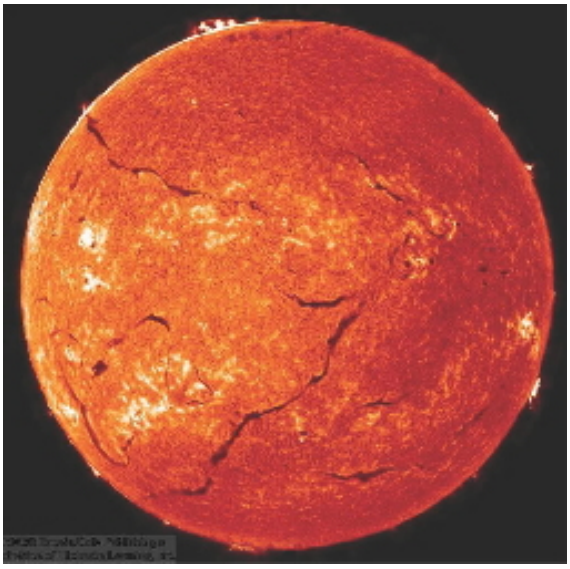
1 Sun - Our Star



A sphere of gas or plasma - electrically charged fluid

Average distance from Earth - 1 Astronomical Unit (1 AU)

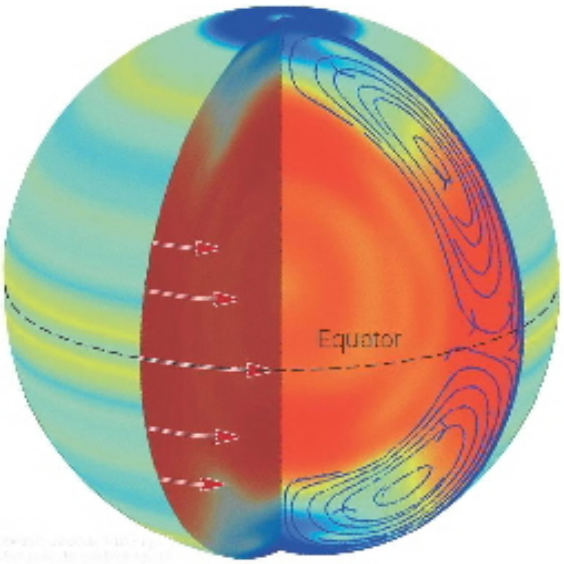
Distance from Earth - 1.4957×10^{11} m = 149.57 million kilometers = 93 million miles

Mass of Sun - 1.99×10^{30} kg = 332, 780 Earth masses

Diamter of Sun - 109 Earth diameters = $1,391,900$ km = $837,924$ mi

1.1 Structure

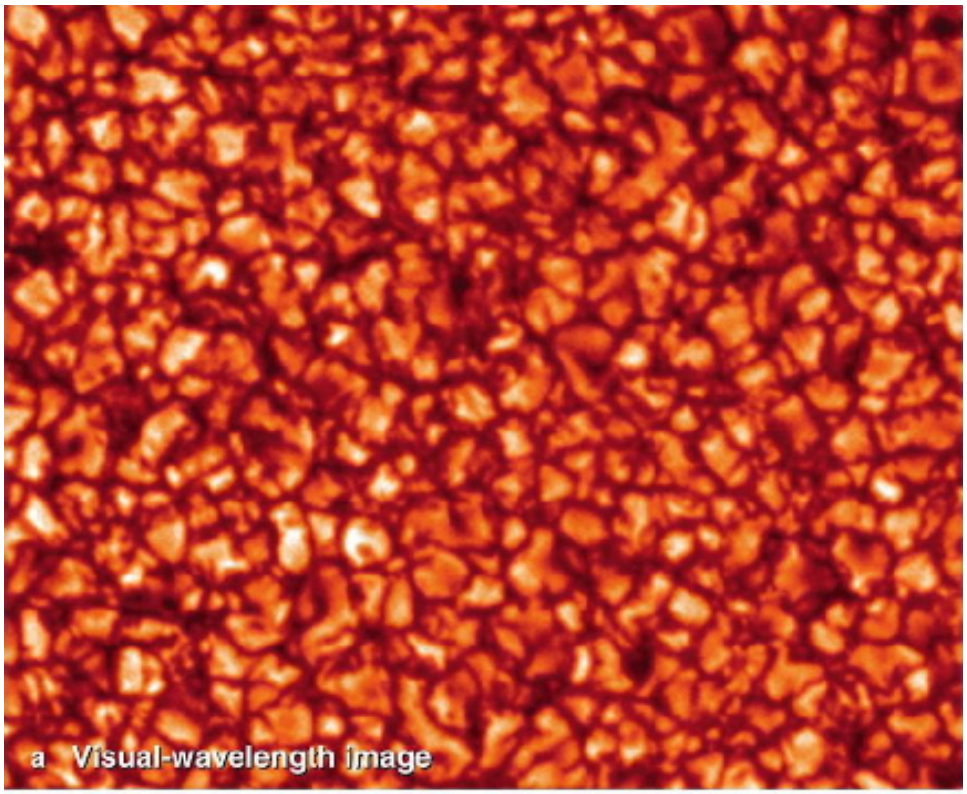
1.1.1 Interior

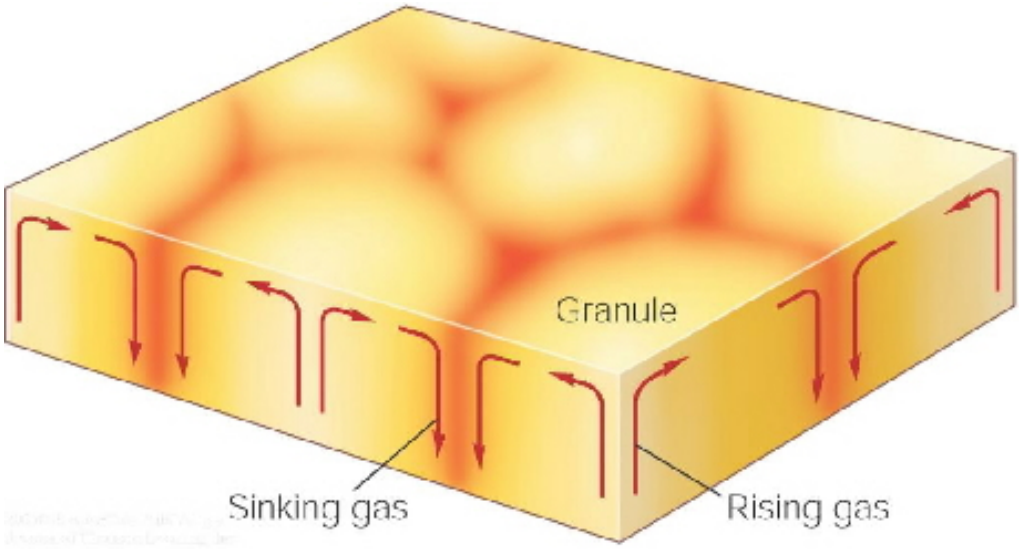


Core - center of Sun,
temperature is approximately 15 million Kelvins,
nuclear fusion - hydrogen is fusing together to form helium, high temperature is necessary for fusion to occur, high velocities of hydrogen atoms (protons)
Mass is converted into energy, $E = mc^2$
The energy that is created in the core must get out of sun into space

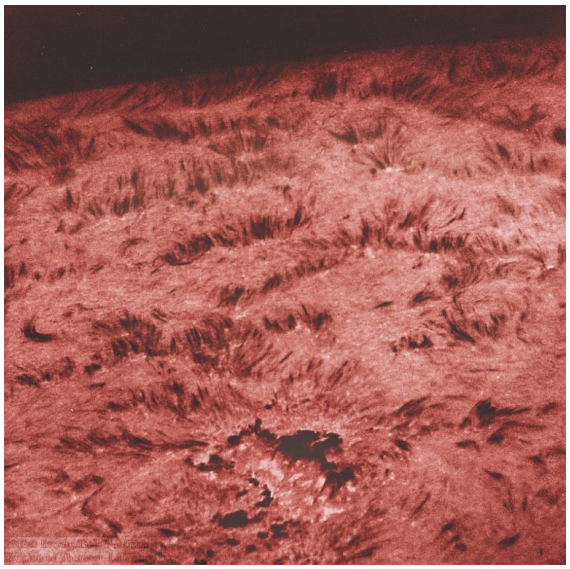
Radiative zone Transparent layer immediately outside the Sun's core
Energy tries to move outward, absorbed then reemitted in different direction

Convective zone Opaque layer outside the radiative zone to the surface
Fluid is heated from below, fluid becomes less dense, rises to the surface
Granulation is the tops of the convective cells
Millions of these on the surface

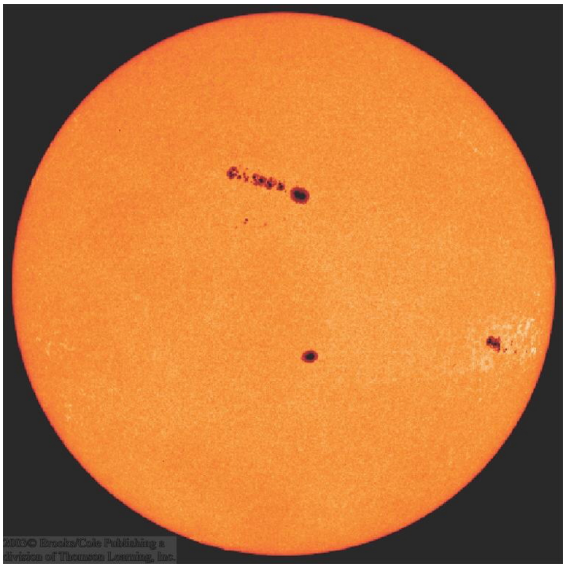




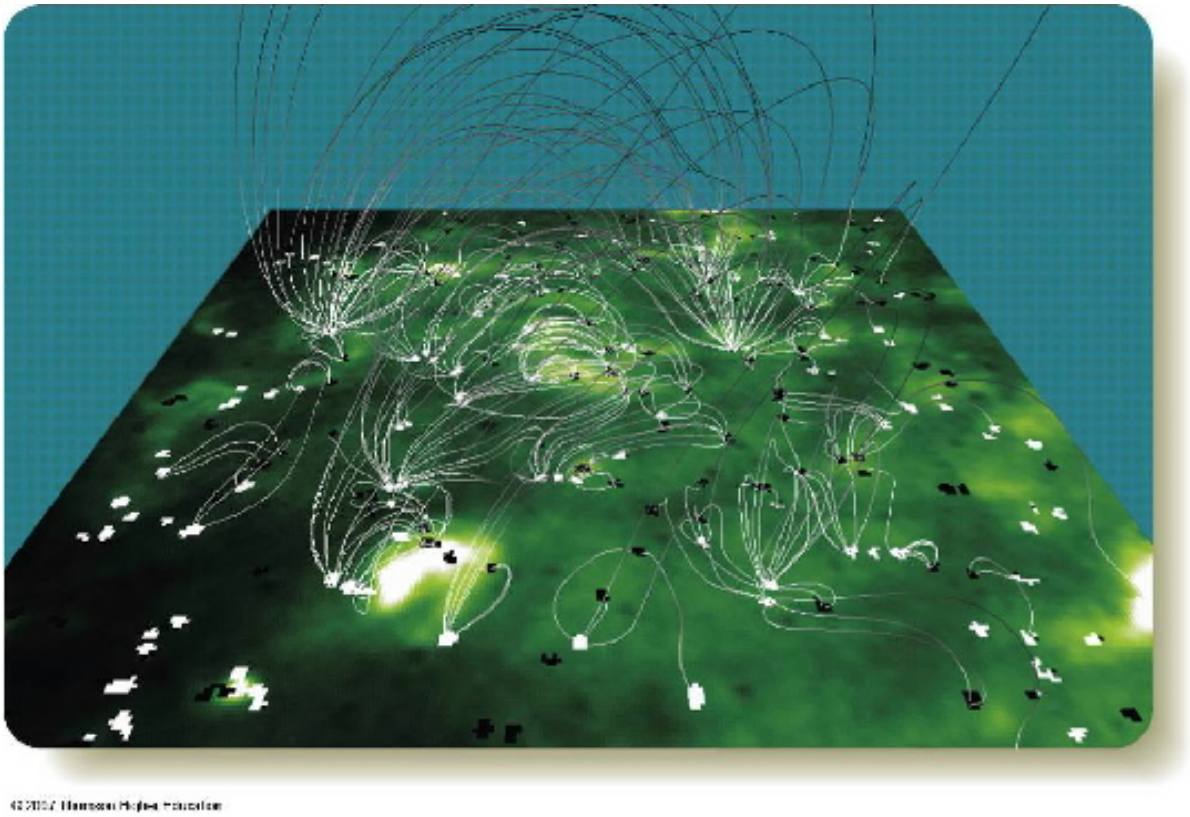
Photosphere Temperature - 5800 K
Sun's surface
Boundry between convective zone and atmosphere
Granulation
Spicules



Flares
Prominences
Sunspots



A closeup of the magnetic fields of Sun



1.1.2 Atmosphere

Chromosphere Mostly invisible gas, 1000 times fainter than photosphere

Temperature decreases for a short distance from the photosphere (6000 K) but increases at higher altitudes (1,000,000 K)

H - alpha filters detects light emitted by hydrogen atoms high in the chromosphere

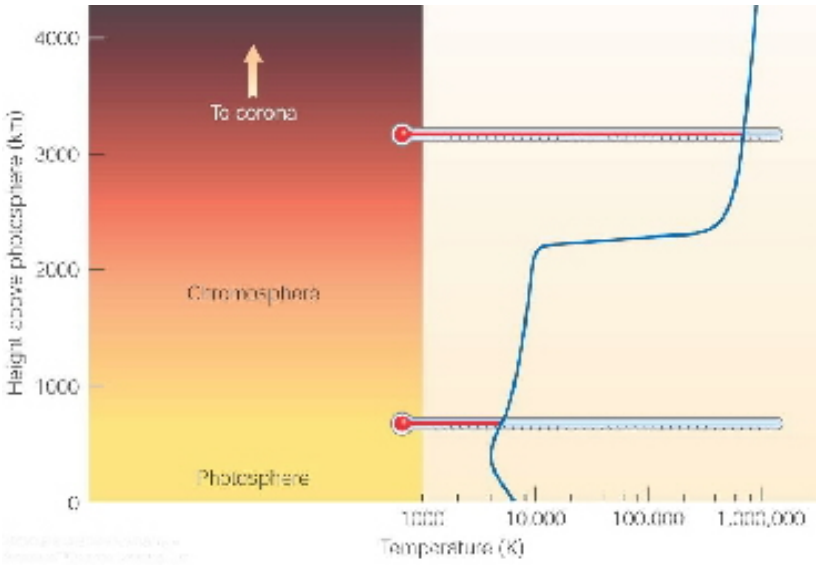
Spicules - extend into the chromosphere (about 12,000 km), cooler (10,000 K) than the surrounding chromosphere (500,000 K)

Corona

Upper-most atmosphere

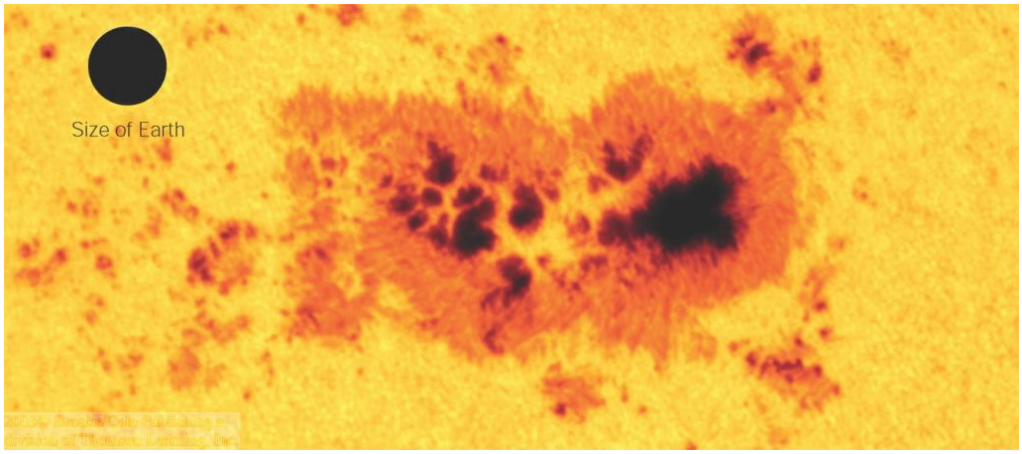
Temperatures around $500,000\,\mathrm{K}$ in lower corona, around $3,500,000\,\mathrm{K}$ in upper corona

Source of the solar wind - Sun losses 10^7 tons per year

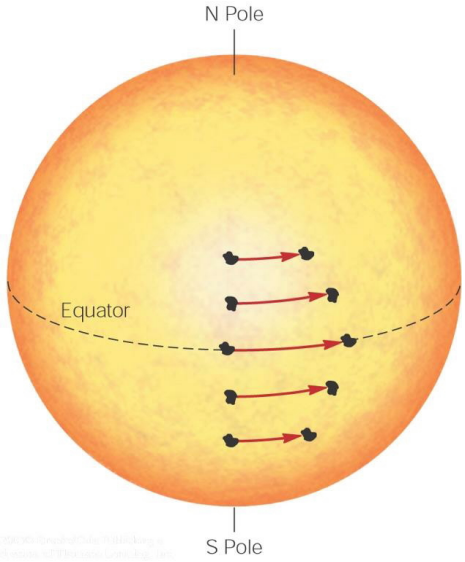


1.1.3 Solar Activity

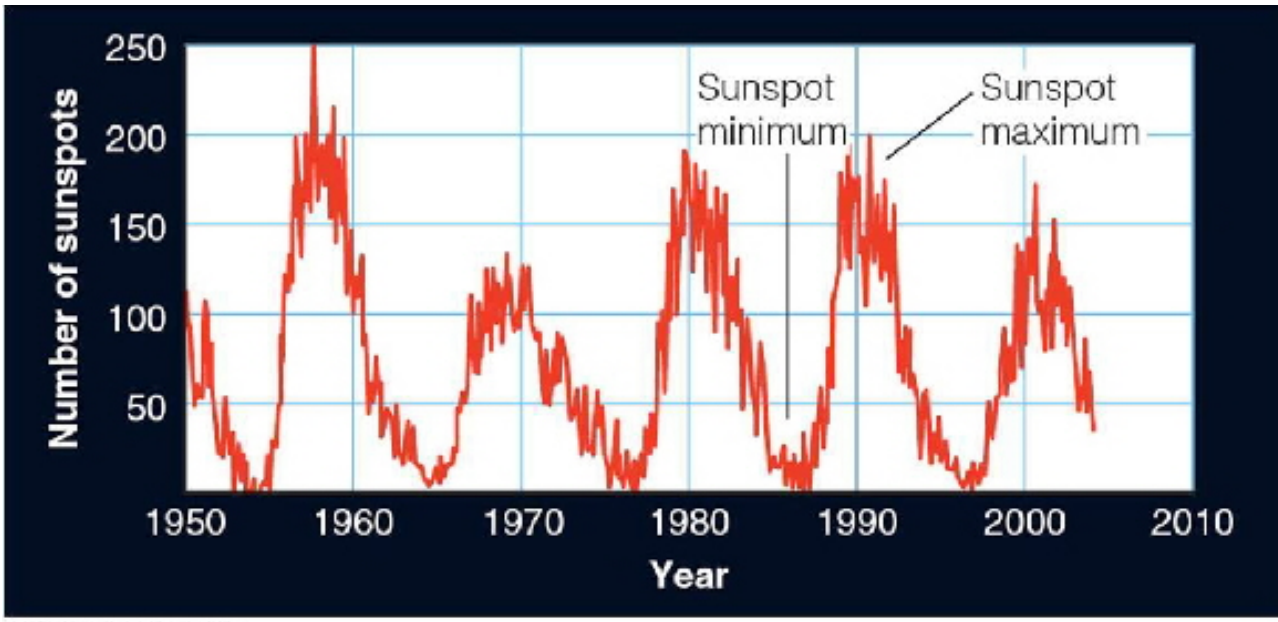
Sunspots

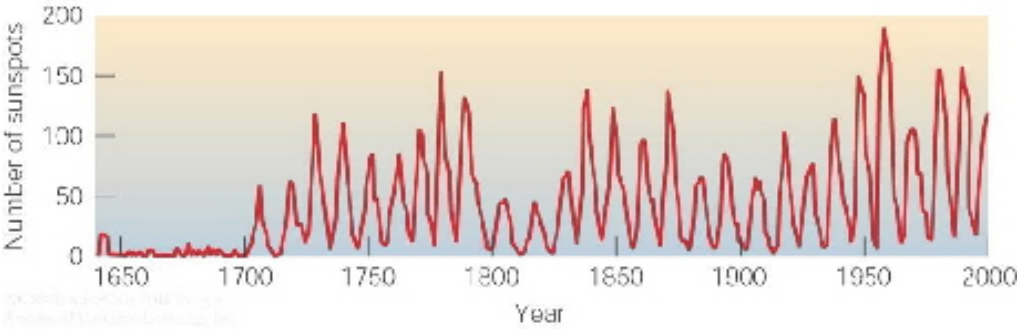


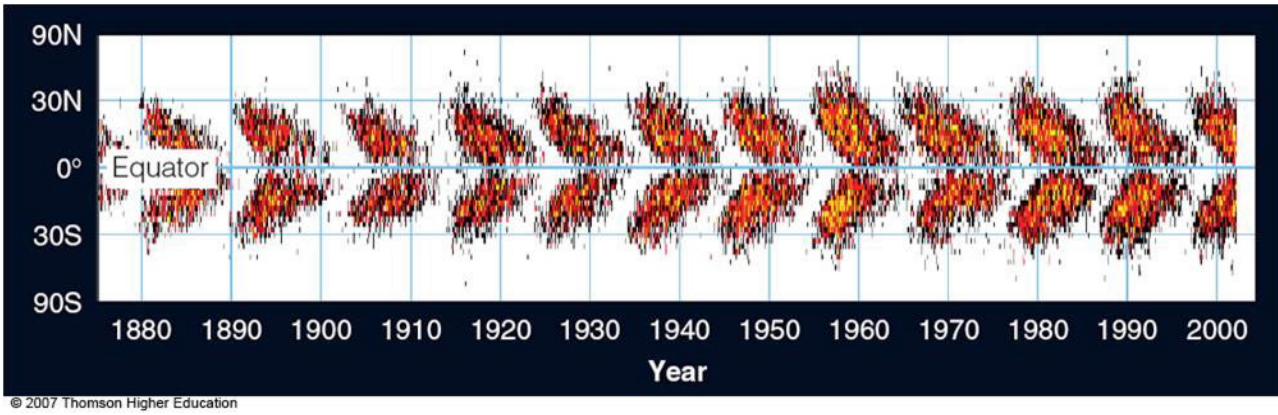
Cooler areas on the photosphere (center of a large sunspot - 4240 K)
Magnetic origins - form in pairs, one north pole - one south pole
Differential rotation



Dynamo Effect - Sun's interior
11 year cycle
22 year magnetic cycle

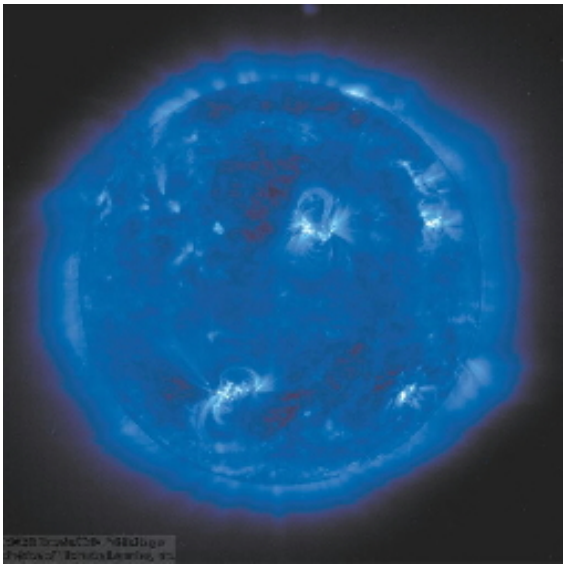






Other stars seem to have similar cyles - 107 Piscium seems to have sunspot cycle of 9 years

Prominences - follow magnetic field lines



Flares - Solar eruptions, may last an hour or less

1.1.4 Effects on Earth

Of course Sun provides Earth with all of its energy

Northern lights

Power outages

Solar constant Amount of energy arriving at Earth from Sun

Measure of solar output

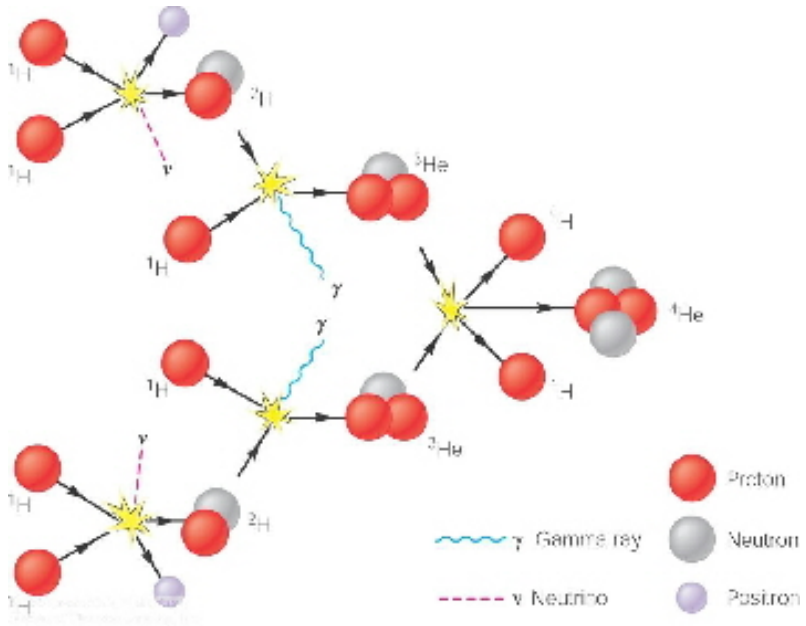
Solar constant (avg) = 1360 $\frac{\text{J}}{\text{m}^2\,\text{s}}$

Check out http://en.wikipedia.org/wiki/Sunlight

Measurement typically made above Earth's atmosphere by satellites

1.2 Nuclear Fusion

High temperatures (high velocities) allow the protons to overcome the Coulomb barrier (electromagnetic repulsion) of the protons (hydrogen nuclei) and fuse together to eventually form helium, **proton - proton chain reaction**



In the process of fusing hydrogen into helium a little bit of mass is turned directly into energy, $E = mc^2$

$$\begin{aligned} {}^1_1H + {}^1_1H &\longrightarrow {}^2_1H + e^+ + \nu \\ {}^2_1H + {}^1_1H &\longrightarrow {}^3_2He + \gamma \\ {}^3_2He + {}^3_2He &\longrightarrow {}^4_2He + {}^1_1H + {}^1_1H \end{aligned}$$

Basically, 4 hydrogen atoms come together to form 1 helium atom

Mass of 4 hydrogen atoms = 6.693×10^{-27} kg

Mass of 1 helium atom = 6.645×10^{-27} kg

Difference in mass, $m = 0.048 \times 10^{-27}$ kg

Energy of this one reaction, $E = mc^2 = \left(0.048 \times 10^{-27}\,\text{kg}\right)\left(2.99792458 \times 10^8\,\text{m}\,\text{s}^{-1}\right)^2 = 0.43 \times 10^{-11}\,\text{J}$

Sun needs 10^{38} reactions per second to generate the energy measured

Sun transforms 5 million tons of mass into energy every second
This fusion reaction takes place in a very small volume of Sun's interior core

Hydrostatic Equilibrium Two forces are at work
Inward pull of gravity
Outward push of the energy trying to escape
These two forces are equal but opposite in direction
Sun shines steadily

Neutrinos Theorized to exist many years before its discovery
Neutrinos do not interact with normal matter very well
Every second 10^{12} neutrinos pass through your body and Earth
Neutrino detectors - buried in mines