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The Sun



Facts about the Sun

- 1. The SUN is just ONE of about 100 billion STARS in our GALAXY the Milky Way.
- 2. It has a DIAMETER of 1,390,000 km or 865,000 miles
- 3. Its CORE temperature is 15 million ° C or 26 million F
- 4. Its SURFACE temperature is 5,500 °C or 10,000F. Cooler (3,800 °C, 7000F) surface areas are called SUN SPOTS.
- 5. It is the LARGEST object in the SOLAR SYSTEM and makes up 99.8% of the total MASS of the Solar System.
- 6. It consists of roughly 75% HYDROGEN and 25% HELIUM with trace elements up to IRON making up the rest.
- 7. The ENERGY output of the Sun is about 386 billion megawatts and is produced by NUCLEAR FUSION, using Hydrogen as fuel to create Helium.
- 8. Apart from HEAT and LIGHT, the Sun also emits a stream of CHARGED PARTICLES called the SOLAR WIND. The Solar Wind:-
 - a. - Causes Radio INTERFERENCE at certain times
 - b. - Produces the AURORA BOREALIS or "The NORTHERN LIGHTS"
 - c. - Causes the characteristic TAILS of COMETS.
 - d. - Alters the TRAJECTORY of SPACECRAFT
- 9. The Sun is about 4.5 BILLION YEARS old. It will probably continue to exist in its present FORM for about another 5 BILLION YEARS before RUNNING out of HYDROGEN.
- 10. There are 8 planets orbiting the SUN (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune)
- 11. There are thought to be over a million other thumbnail or larger sized objects left over from the formation of the Solar System orbiting the Sun.

How Big is it Compared to Other Objects?

①

Mercury < Mars < Venus < Earth



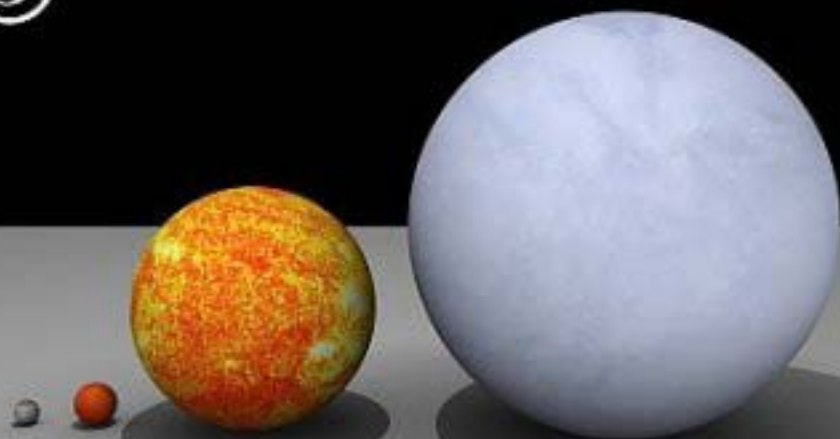
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Earth < Neptune < Uranus < Saturn < Jupiter



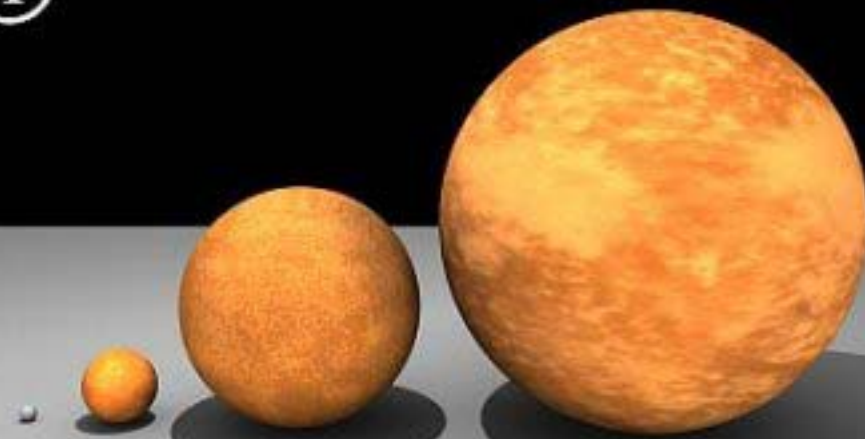
③

Jupiter < Wolf 359 < Sun < Sirius



④

Sirius < Pollux < Arcturus < Aldebaran



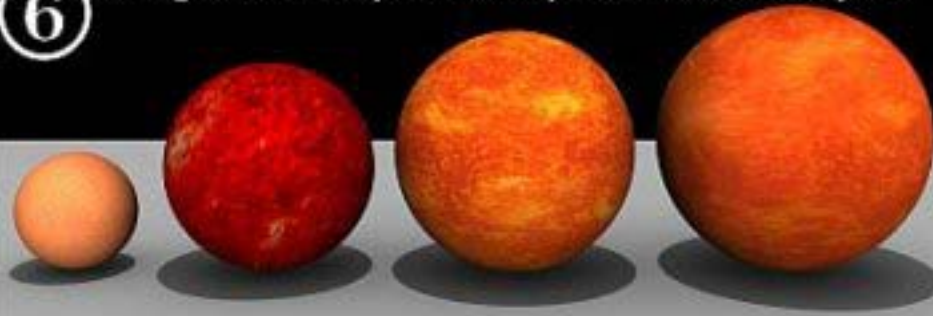
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Aldebaran < Rigel < Antares < Betelgeuse



⑥

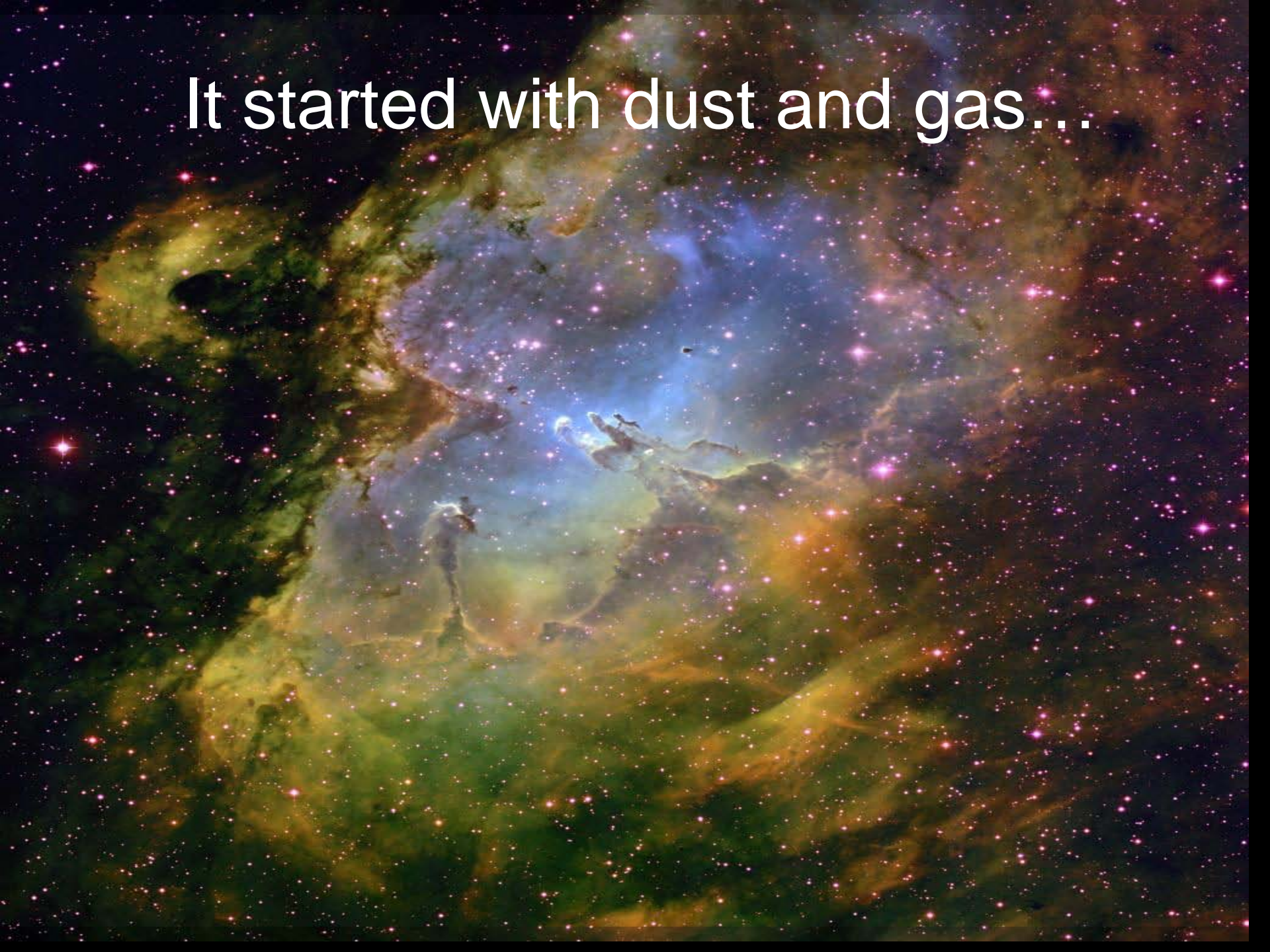
Betelgeuse < Mu Cephei < VV Cephei A < VY Canis Majoris



What does the Sun mean to you?

- Largest, brightest object in our sky
- Responsible for all life on Earth
- Huge round glowing ball of plasma
- Keeps us warm
- Lights our way
- Ever changing source of wonder to astronomers
- Makes a good nickname? Sunny, Sundawg, etc...
- How did it come to be?

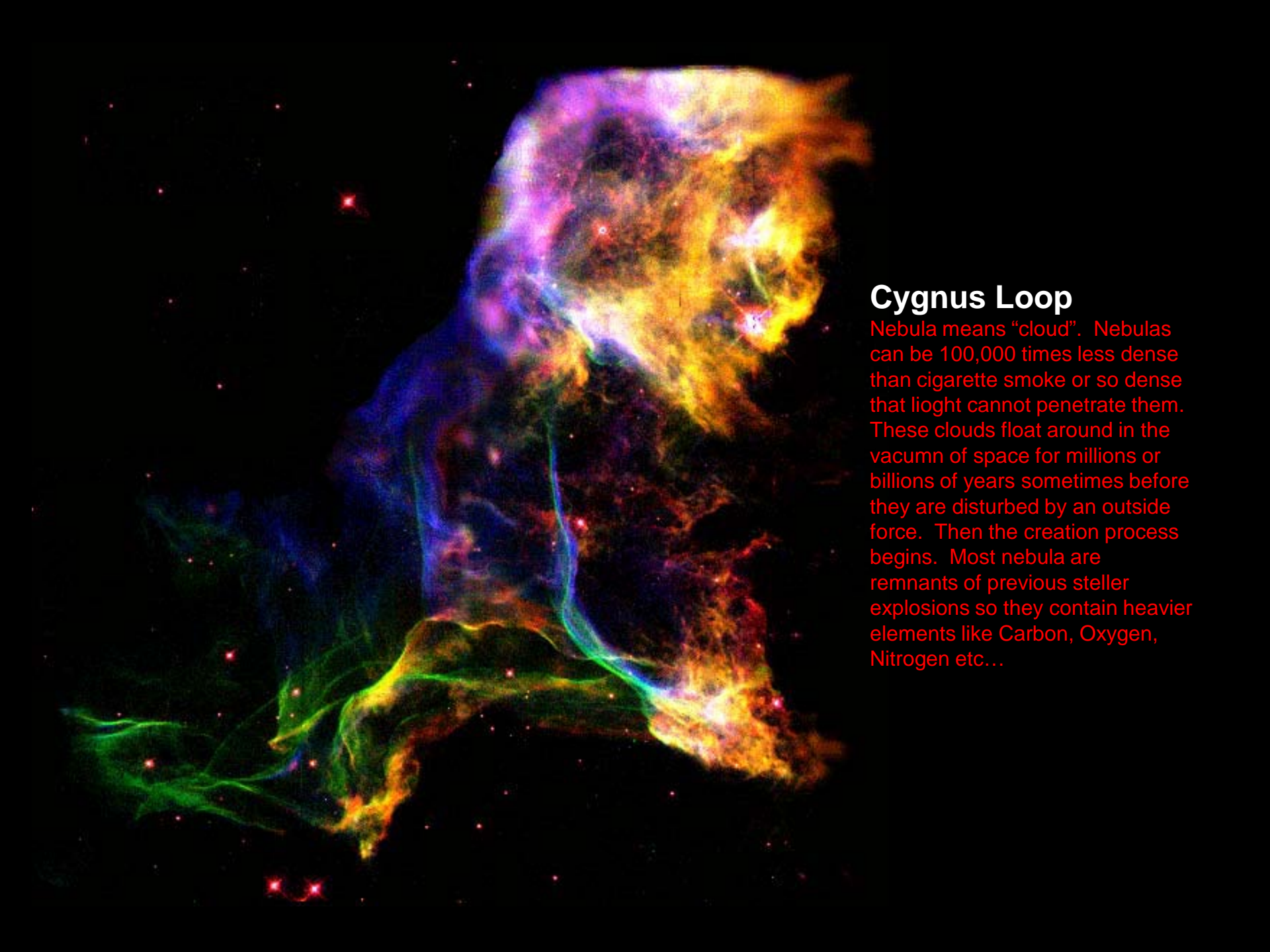
It started with dust and gas...



Dark clouds of dust and gas

Dark, dusty Horsehead nebula
silhouetted against a
background emission nebula.





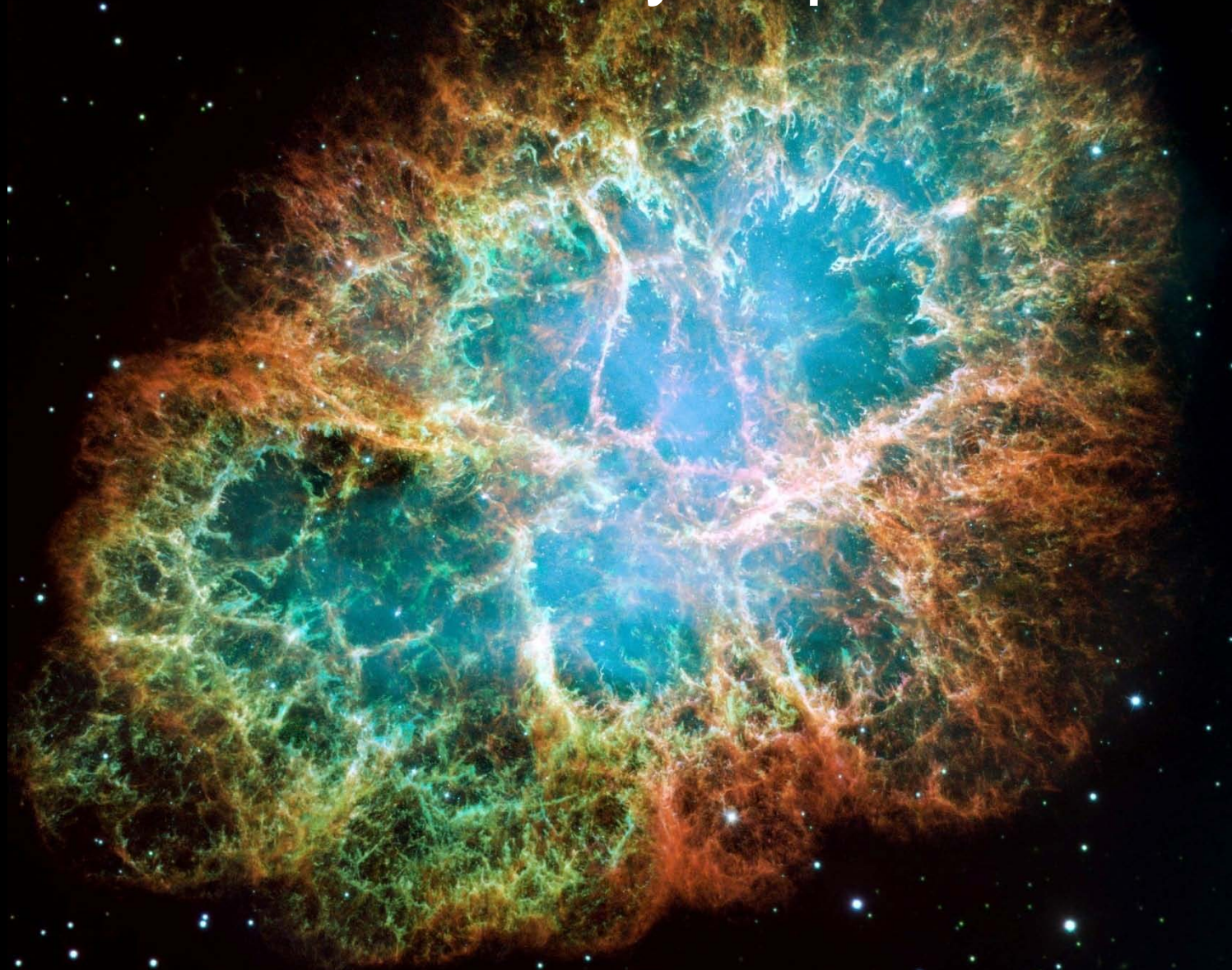
Cygnus Loop

Nebula means "cloud". Nebulas can be 100,000 times less dense than cigarette smoke or so dense that light cannot penetrate them. These clouds float around in the vacuum of space for millions or billions of years sometimes before they are disturbed by an outside force. Then the creation process begins. Most nebula are remnants of previous stellar explosions so they contain heavier elements like Carbon, Oxygen, Nitrogen etc...

There are several nebulae that are called molecular clouds because of their content of complex molecules. This nebula in the constellation Aquila is dense and cool enough so that it has formed mostly ethyl alcohol. Yes, Beer. Notice it is opaque because of its higher density.



add in a nearby supernova...



Supernova 1987a, Large Magellanic Cloud



Supernova 1987a in the Large Magellanic Cloud, shining brighter than an entire galaxy for several days. The explosion dispersed unburned hydrogen and heavy elements to the rest of space.



...or a passing star or shockwave



Gravitational collapse of dust and gas clouds

"Pillars" of dense, cold dust
and gas, in which new stars are
forming.

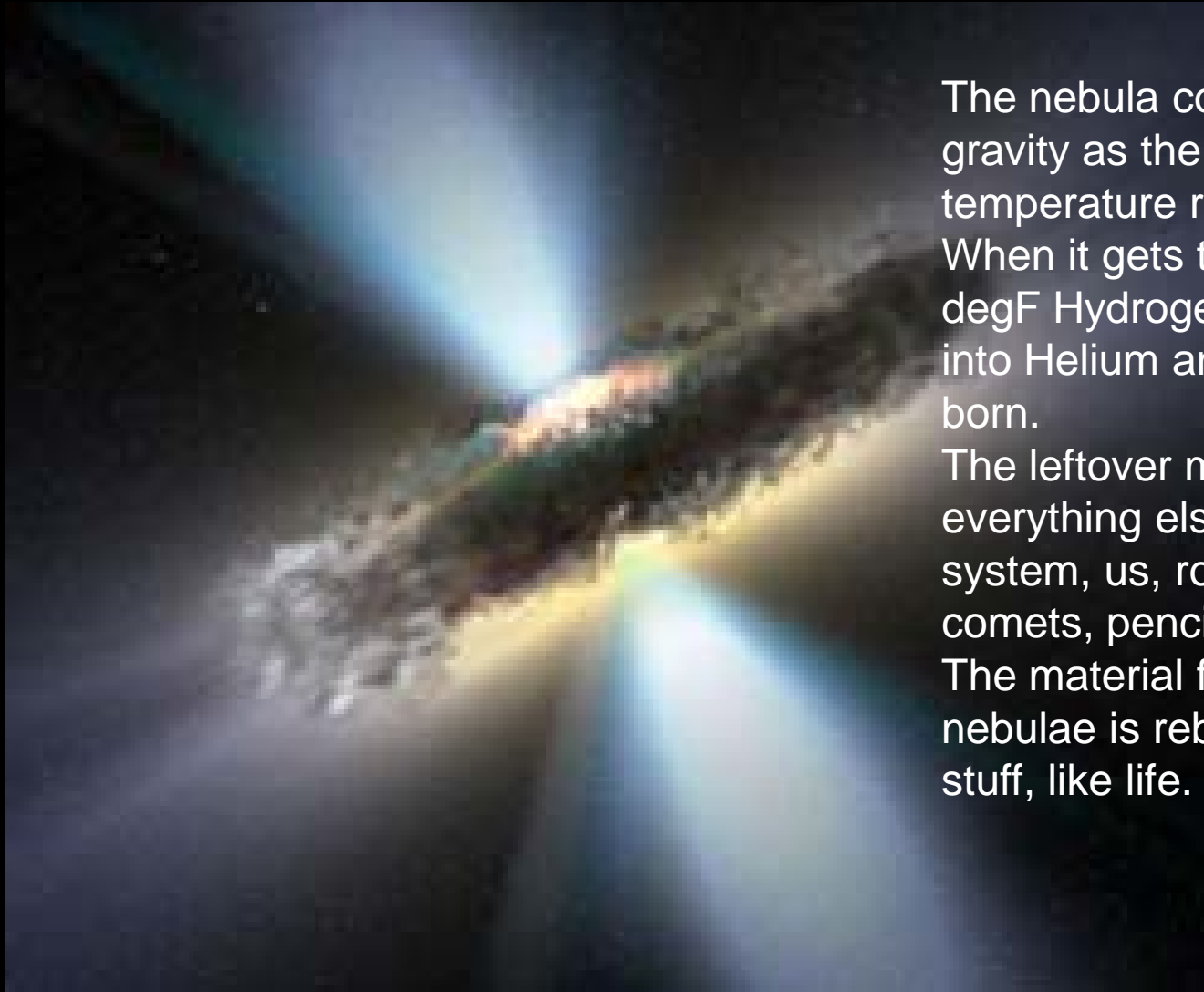


M42 (Orion Nebula)





Collapsing protostars forming in the interior of the Orion Nebula.



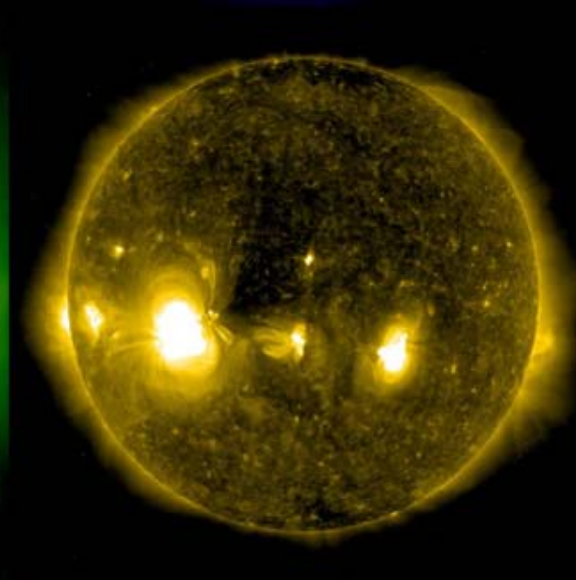
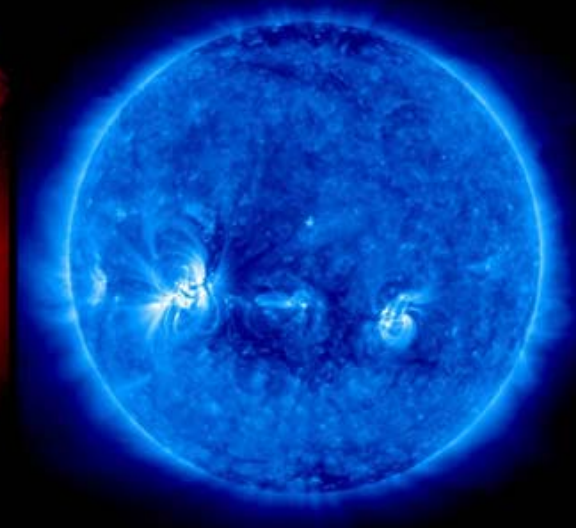
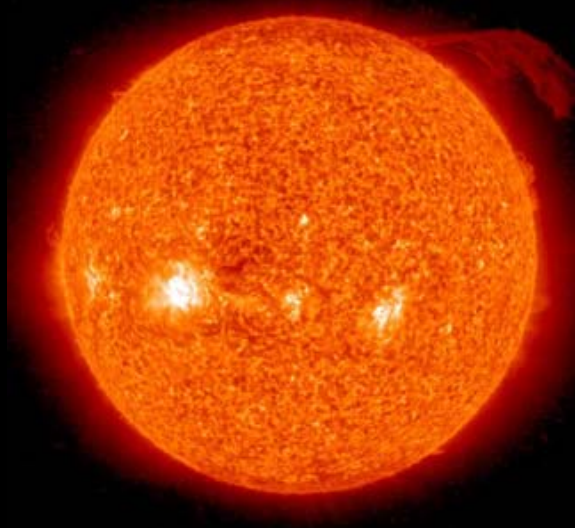
The nebula collapses due to gravity as the core temperature rises.

When it gets to around 25M degF Hydrogen starts to fuse into Helium and the Star is born.

The leftover materials make everything else in the solar system, us, rocks, planets, comets, pencils, steel, etc..

The material from the nebulae is reborn into new stuff, like life.

What exactly is the Sun?



75% Hydrogen

24% Helium

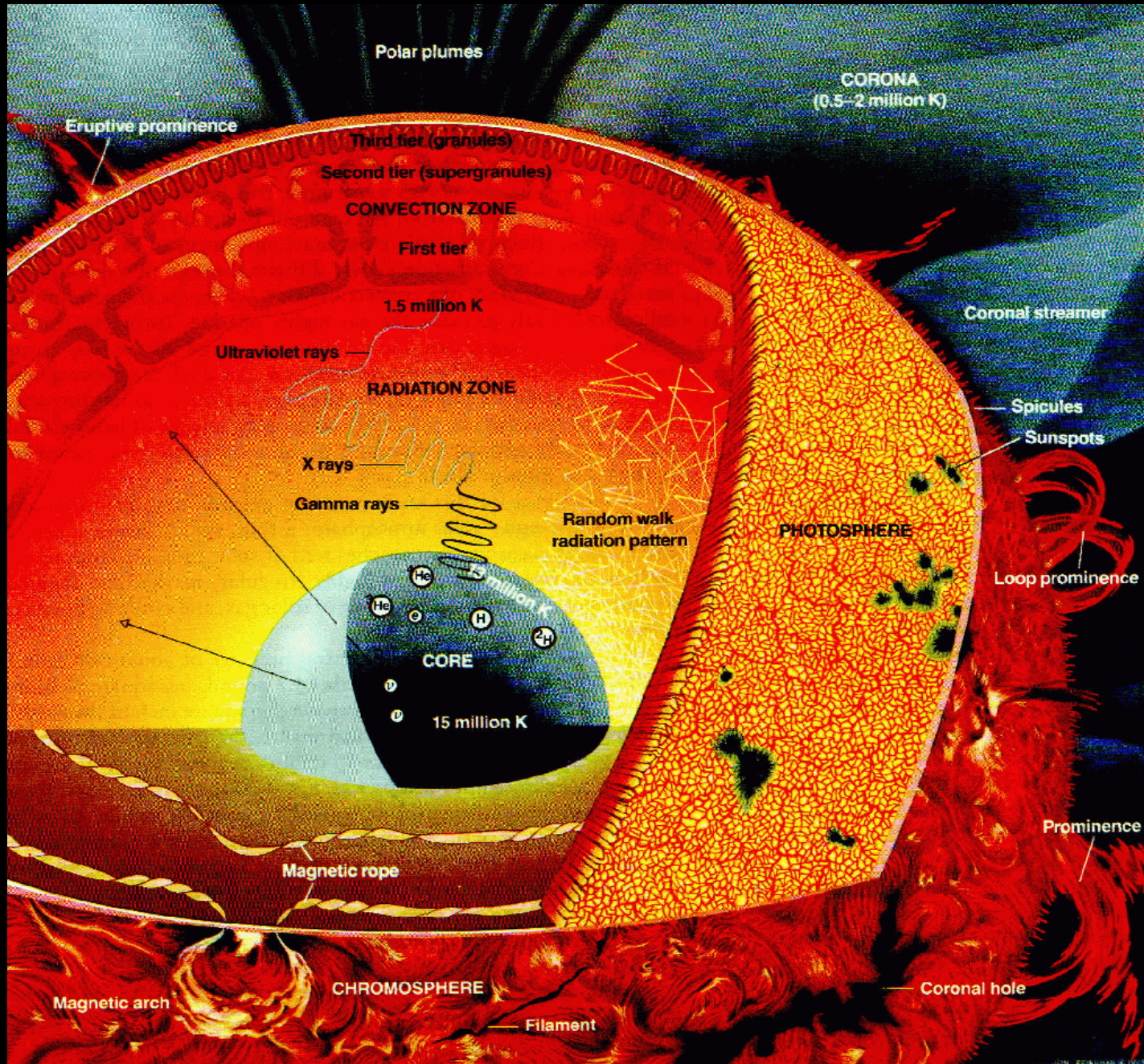
<1% heavier elements

This table of elements was constructed from analysis of the solar spectrum, which comes from the photosphere and chromosphere of the Sun. But it is thought to be representative of the entire Sun with the exception of the solar core because of the degree of mixing which takes place between the layers of the Sun's interior.

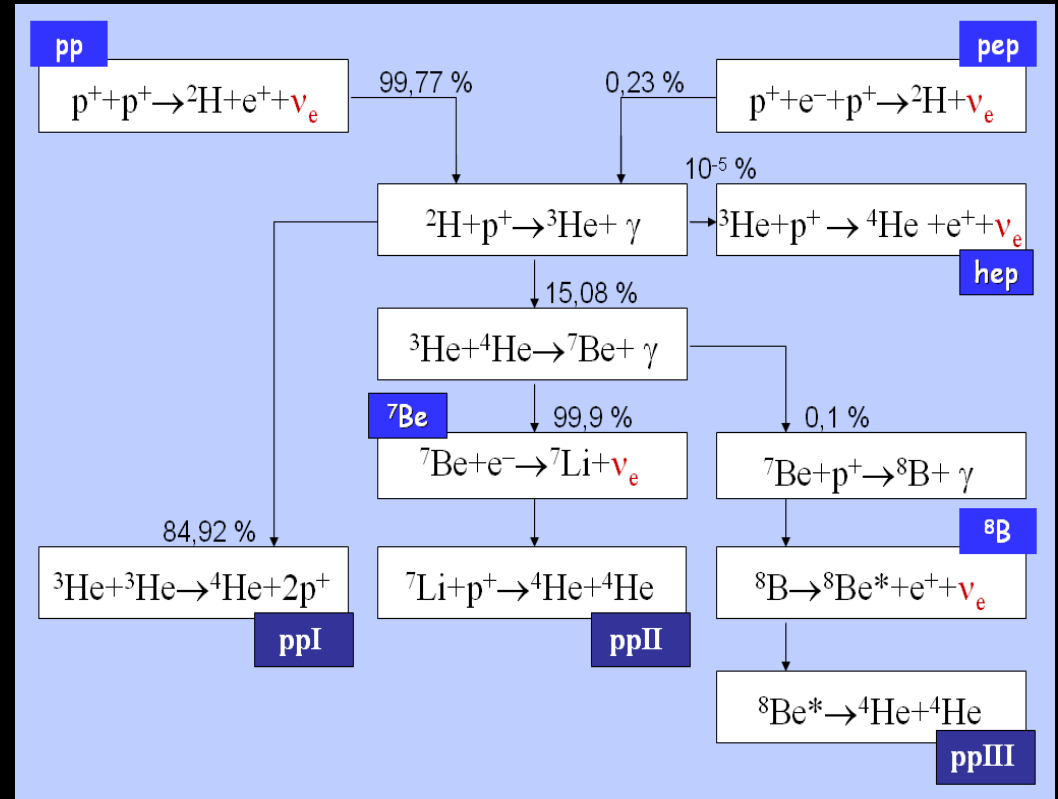
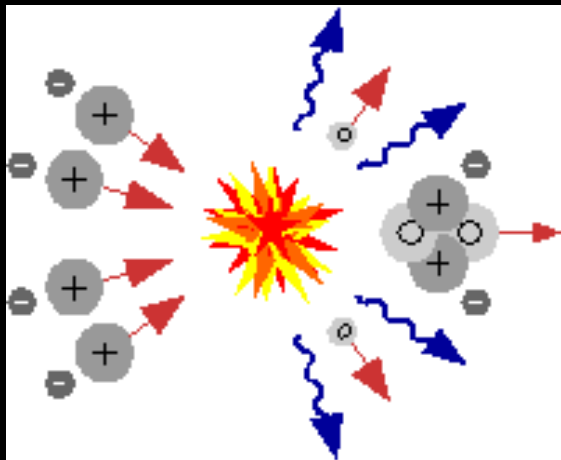
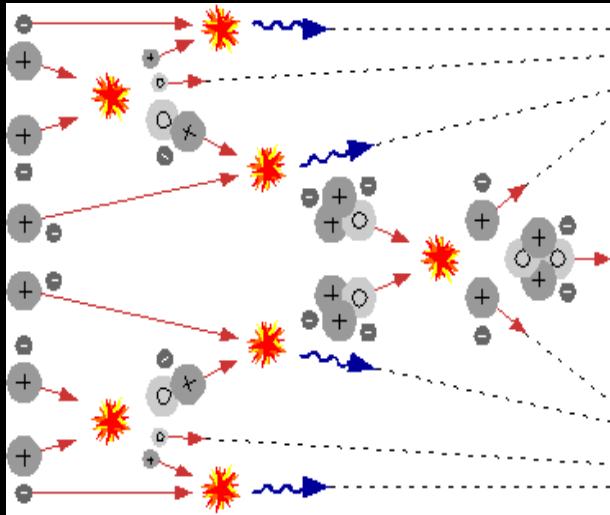
About 67 elements have been detected in the solar spectrum.

Element	Abundance (percentage of total number of atoms)	Abundance (percentage of total mass)
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	0.0030	0.14
Sulfur	0.0015	0.040

Inside the Sun

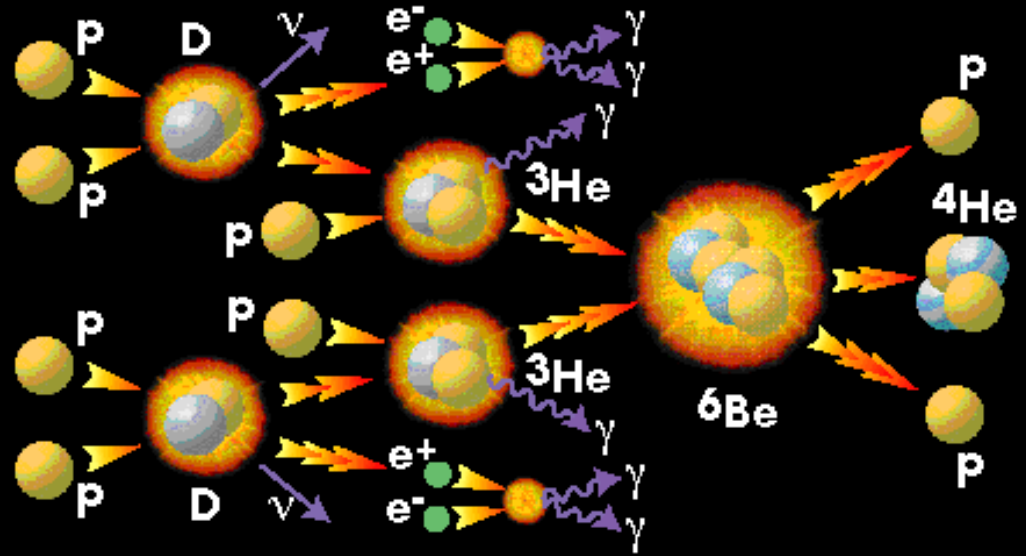


Nuclear Fusion in the Core



??????????

Solar Fusion



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H nucleus (p) made of one proton

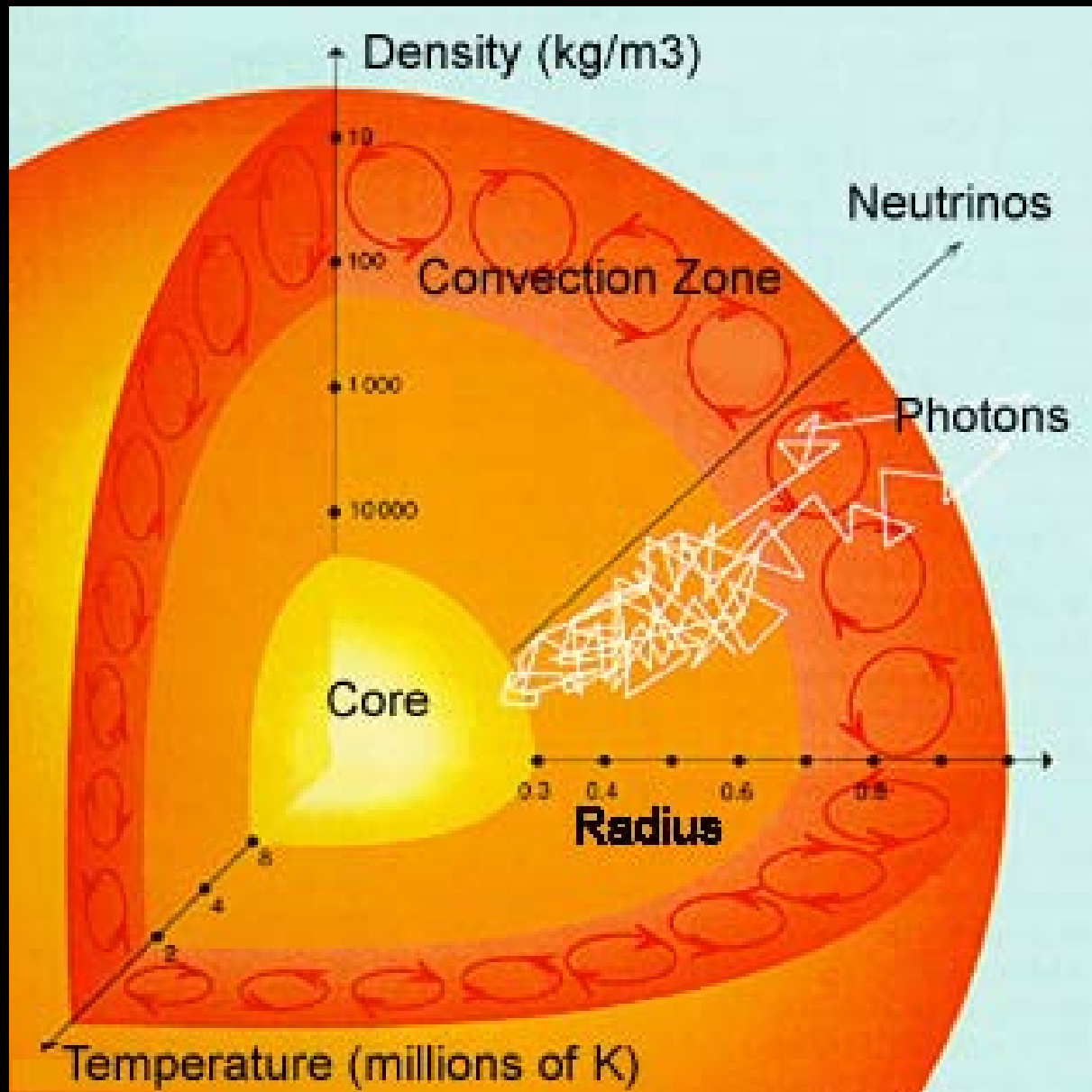


^4He nucleus (ppnn) made of two protons and two neutrons (called alpha particles)

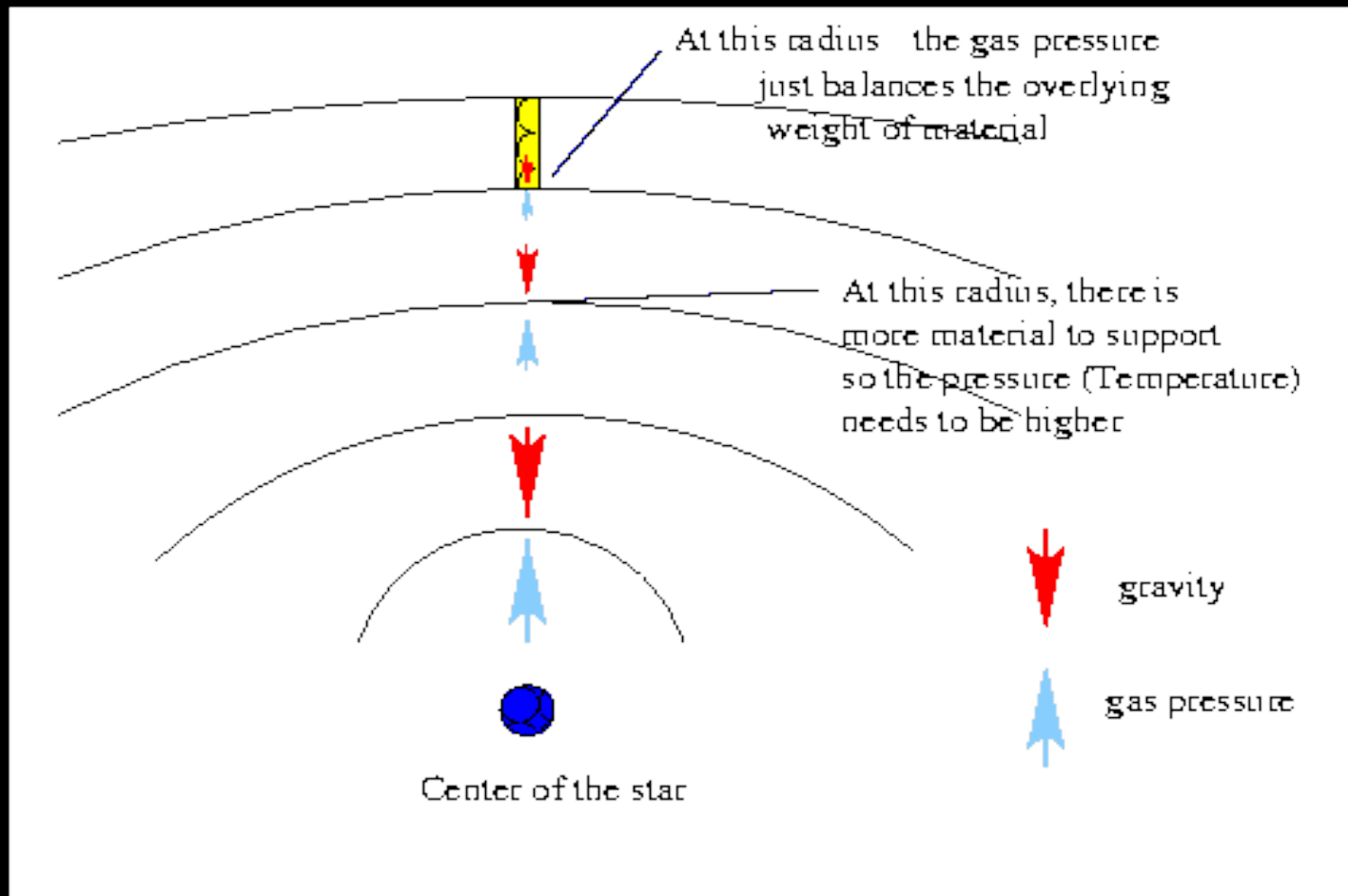
$$E = mc^2$$

The Sun puts out enough energy EVERY second of EVERY day to power all mankind's current energy needs for over 1 million years

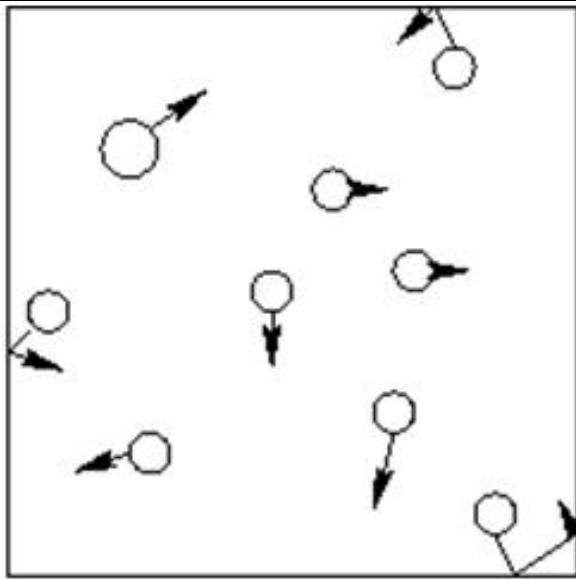
Gamma rays and Photons radiated out through the Sun's interior. Takes as much as 100,000+ years or as little as a few minutes.



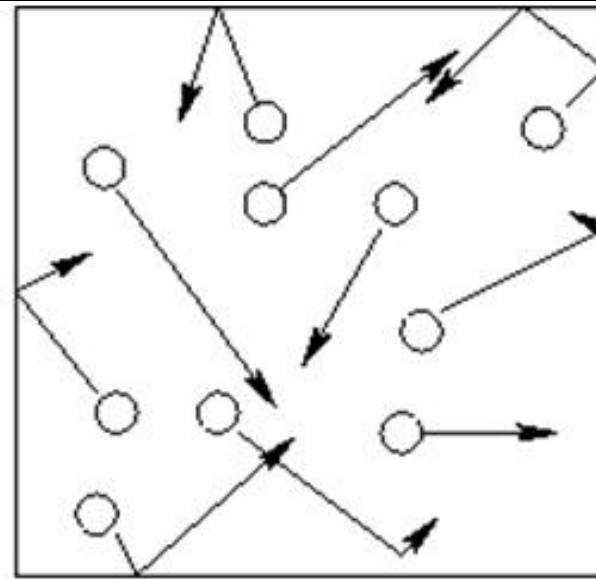
The Sun is almost a perfect sphere because of the mechanical balance between gravity causing collapse and gas pressure causing expansion.



The Sun's core is hotter because of the increased temperature and pressure. It takes 25 million degrees to start the Hydrogen fusion reaction.

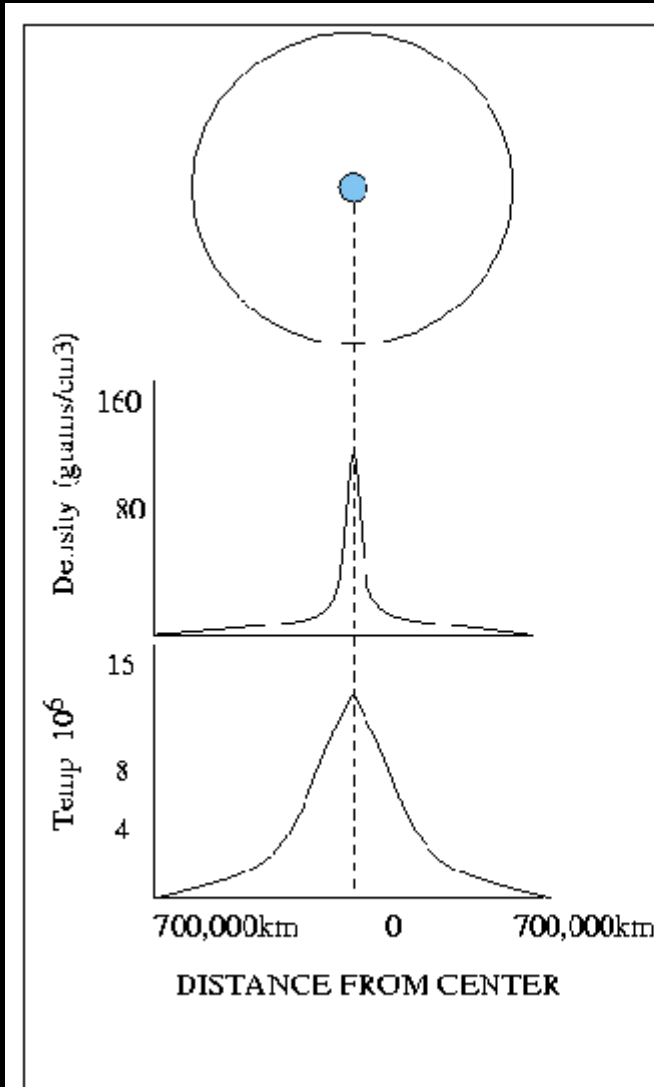


Cool gas, fewer and less energetic collisions



Hot gas, more and more energetic collision

The Sun's core is hotter because of the increased temperature and pressure.
It takes 15 million degrees K to start the Hydrogen fusion reaction.



$$T_c = 1.5 \times 10^7 \text{ K}$$

$$P_c = 3.4 \times 10^{11} \text{ atmospheres}$$

Note that the average Plasma Density of the Sun is $\frac{1}{4}$ that of the average Earth density.

Pretty close to the density of water.

685 million tons of hydrogen is converted to helium each second.

$$E=mc^2$$

**The Suns Energy each
second = 4,200,000,000
kw/sec X 186,000m/sec X
186,000m/sec**

or

3.8×10^{26} Watts

380,000,000,000
,000,000,000,00
0,000

Watts per Second





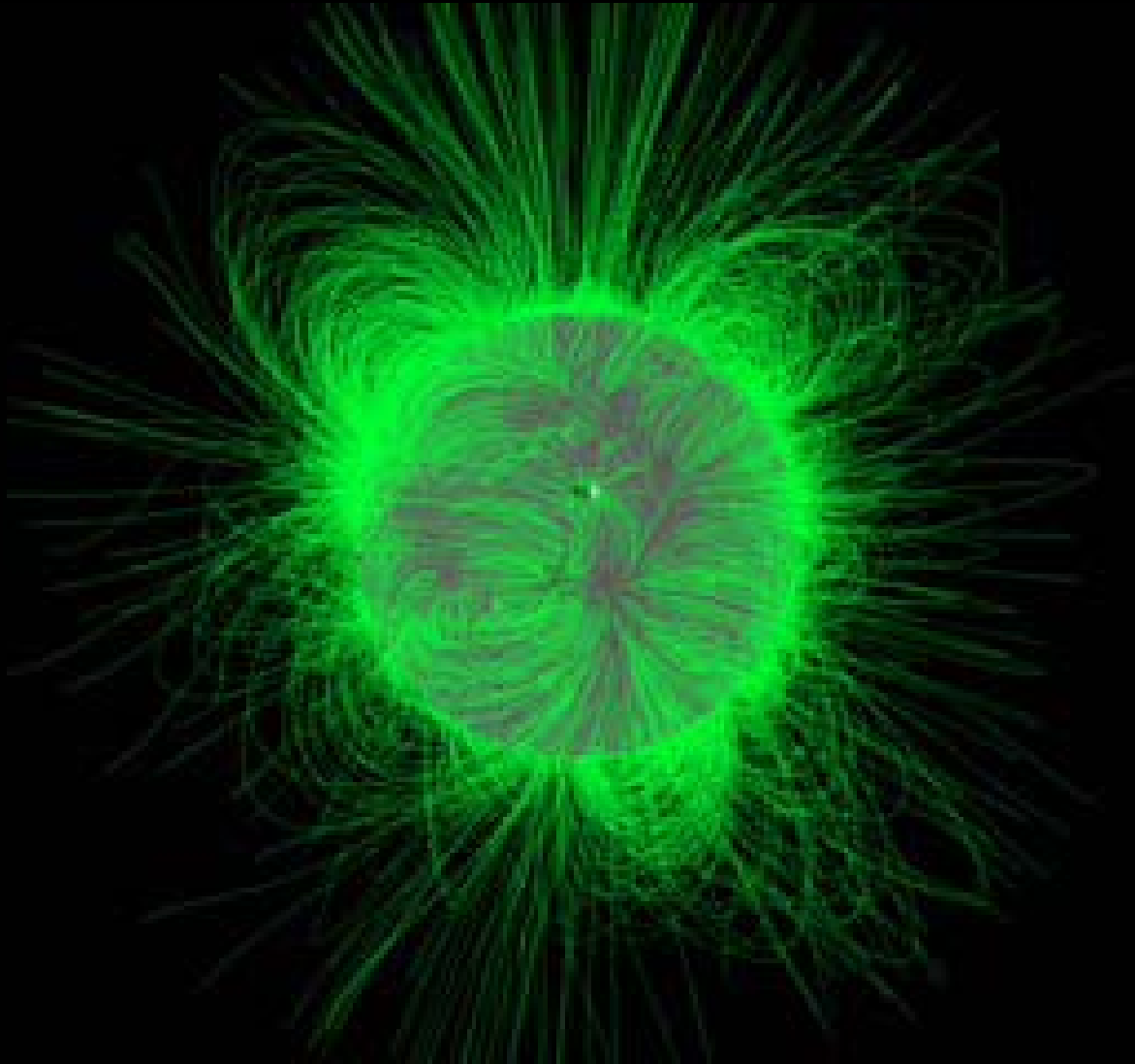
The Moon does
not emit light.

What are you
seeing here?

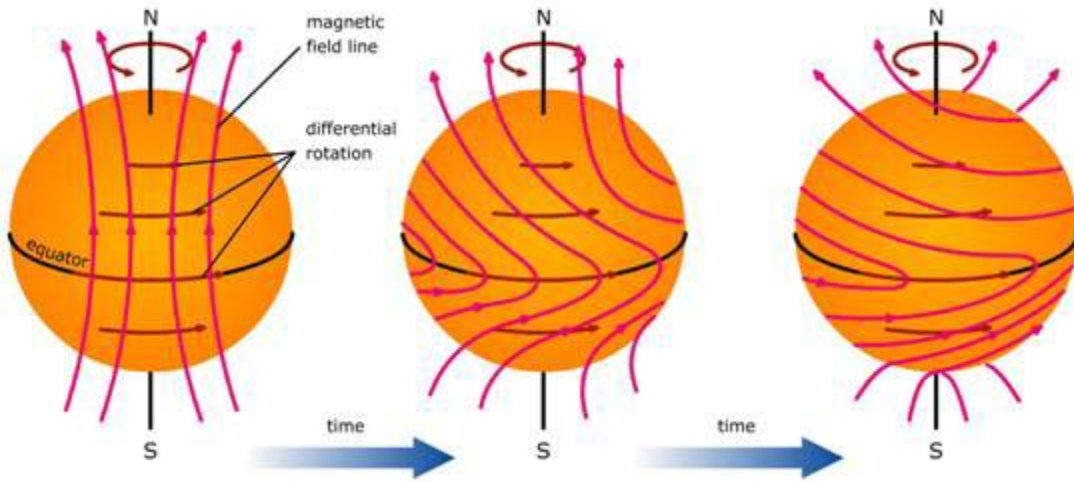
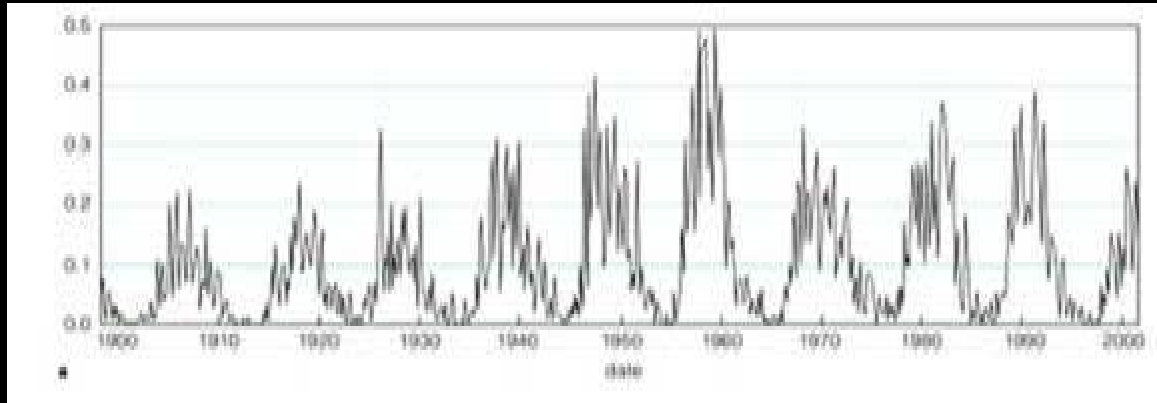
Only stars emit
light in the sky.

Everything else
reflects or
absorbs it.

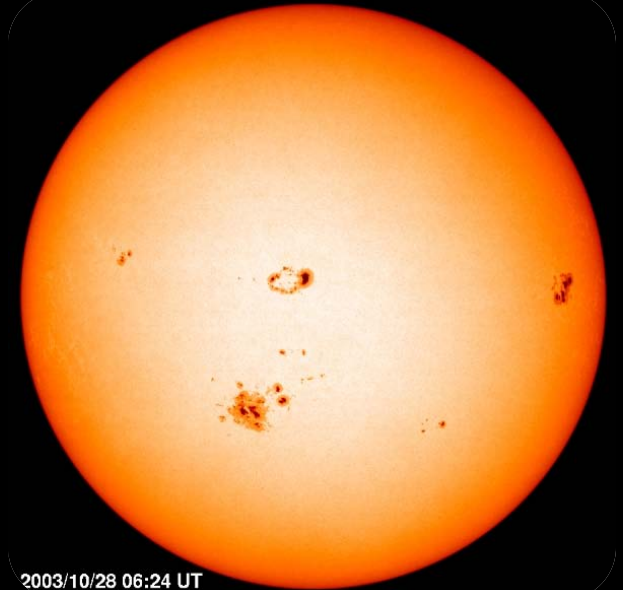
Magnetic Fields



The Solar Cycle



The number of Sunspots and solar flares increase and decrease on an 11-year cycle.



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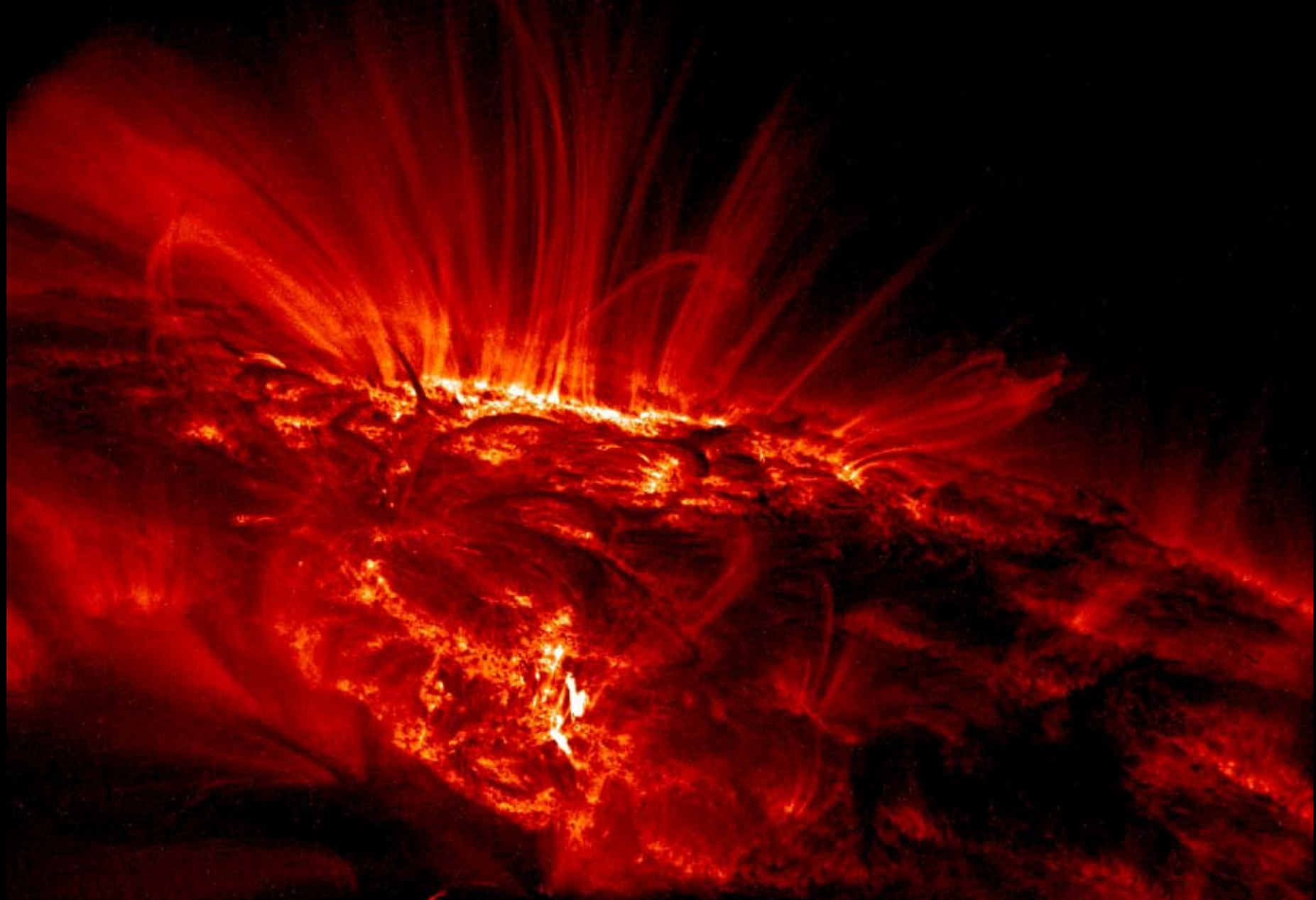
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The Sun's magnetic field becomes more and more twisted and complex from differential rotation. It finally breaks and flips every 11 years. So the total cycle is really 22 years from start to finish.

Sunspot Formation



Solar Flares and Prominences



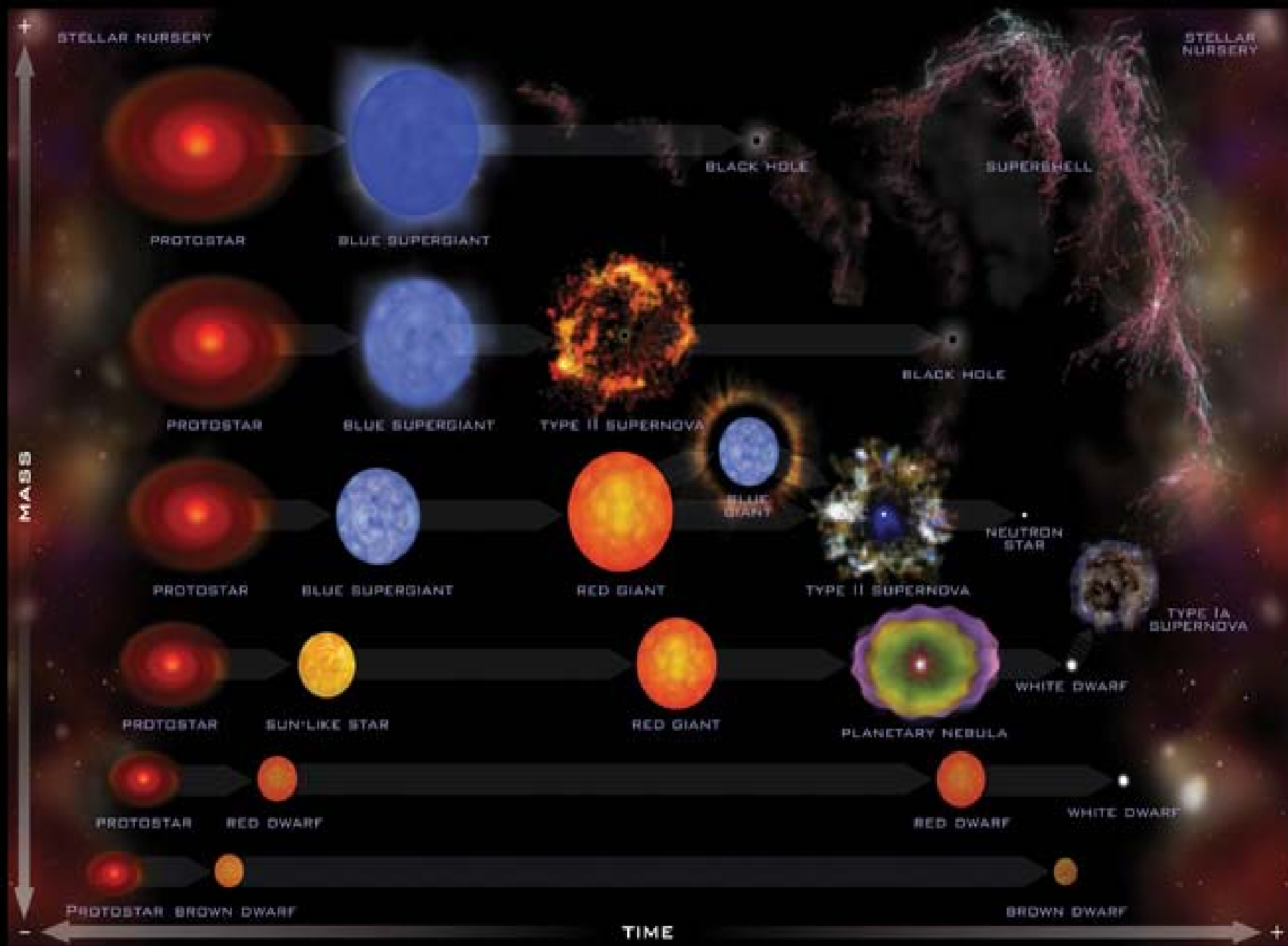
Solar Maximum



Death of the Sun

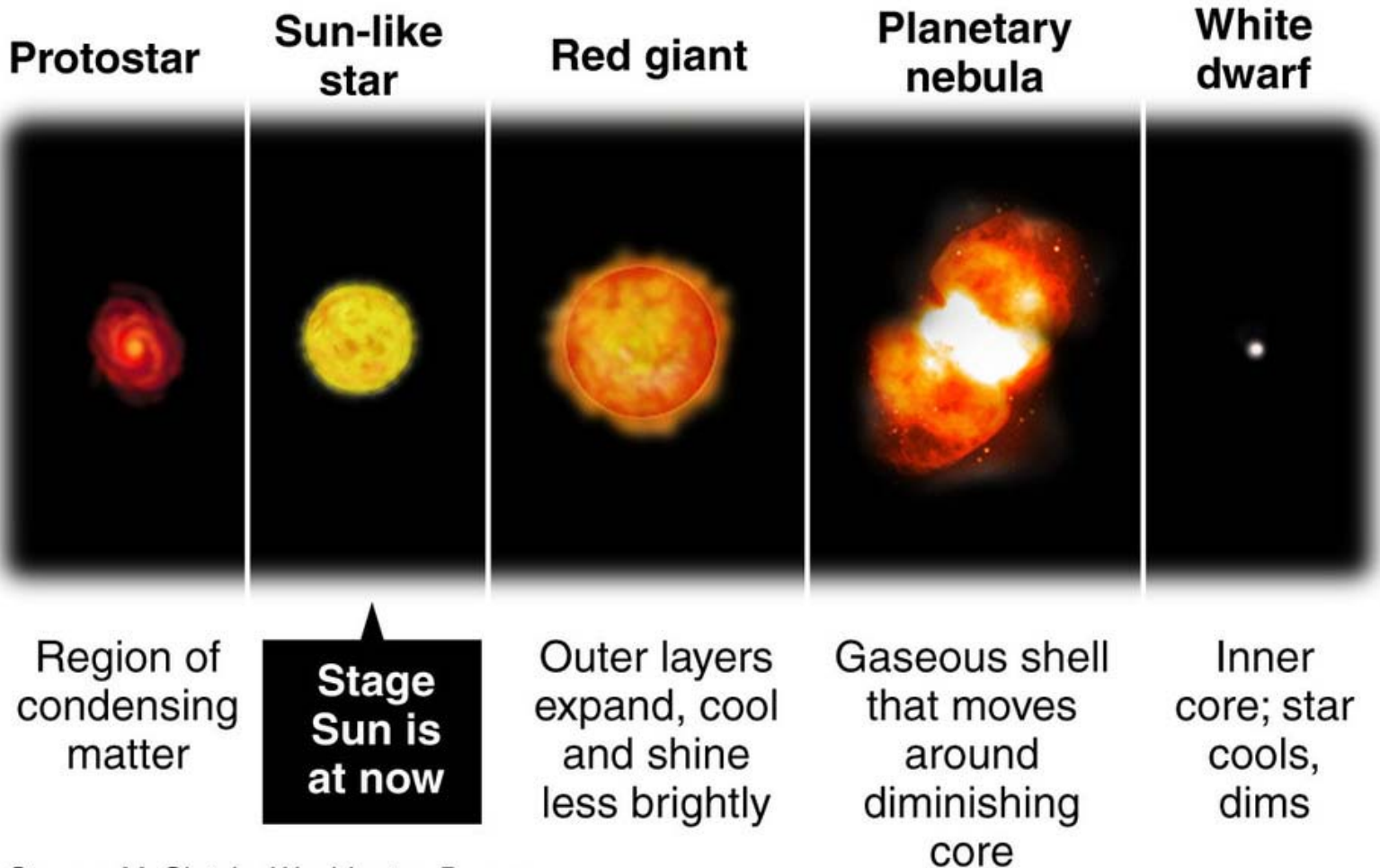


Stellar fusion reactions gradually convert hydrogen into helium through the p-p chain. When a star runs out of hydrogen fuel, it either stops burning (becoming a dwarf star) or, if it is large enough (so that gravity compresses the helium strongly) it begins burning the helium into heavier elements. Because fusion reactions cease to release energy once elements heavier than iron are involved, the larger stars also eventually run out of fuel, but this time they collapse in a supernova. Gravity, no longer opposed by the internal pressure of fusion-heated gases, crushes the core of the star, forming things like white dwarfs, neutron stars, and black holes (the bigger the star, the more extreme the result).



The fate of the Sun

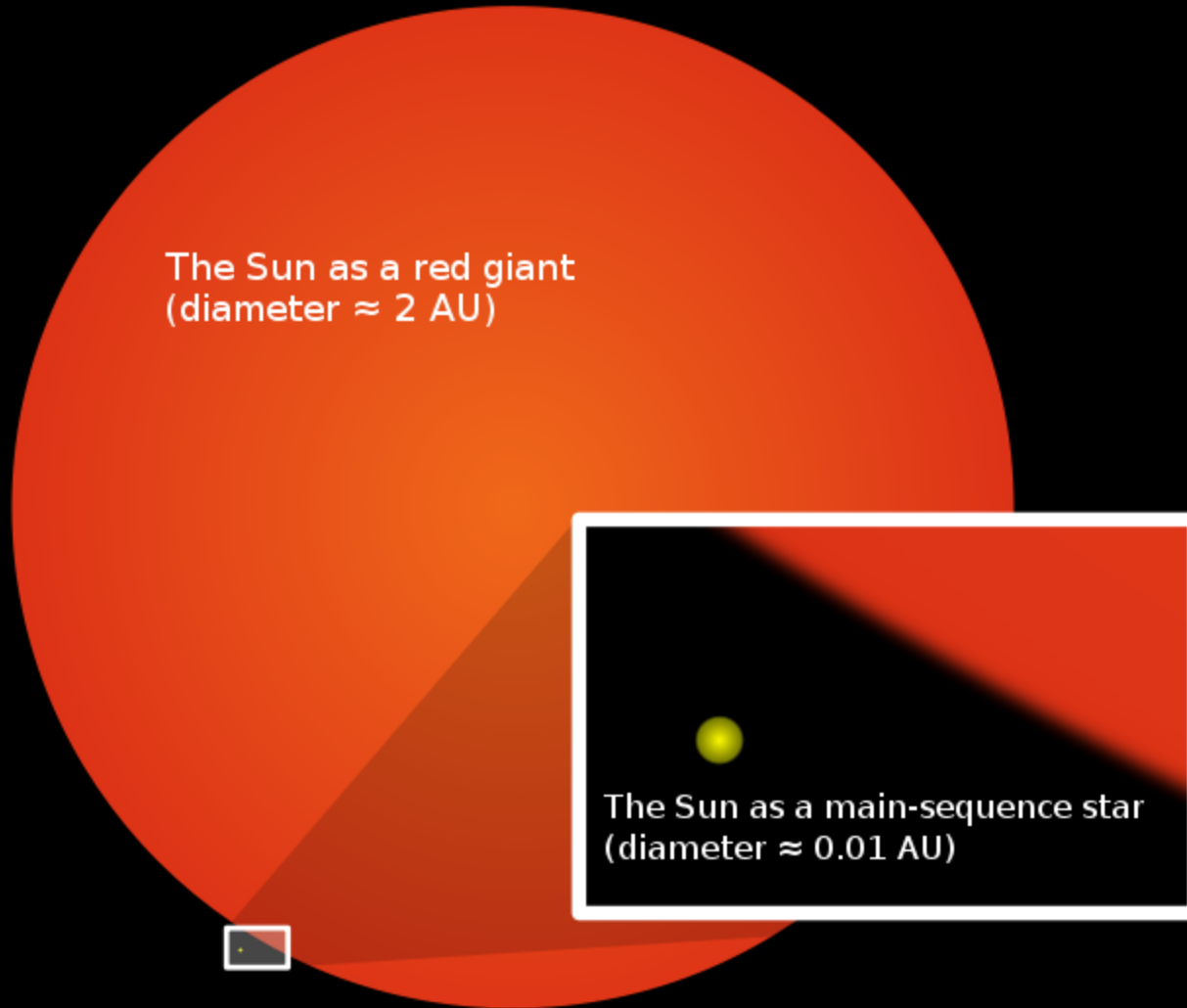
*About 4 billion years from now, the Sun will slowly fade and burn out.
The life cycle of stars, including the Sun:*



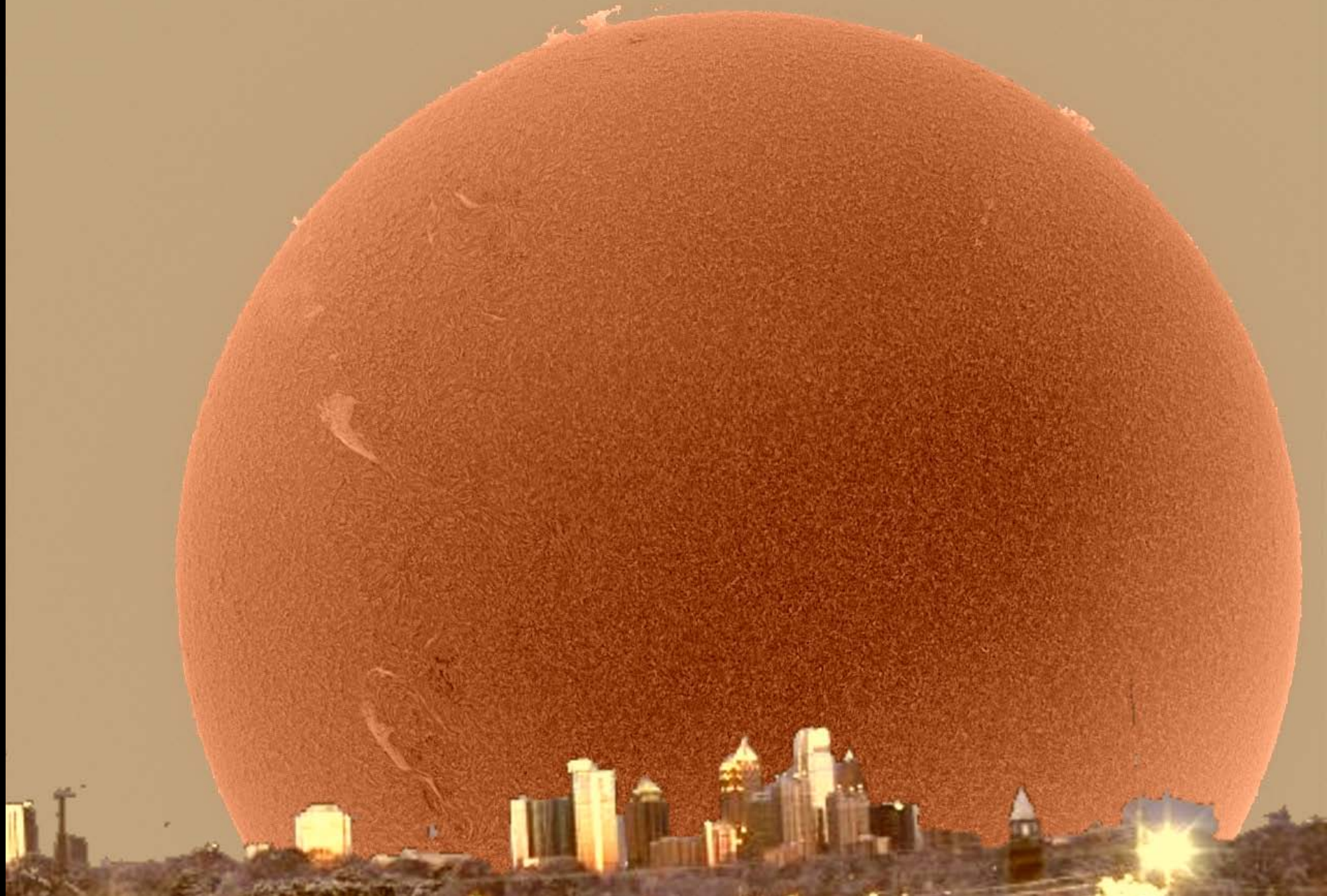
Source: McClatchy Washington Bureau
Graphic: Lee Hulting, Judy Treible

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Red Giant Stage



LOOKS LIKE IT'S GONNA BE A HOT ONE TODAY IN BUCKHEAD...



About 5-9 billion years left...

The Mayans and 2012 have
nothing to do with the death of
our Star or anything else.

Don't believe the hype.

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WHITE LIGHT GLASS FILTER



WHITE LIGHT BAADER FILM

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Hydrogen Absorption Spectrum

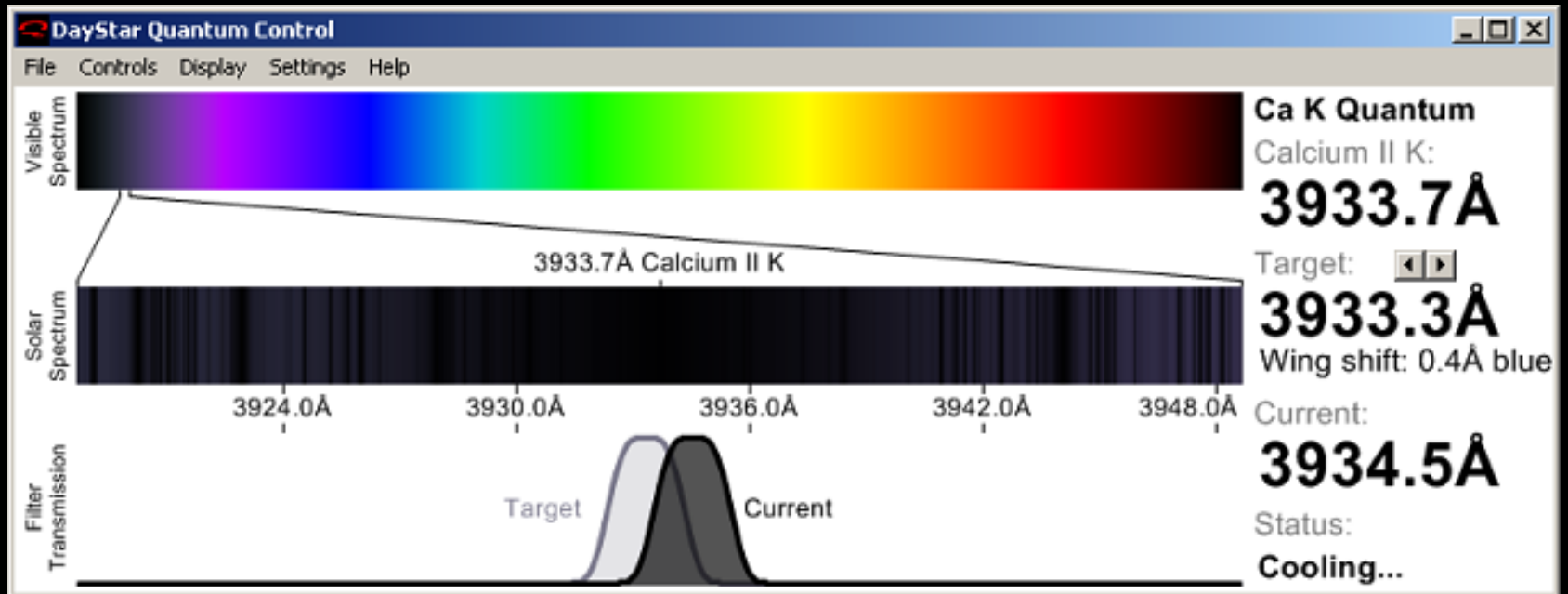


Hydrogen Emission Spectrum



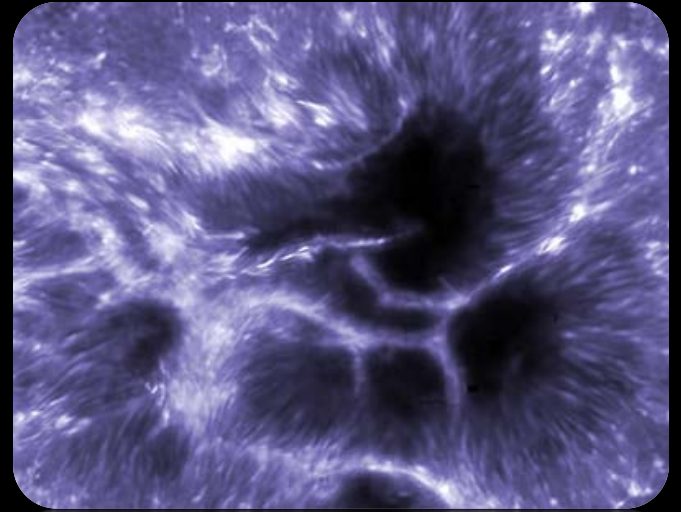
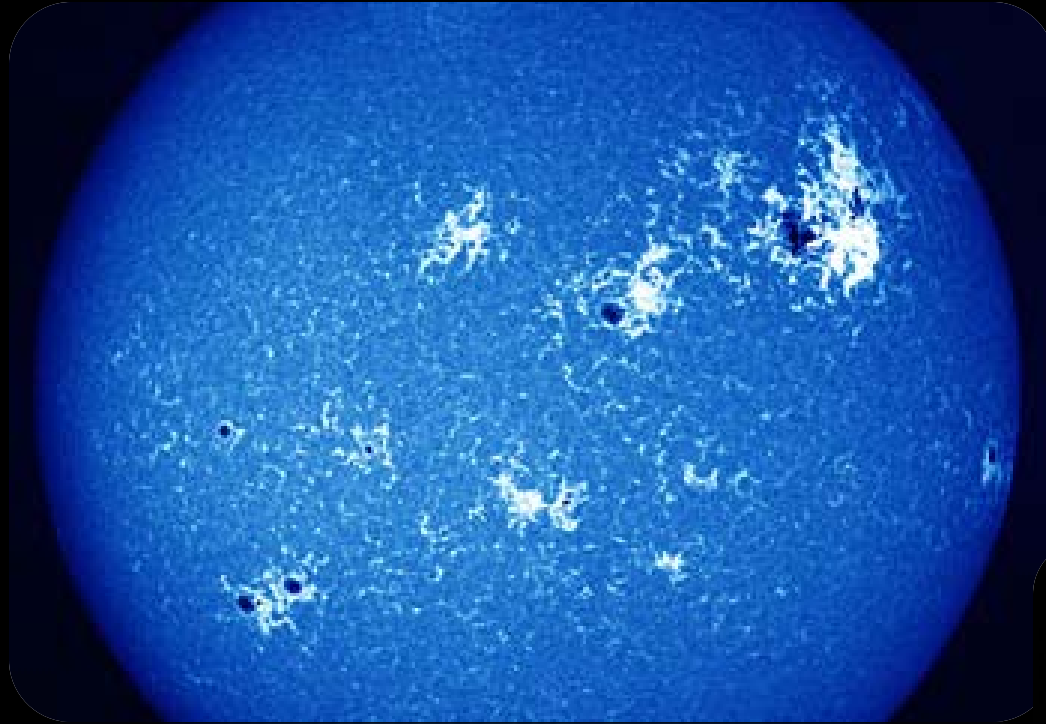
HYDROGEN A LINE EMISSIONS

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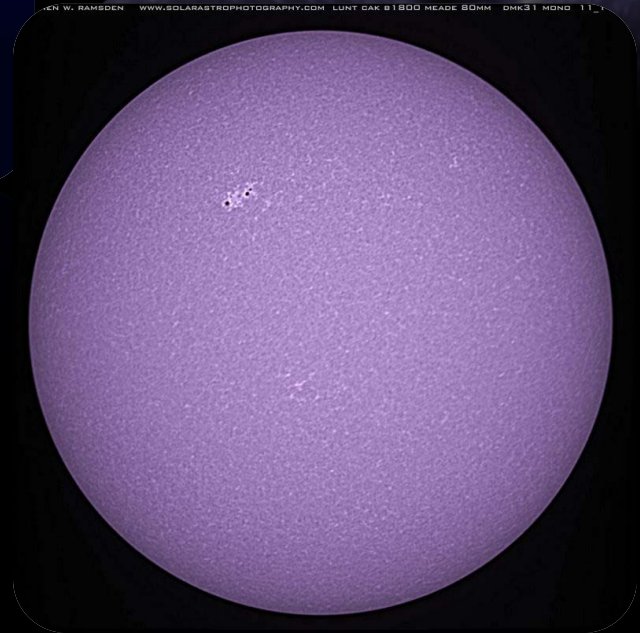


CALCIUM K LINE EMISSIONS

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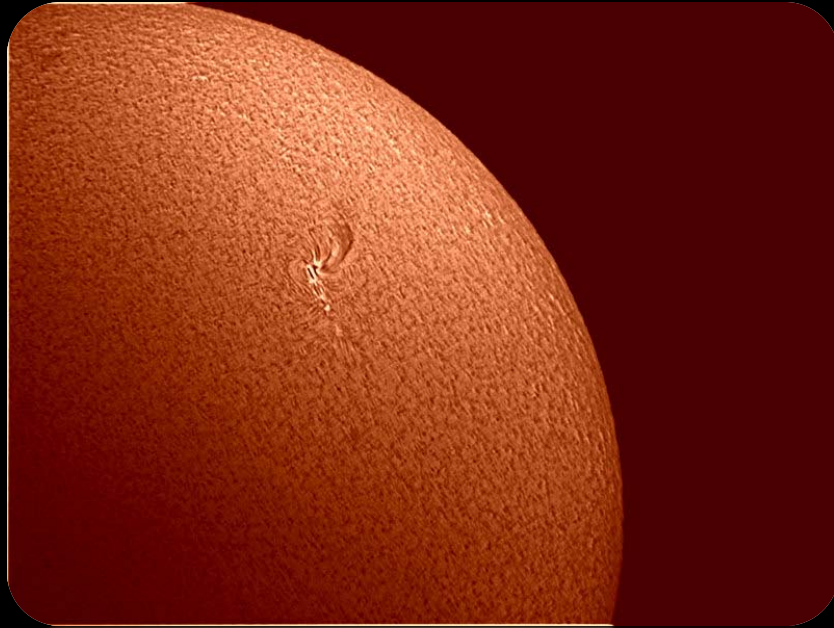


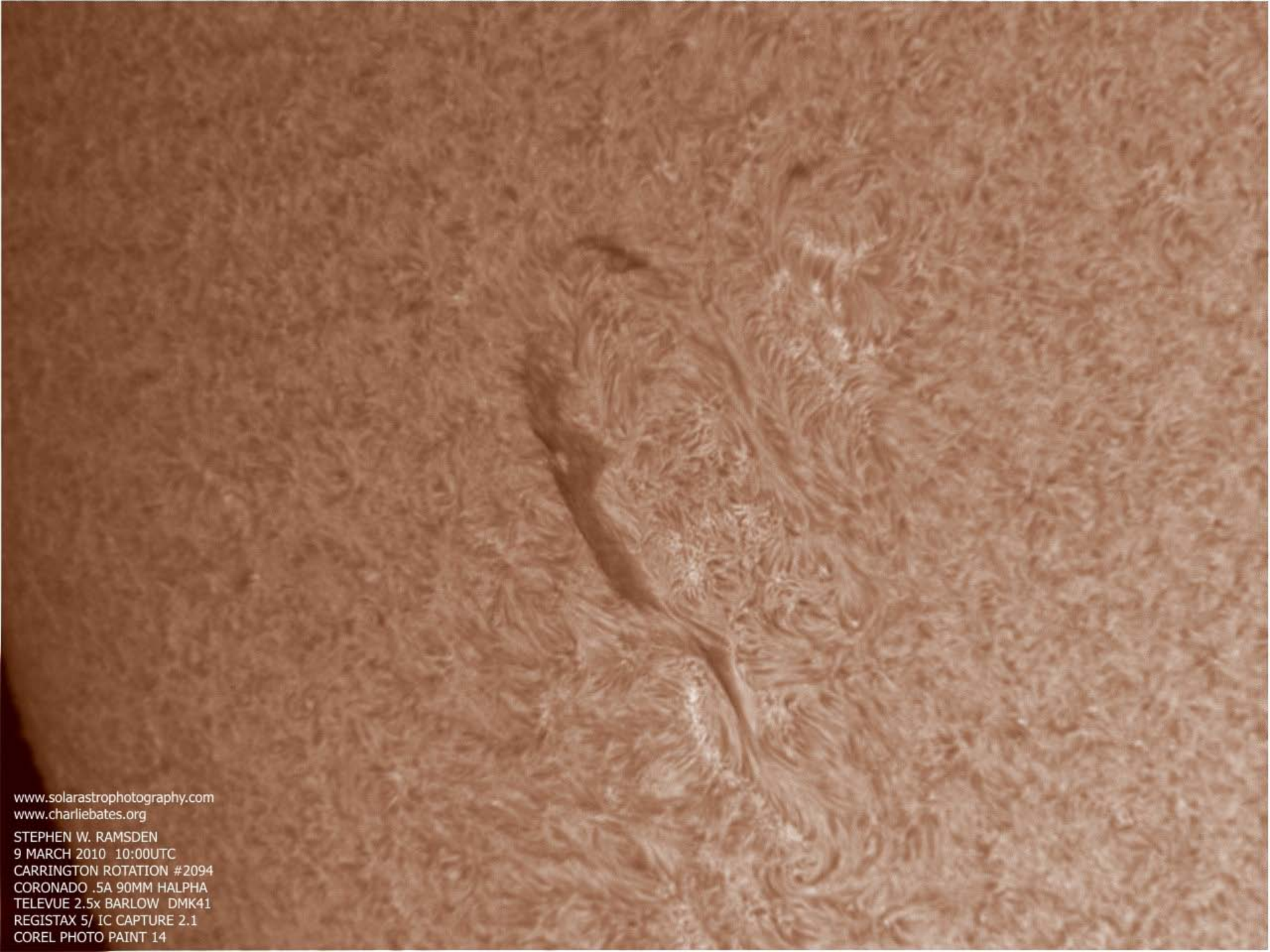
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CALCIUM K

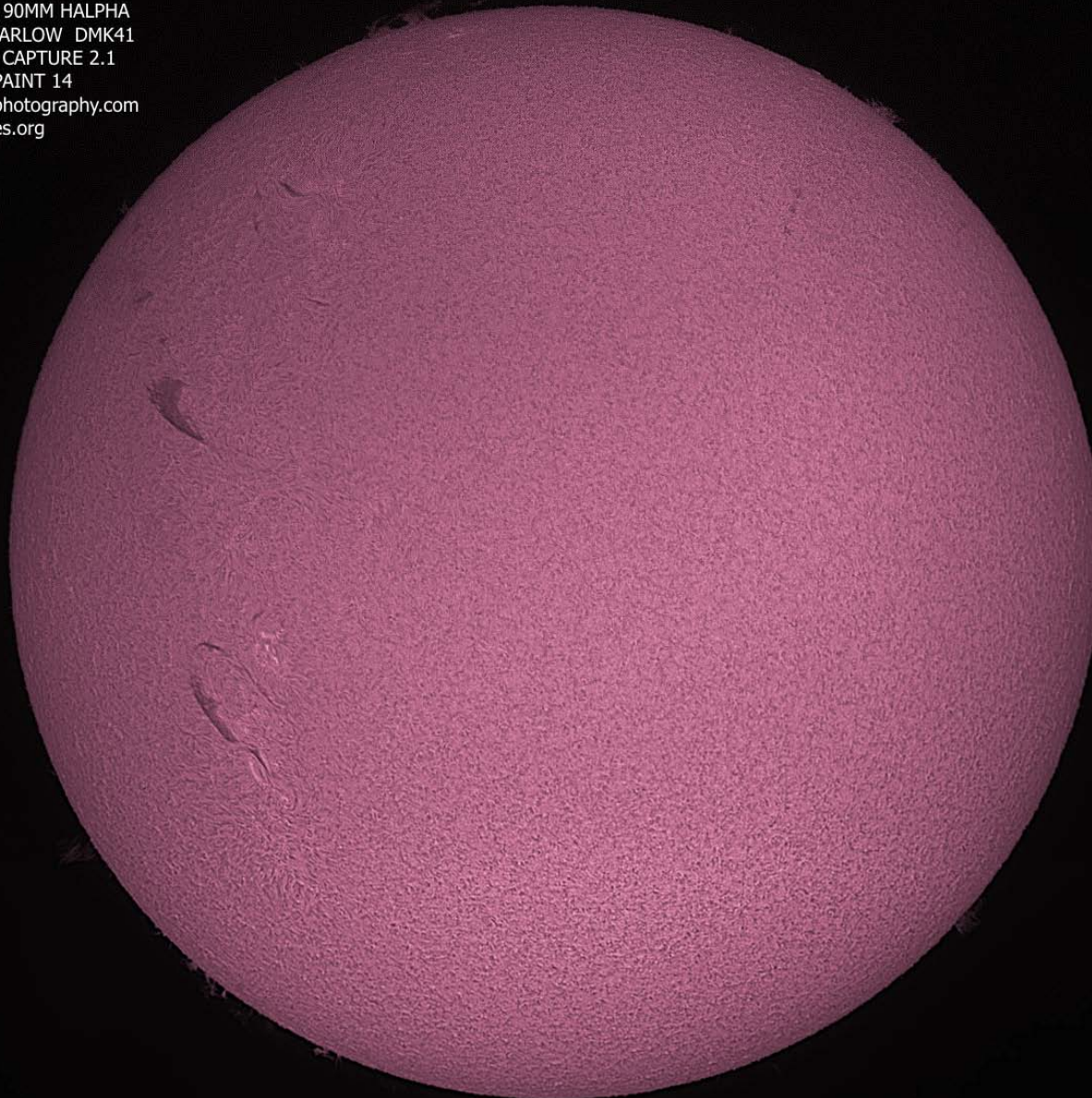
Different ways to observe the Sun





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FEATURE

Solar 'Current of Fire' Speeds Up

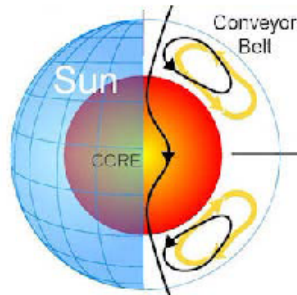
03.12.2010

March 12, 2010: What in the world is the sun up to now?

In today's issue of *Science*, NASA solar physicist David Hathaway reports that the top of the sun's Great Conveyor Belt has been running at record-high speeds for the past five years.

"I believe this could explain the unusually deep solar minimum we've been experiencing," says Hathaway. "The high speed of the conveyor belt challenges existing models of the solar cycle and it has forced us back to the drawing board for new ideas."

The Great Conveyor Belt is a massive circulating current of fire (hot plasma) within the sun. It has two branches, north and south, each taking about 40 years to complete one circuit. Researchers believe the turning of the belt controls the sunspot cycle.



Right: An artist's concept of the sun's Great Conveyor Belt. [[larger image](#)]

Hathaway has been monitoring the conveyor belt using data from the Solar and Heliospheric Observatory (SOHO). The top of the belt skims the surface of the sun, sweeping up knots of solar magnetism and carrying them toward the poles. SOHO is able to track those knots—Hathaway calls them "magnetic elements"—and thus reveal the speed of the underlying flow.

"It's a little like measuring the speed of a river on Earth by clocking the leaves and twigs floating downstream," Hathaway explains.

SOHO's dataset extends all the way back to 1996 and spans a complete solar cycle. Last year, Lisa Rightmire, a student of Hathaway from the University of Memphis, spent the entire summer measuring magnetic elements. When she plotted their speeds vs. time, she noticed how fast the conveyor belt has been going.

A note about "fast": The Great Conveyor Belt is one of the biggest things in the whole solar system and by human standards it moves with massive slowness. "Fast" in this context means 10 to 15 meters per second (20 to 30 miles per hour). A good bicyclist could easily keep up.

Below: The velocity of the Great Conveyor Belt (a.k.a. "meridional flow") since 1996.



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