ASTR 2310: Chapter 7, “The Sun”

- Observable Layers of the Sun
  - (Interiors deferred to Ch. 15, ASTR 2320)
- Solar Activity
- Angular Momentum of the Sun
Observable Layers of the Sun

A Really Great Webpage with Basic Info and Images/Animations of the Sun: http://ircamera.as.arizona.edu/NatSci102/lectures/sun.htm

Also see Wiki: http://en.wikipedia.org/wiki/Sun

Photosphere: where the light comes from (optical depth of 1), about the top 400 km, R=696,000km from the center.

Absorption Lines indicate surface layer is cooler. Lines indicate H is 73.4% by mass, Helium 25.0%
Atmospheric Opacity

- Main source is the H⁻ ion.
- Hydrogen atom with an extra electron
- Trace “metals” easily give up some outer electrons, partly ionized, and electrons are captured by neutral hydrogen to make ion
- First electron ionization potential 13.6 eV, second only a mere 0.75 eV, so easily lost again, absorbs photons with wavelengths on order of 1.7 microns and shorter.
- Need right range of densities and temperatures for this negative hydrogen ion to be common. Sun has them.
Atmospheric Opacity

- Limb Darkening: photons come from tau of 1, the photosphere. At the edge, that is from a shallower depth (and lower temperature) than in the center of the disk ($T = 6100 \text{ K}$), for average of $T = 5700 \text{ K}$.

Light observed near the limb of the Sun is emitted from cooler regions of the photosphere – from Planck’s curve we know that this light will be dimmer than light emitted from the hotter regions.

The final effect is that the Sun’s limb looks darker than the middle regions.
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- **Other Atmospheric Phenomena**
  - *Granules* that are convection cells (see movie on website on page 2 of the slides)
  - *Chromosphere* – hot, tenuous region above the photosphere with an emission-line spectrum, and temperature increasing with altitude
  - Other features include plages, filaments, prominences, and spicules
Other Atmospheric Phenomena

- **Corona**
  - Very hot – into the millions of degrees
  - Story of “Coronium” and forbidden Fe XIV
  - Most easily seen in eclipses
Other Atmospheric Phenomena

- Corona and solar wind
  - Origin of heating unclear, but acoustic and magnetic effects implicated
  - Rms speed of corona particles \( \left( v_{\text{rms}} = (3kT/m)^{1/2} \right) \) is on order a few hundred km/s
  - Escape velocity \( \left( v_{\text{esc}} = (2GM/r)^{1/2} \right) \) is a bit larger, but...
  - The outer, hotter part of the corona has an increasing fraction of gas particles being lost
- “Solar Wind” -- can make estimates on the whiteboard (from pages 178-180 of the text)
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- Solar Activity
  - *Magnetic Fields and Lorentz Force*
    - Important for all solar activity
    - Especially sunspots
    - Some basic physics first (whiteboard)
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- **Solar Activity**
  - *Sunspots*
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- Solar Activity
  - Sunspots
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- Solar Activity
  - Coronal Mass Ejections and Solar Flares, Auroras