

ASTR 1020: Stars & Galaxies

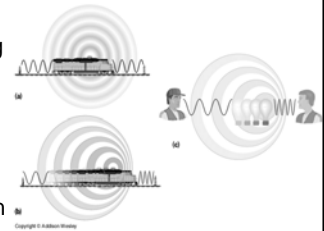
January 30, 2008

- Reading: Chapter 14, section 14.2.
- *MasteringAstronomy* Homework on Light and Spectroscopy is due Feb. 4th.
- Planetarium on Jan. 31 – Elin Deeb presents “Cassini Mission Update”.
- Guest lectures on Monday & Wednesday of next week.

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Measuring velocities without a stopwatch: the Doppler Shift

- Familiar shift in pitch of SOUND: higher when approaching, lower when receding
- Similar shift in frequency of light: higher (blueshift) when approaching, lower (redshift) when receding



Doppler Movie

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- **Clicker Question:** A brave student volunteer swings the “Doppler ball” in a circle directly over her head. What does she hear?

- a) A changing pitch, higher and lower, with each circular swing
- b) no change in pitch
- c) nothing at all

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- (c) Nothing at all!

If the ball is swung directly over her head, the ball is never moving TOWARDS or AWAY from her, only tangentially around her. There should be no doppler change in pitch.

Doppler effect is limited to only motions towards or away from the listener/viewer. No Doppler shift if object is moving tangentially (across or in a perfect circle around)

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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

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Clicker Homework Question:

Is the Sun hotter in its interior or at its surface?

- A) Interior
- B) At the surface
- C) The Sun is the same temperature throughout

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Clicker Homework Question:

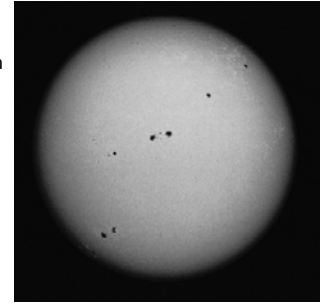
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Sun facts

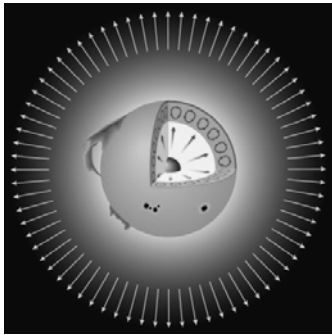
- Mass = 300,000 times Earth
- Radius = 100 times Earth
- 70% hydrogen by mass, 28% helium
- Traces of other elements
- Energy released is 1 second is 3,000,000 times yearly energy consumption of entire USA.



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Structure of the Sun- from the core outwards

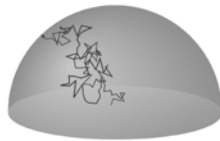
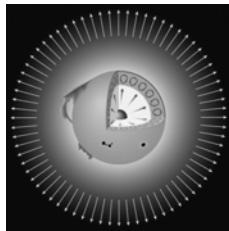
- Core temp 15 million K, hot & dense from the gravitational weight of all that mass.
- Hydrogen fuses into helium, releasing energy (gamma rays). Much more on this next class!



- Energy generation increase pressure pushing outwards, balancing gravity.
- Gravitational equilibrium: Outward force (pressure) balanced by inwards force (gravity).

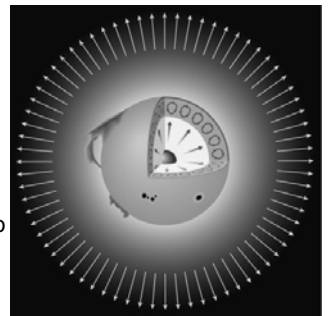


- Radiation moves through the interior of the Sun = Radiation Zone.
- Absorption and re-radiation in cooler layers converts gamma-rays to less energetic photons.

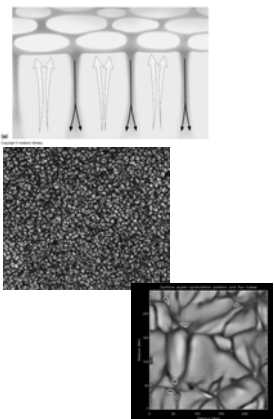


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- Outer third: gas becomes turbulent.
- Convection zone: hotter regions rise, cool, sink.
- Energy continues to work its way out- 1 million years to get out.

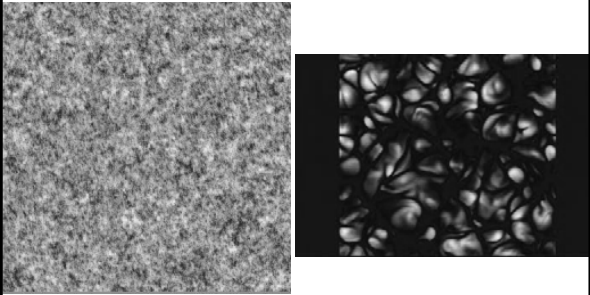


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- Convection: up and down movement of heating and cooling gas.
- Granulation: appearance of convection patterns.
- Darker areas are cooler, sinking on outside of pattern.
- Videos of convection.

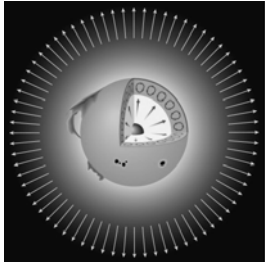
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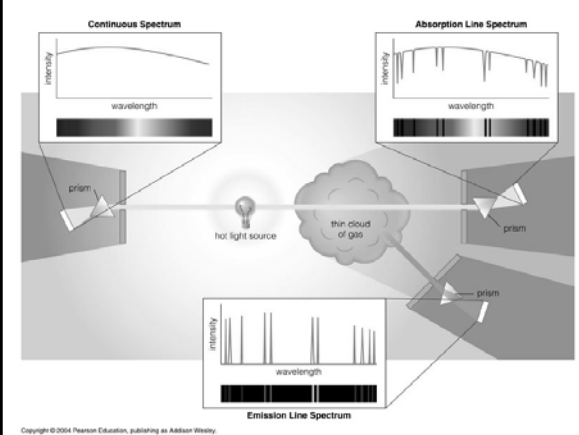
Convection on the Sun

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



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Continuous Spectrum

Absorption Line Spectrum

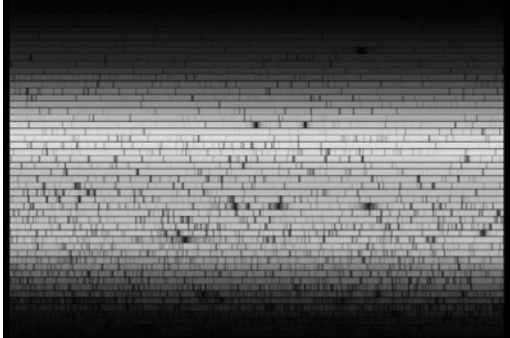
hot light source

thin cloud of gas

Emission Line Spectrum

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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.

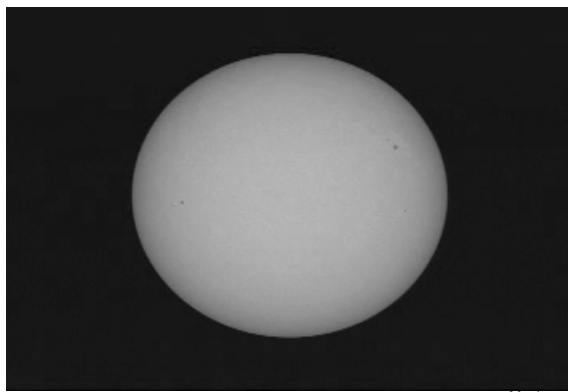
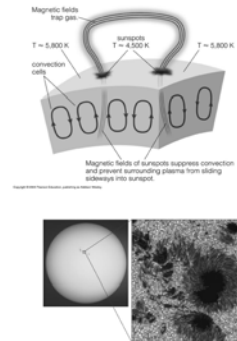
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- (A) only!
- It will take about 1 million years+ 8 min for the radiation change to be seen at Earth.
- The collapse of the Sun's core will actually cause it to heat up, probably increasing fusion reactions again!

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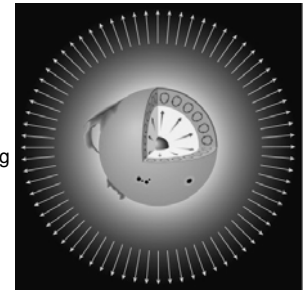
Magnetic Fields in the Sun

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



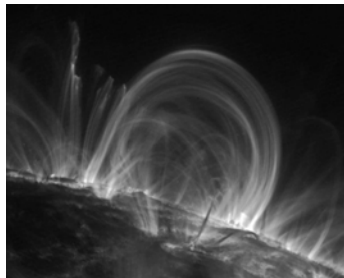
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- Outer regions are hotter:
- Chromosphere,
T= 10,000 K, Hydrogen alpha emission from thin gas (pink!)
- Heated by energy twisting and spilling around magnetic field lines?



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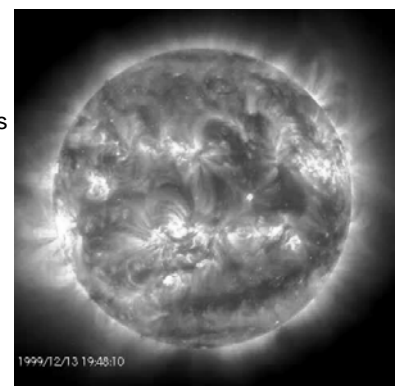
- Energy deposited by big flares and ejected gas?



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Corona =
outermost parts

T= 1 million K
=>X-rays!



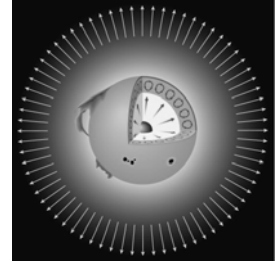
- Solar eclipse by the Moon:

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



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



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