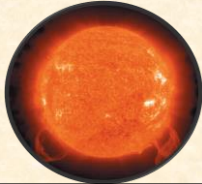


ASTR 1020: Stars & Galaxies

September 16, 2013

- Reading: Chapter 14, sections 14.2-14.3.
- *MasteringAstronomy* Homework on **Light & Matter** is due tonight.
- Volunteer for "Astronomy in the News".



Astronomy in the News: NASA's LADEE Moon probe lifts off

Piper Jackson-Sevy



The Lunar Atmosphere and Dust Environment Explorer (LADEE)



Today's Class: The Sun



- The Sun is a mass of incandescent gas
- A gigantic nuclear furnace
- Where hydrogen is built into helium
- At temperatures of millions of degrees

Clicker Homework Question:

Which of the following parts of the Sun has the lowest temperature?

- A. core
- B. photosphere
- C. chromosphere
- D. corona

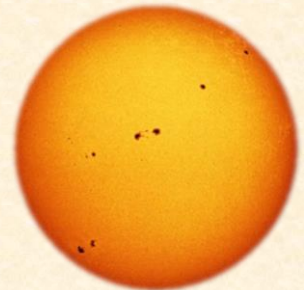
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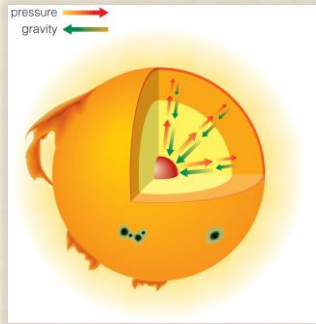
Sun Facts

- Mass = 300,000 times Earth
- Radius = 100 times Earth
- 70% hydrogen by mass, 28% helium
- Traces of other elements
- Energy released is 1 second is 3,000,000 times yearly energy consumption of entire USA. Power is equivalent to 4×10^{24} light bulbs of 100 Watts each.



Structure of the Sun- from the core outwards

- Core temp 15 million K, hot & dense from the gravitational weight of all that mass.
- Hydrogen fuses into helium, releasing energy (gamma rays). Much more on this next class!

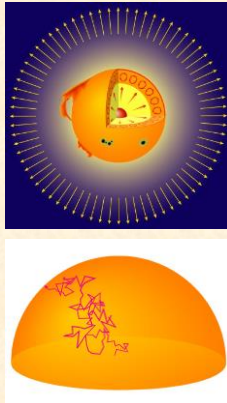


- Energy generation increase pressure pushing outwards, balancing gravity.

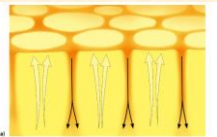
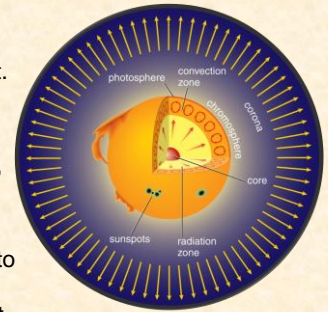
- **Gravitational equilibrium:** Outward force (pressure) balanced by inwards force (gravity).



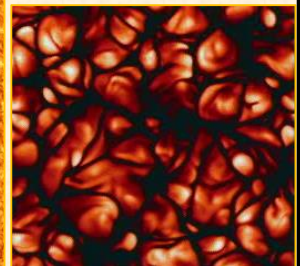
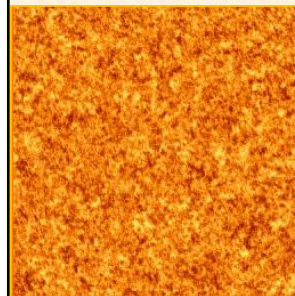
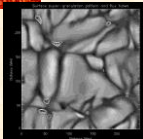
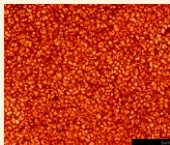
- Radiation moves through the interior of the Sun = **Radiation Zone**.
- Absorption and re-radiation in cooler layers converts gamma-rays to less energetic photons.



- Outer third: gas becomes turbulent.
- **Convection zone:** hotter regions rise, cool, sink.
- Energy continues to work its way out: 1 million years to get out.

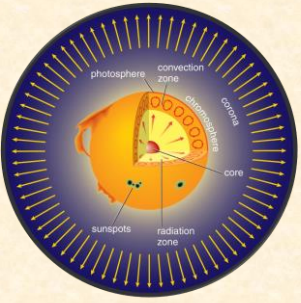
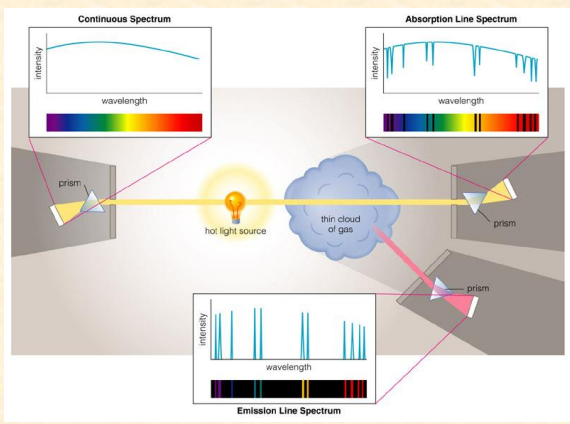


- Convection: up and down movement of heating and cooling gas.
- **Granulation:** appearance of convection patterns.
- Darker areas are cooler, sinking on outside of pattern.

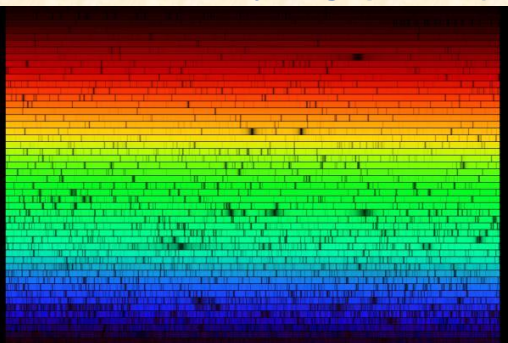


Convection on the Sun

- “Visible surface” of the Sun: **photosphere**.
- $T =$ only 5800 K.
- Photons free to fly-seen at Earth 8 min later.
- Thermal spectrum, $T=$ 5800 K plus absorption from cooler gasses just on top.

Solar spectrum (shown in tiers instead of one very long spectrum)



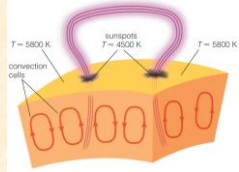
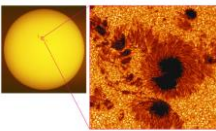
Clicker Question: The Sun suddenly stops burning hydrogen and loses its energy source. Which is true?

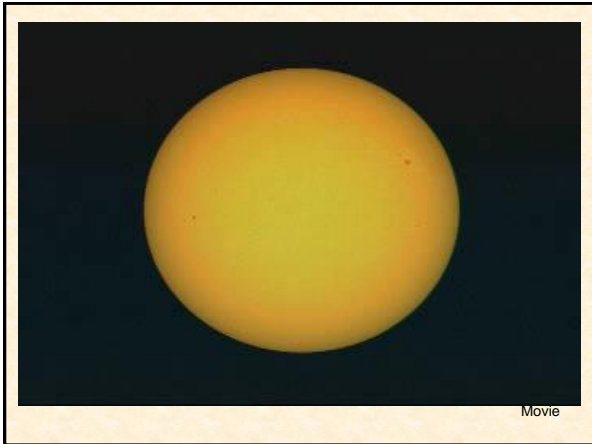
- A) The core will start to collapse.
- B) The Sun will appear fainter to us after 8 minutes.
- C) The core will become cooler.

- (A) only!
- It will take about 1 million years+ 8 min for the radiation change to be seen at Earth.
- The collapse of the Sun’s core will actually cause it to heat up, probably increasing fusion reactions again!

Magnetic Fields in the Sun

- Magnetic fields entrain gas in huge bubbling loops
- Cooler areas at “liftoff” cause dark “sunspots”



- Outer regions are hotter:
- **Chromosphere**,
- T= 10,000 K, Hydrogen alpha emission from thin gas (pink!)
- Heated by energy twisting and spilling around magnetic field lines?

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- Energy deposited by big flares and ejected gas?

21

Corona =
outermost parts

T = 1 million K
=>X-rays!

22

- Solar eclipse by the Moon:

chromosphere and corona become clearer in visible light without glare from the rest of the Sun

23

- **Solar wind:** particles (electrons, protons etc.) streaming into space at 500 km/sec

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