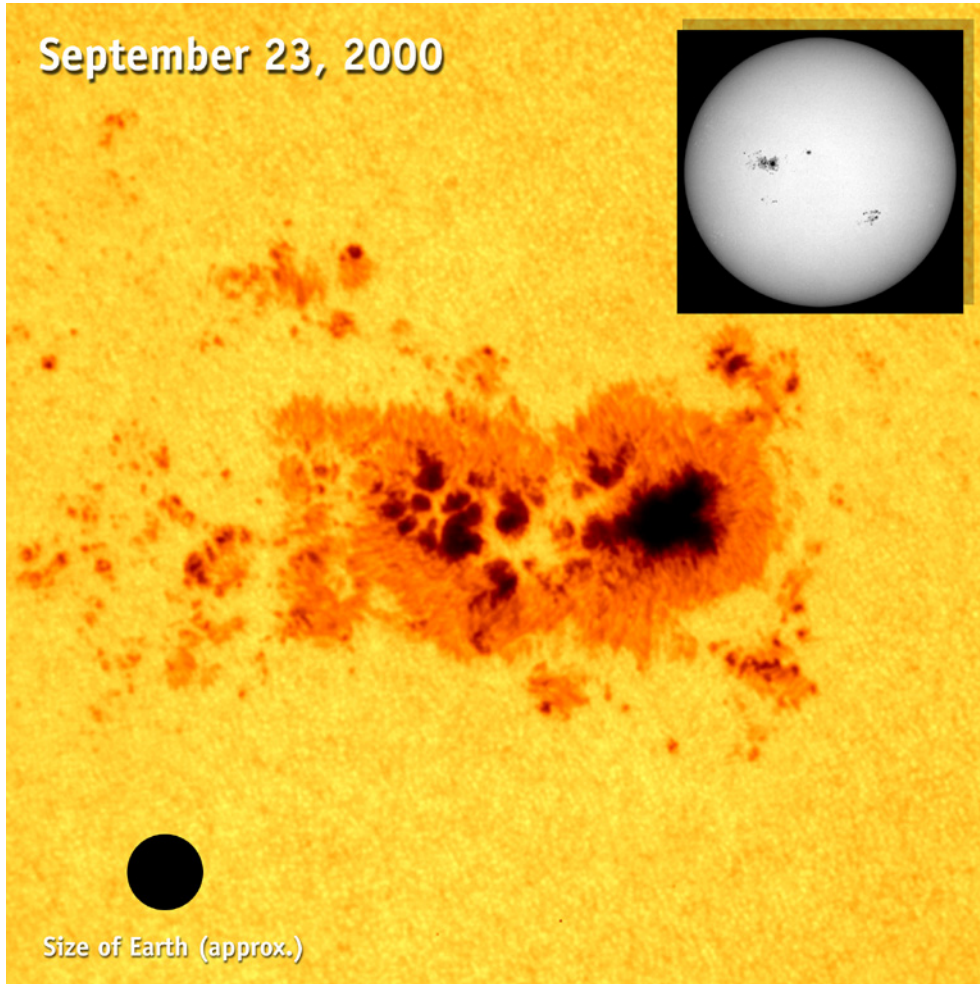
Sunspots



Sunspots are dark splotches on the face of the Sun. They are typically about, 2,000 degrees Kelvin cooler than the average temperature on the photosphere. This makes them appear to be dark in comparison to their very bright surroundings.

Following long-lived sunspots through time allows one to determine the rotation rate of the Sun. It turns out that the Sun spins faster at the equator than at the poles. The Italian astronomer Galileo was one of the first people to use Sunspots in this way.

The Sun Changes Its Spots



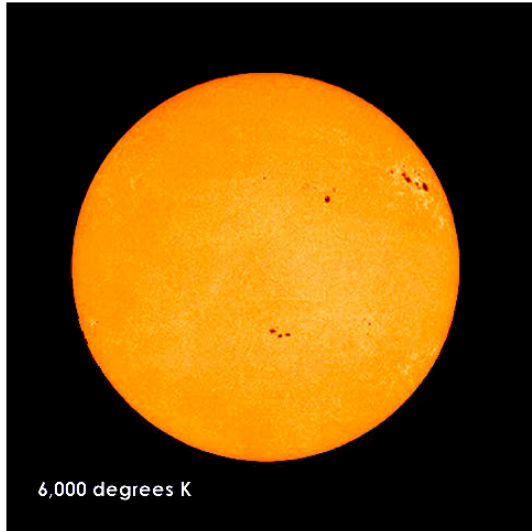
Sunspots are often Earth-sized or bigger.

Sunspots change their shapes with time.

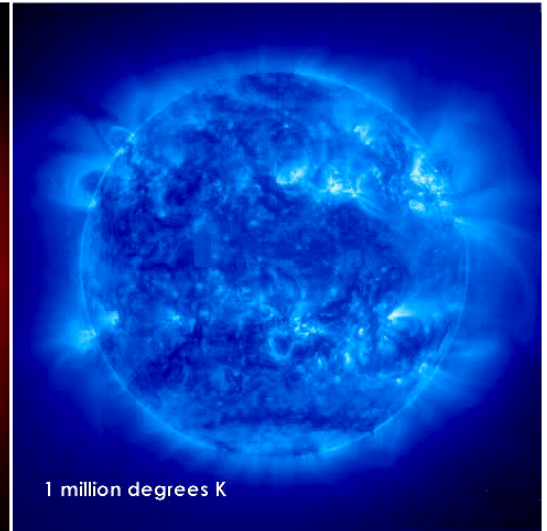
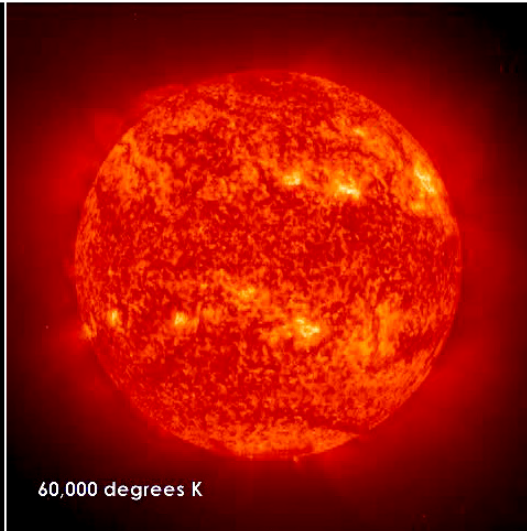
Inner dark parts called umbra, and outer lighter parts called penumbra.

The Multiwavelength Sun

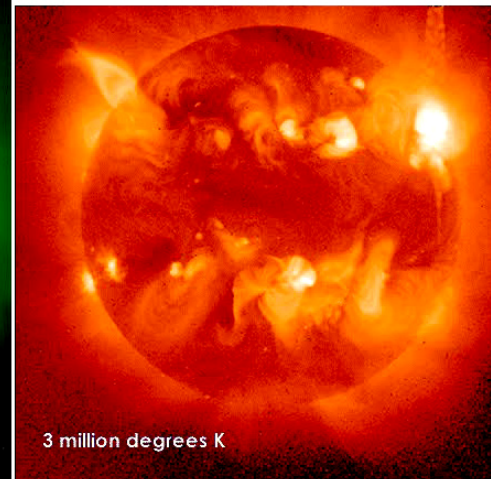
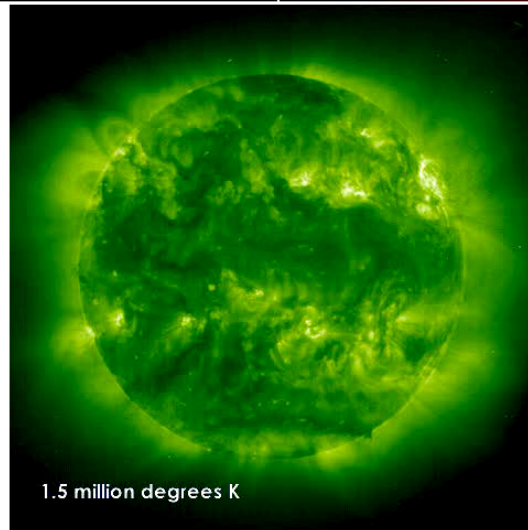
The **Photosphere** is seen in visible light.



The **Chromosphere** and **Corona** are seen in UV light.



Very hot regions of the **Corona** are visible in extreme UV light.



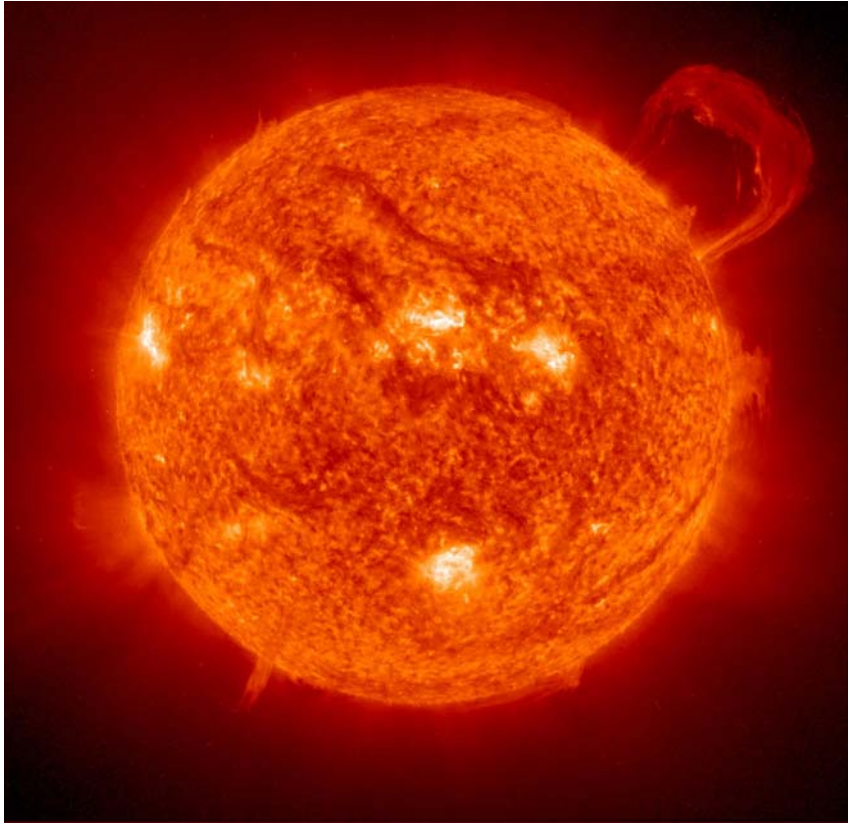
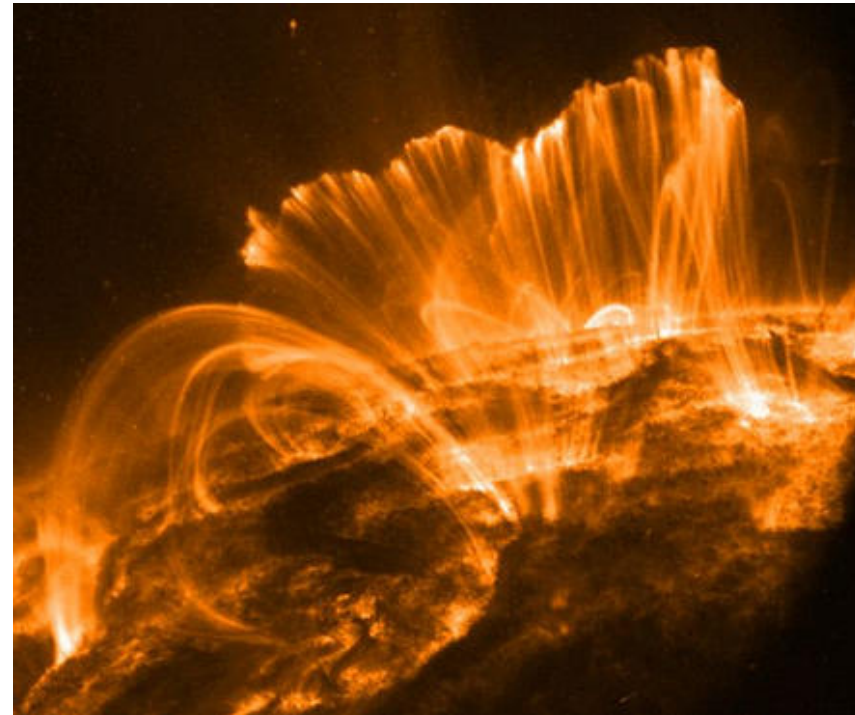
The hottest parts of the **Corona** are seen in X-rays

The Magnetic Sun

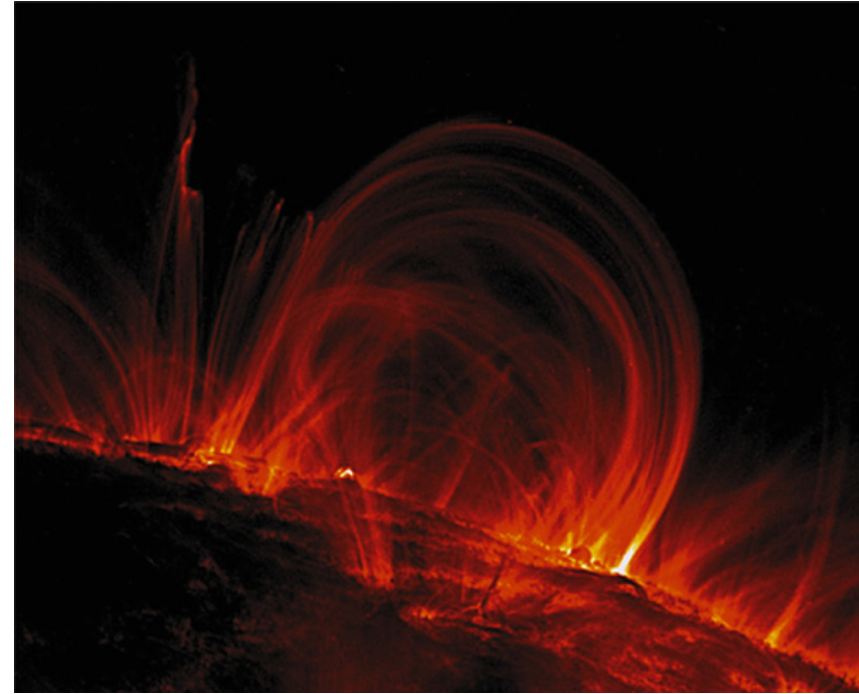
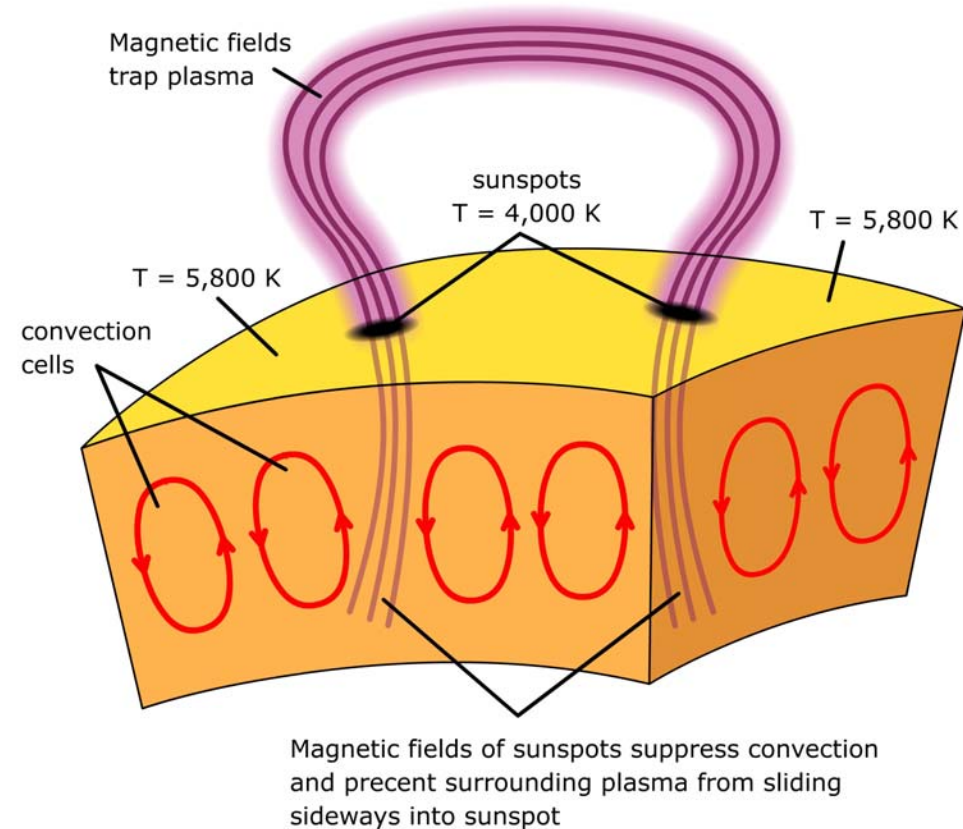
Images of the Sun in invisible light reveal loops of hot ionized gas (plasma) above the locations of Sunspots.

Notice that the shapes of these loops are just like the loops of force between two opposite poles of a magnetic field. The plasma acts just like iron filings and traces out the magnetic field on the Sun.

The plasma is trapped within the magnetic fields. It can flow lengthwise along the loops but it cannot flow sideways across the loops.



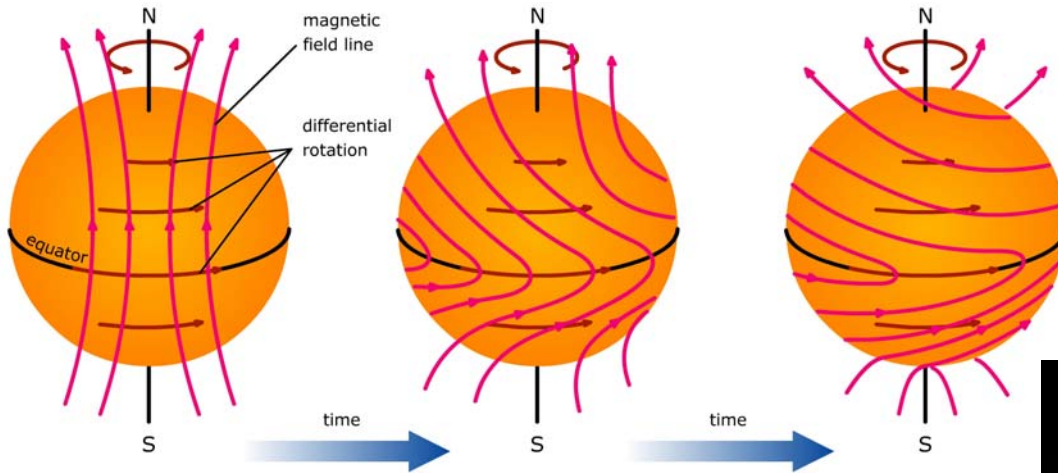
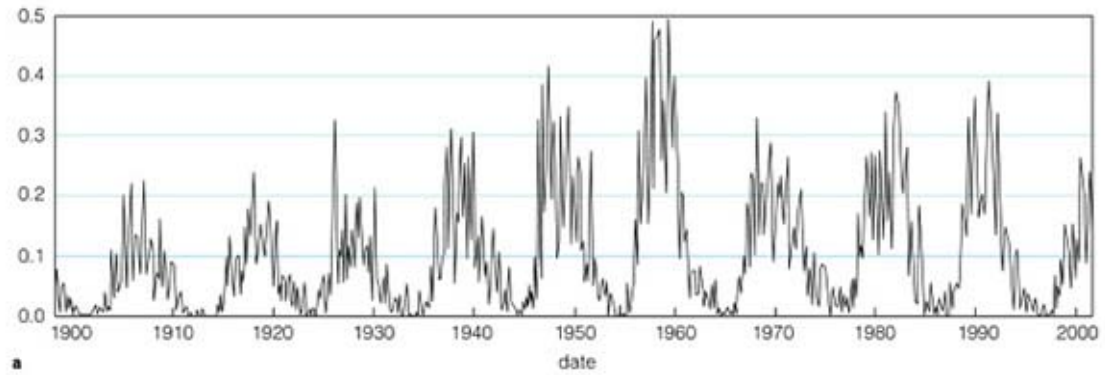
The Magnetic Sun



Sunspots are cooler because the magnetic fields do not allow plasma from the surrounding region to enter. The plasma pressure in the Sunspot drops and the temperature cools.

The magnetic field strength in a Sunspot is an average of 1,000 times stronger than the magnetic field at Earth's surface.

The Solar Cycle



The number of Sunspots and Solar flares increases and decreases on an 11 year cycle.

The Sun's Magnetic field becomes more and more twisted and complex from differential rotation and finally breaks and flips every 11 years. So the total cycle is really 22 years from start to finish.

