

The Sun—March 4

- Your grade at midterm has been e-mailed to you.
- Average is 2.9.
- Clicker answers for Wed., 2 March were lost when computer crashed.
- Grade at midterm
- Parts of the sun
- Models of the inside of the sun

Grade at midterm

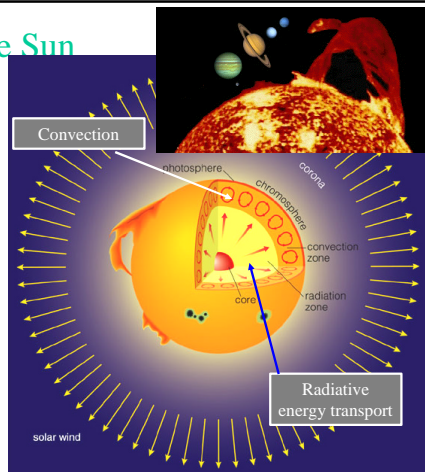
- Average is 2.9.
- Weighting
 - Clicker 19%
 - Homework 6% (1hwk= 2 classes)
 - Test 37.5% each
- 38% is done; 62% (Test 3, Final, remaining clicker & homework) remains
- Your true grade at midterm may be slightly higher.
 - Last problem on test 2 not graded
 - Excused absences, some homework corrections, some paper clicker questions not entered

	Your score	Class median / Total	Calculation for median student
Test 1	28	27 / 39	$27/39 * 37.5 = 26$
Test 2	23	20 / 31	$20/31 * 37.5 = 24.2$
Clicker	88	87 / 105	$87/105 * 19 = 15.7$
Homework 1	100	75 / 100	$75/100 * 2 = 1.5$
Homework 2	100	100 / 100	$100/100 * 2 = 2$
Homework 3	92	100 / 100	$100/100 * 2 = 2$
Total	77		71.4

77/100 => 3.5

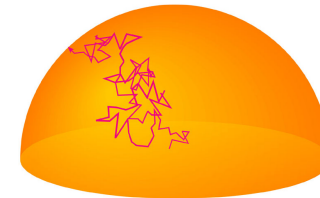
Parts of the Sun

- Core
- Radiation zone
- Convection zone
- Photosphere
- Chromosphere
- Corona
- Wind

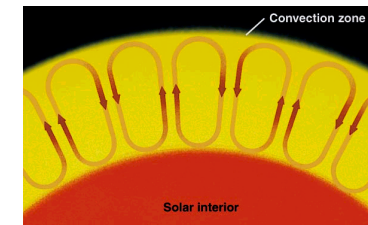


Energy transfer

- Possibilities are:
 - Radiation
 - photons (light) travel a short distance.
 - absorbed by atoms.
 - re-emitted.
 - random walk.
 - Convection
 - hot bubbles rise.
 - cooler bubbles fall.
 - occurs when pressure changes very little with temperature.
 - Conduction
 - Not important in Sun

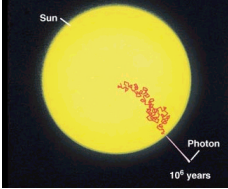
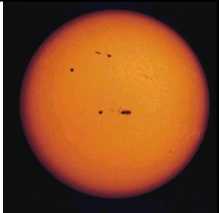
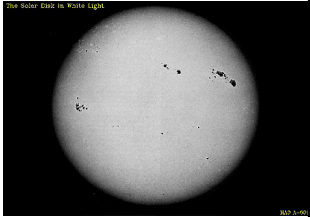


[Fig. 10.7]



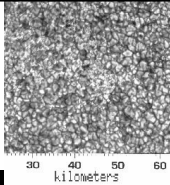
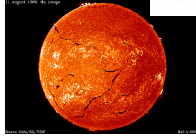
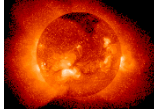
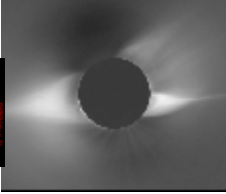
Photosphere

- Deepest layer from which light directly escapes into space.

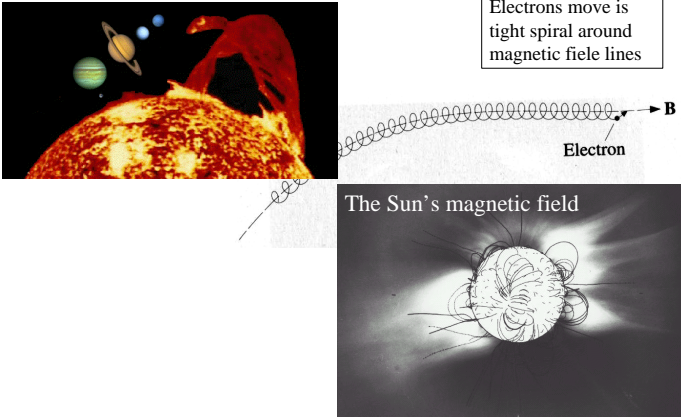




- Low density and pressure (10^{-4} , 0.1 x Earth's surface values)
- But *hot* (5800° K)

- **Granules** (in photosphere)
 - Tops of convection currents.
- **Chromosphere**
 - Transparent gas layer, reaches 2000-3000 km above photosphere.
 - T ~5,000-10,000° K
 - Photosphere = point where we can no longer see through chromosphere.
- **Corona**
 - T > 1,000,000° K
 - Very low density: 10^{-10} bar.
 - Heated by magnetic energy.
 - Several x diameter of photosphere.

Magnetic Field

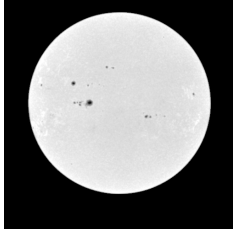
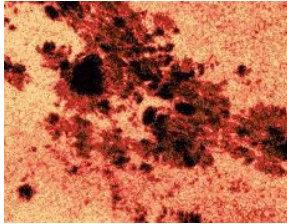
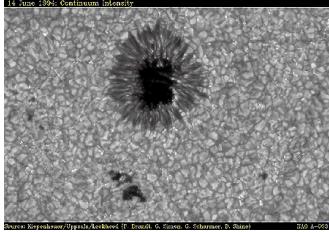


Electrons move in tight spiral around magnetic field lines

The Sun's magnetic field

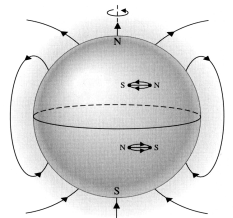
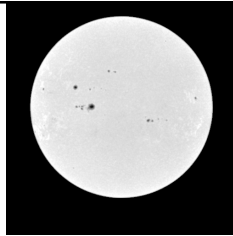
Sunspots

- Cooler areas
 - as much as 1500° less than photosphere.
- This makes them look darker.
 - But they actually are still very bright.
 - Glowing at 4300° K instead of 5800°

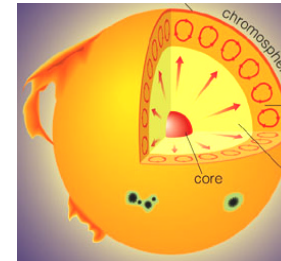
Sunspots

- occur where magnetic field lines leave, re-enter photosphere.
 - Spots come in pairs.
 - leading = 1 magnetic polarity
 - trailing = opposite polarity
 - polarity reverses between N, S hemispheres.
- Magnetic field prevents hotter gas (granules) from entering these regions



Interior of the sun

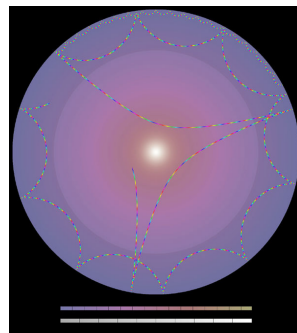
- Use physics to construct models
- Energy is generated by nuclear fusion, which depends on temperature and composition.
- Energy move from center, where fusion occurs, to outside, where it radiates into space.
- Gas pressure holds the mass of the parts above.



[Fig. 10.3]

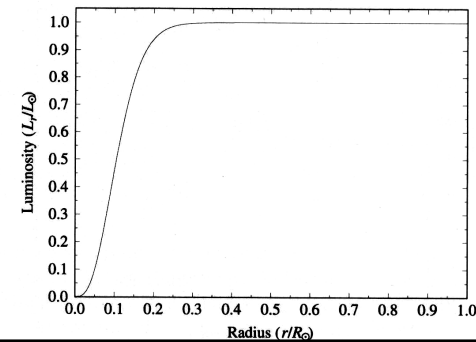
Solar oscillations with GONG

- 2D mapping of velocity of gas on Sun's surface
 - Seismic wave patterns.
 - Caused by sudden collapses of large volumes of gas on surface.
 - Wave pattern shows interior structure
 - similar to analysis of Earth's, Moon's interior structures.
- Results
 - Convection zone down to 30% of Sun's radius.
 - Differential rotation throughout convection zone.
 - Helium abundance same as at surface, except in energy generation zone.



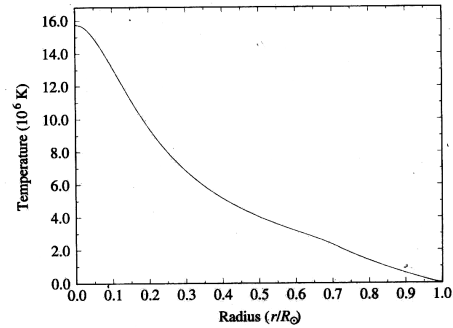
Model: Where is energy produced?

- Where is energy produced? Within central 10% (of radius)



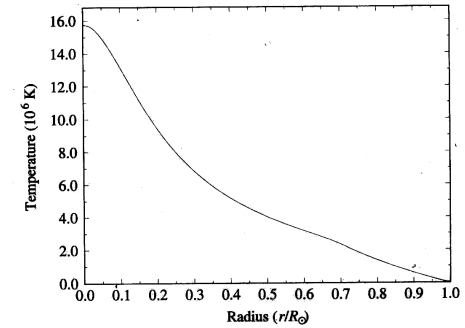
Model: What is temperature of center?

- 16 MK (million degrees Kelvin)



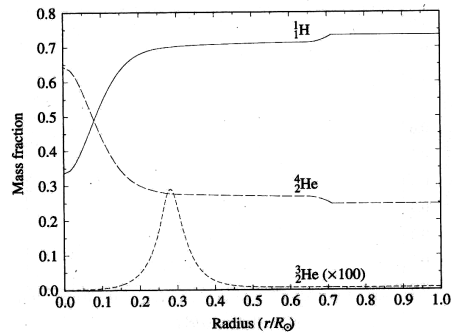
Model: What is temperature of center?

- 16 MK (million degrees Kelvin)



Model: What is composition of sun?

- Q: Why is there more helium than hydrogen in the center?
 - a. The heavier helium sunk to the center
 - b. Helium was made there



Model: Density of sun

- In center, sun is 160 times denser than water, 8 times denser than gold.

