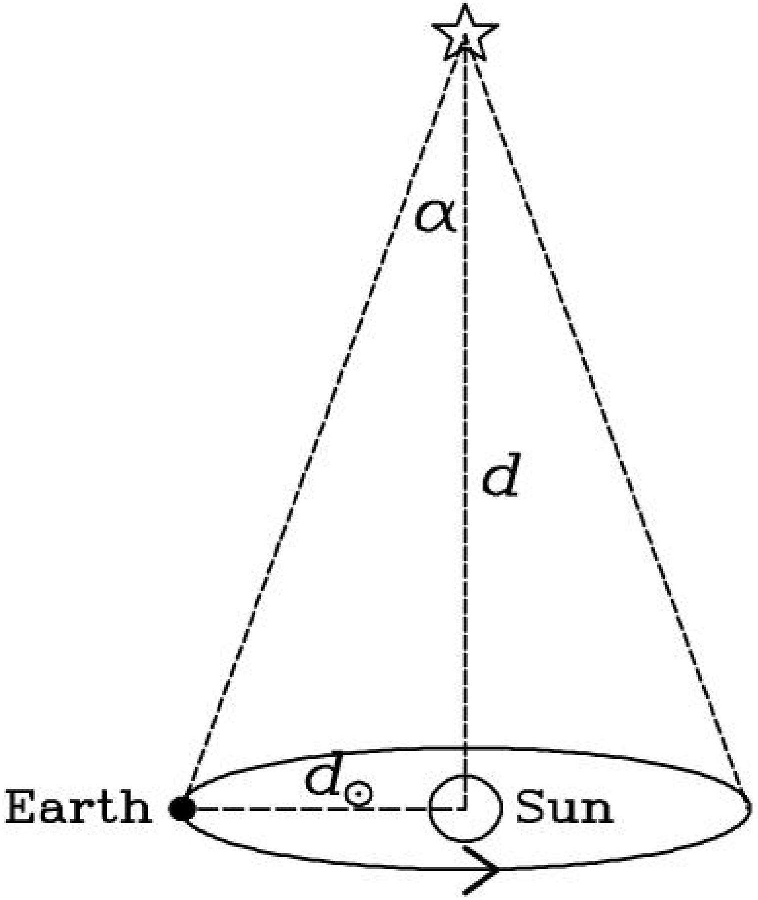
Outline

- Hand in, go over homework problem 2.1
- Parallax
- Luminosity, temperature, radius
- HR diagram

Parallax

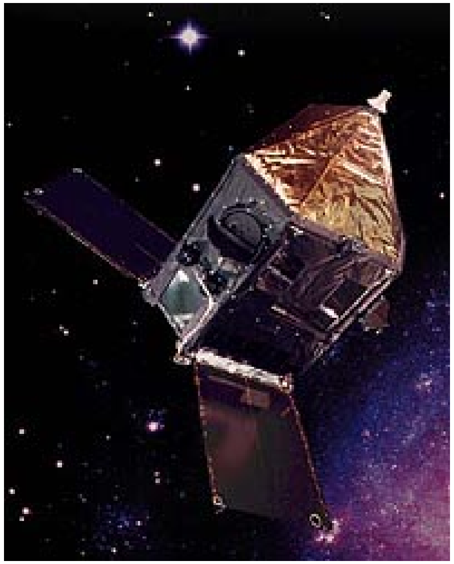
- The apparent positions of nearby stars change as the Earth moves due to parallax.
- A star traces out an ellipse on the sky with angular semi-major axis $\alpha = d_{\odot}/d$, where d = distance to the star and $d_{\odot}$ = Earth-Sun distance.
- In addition, most stars are moving relative to the Earth, so there is a linear component to the motion of the star on the sky.
- 1 parsec = distance to star with parallax of 1”. 1 pc = 3.26 ly.



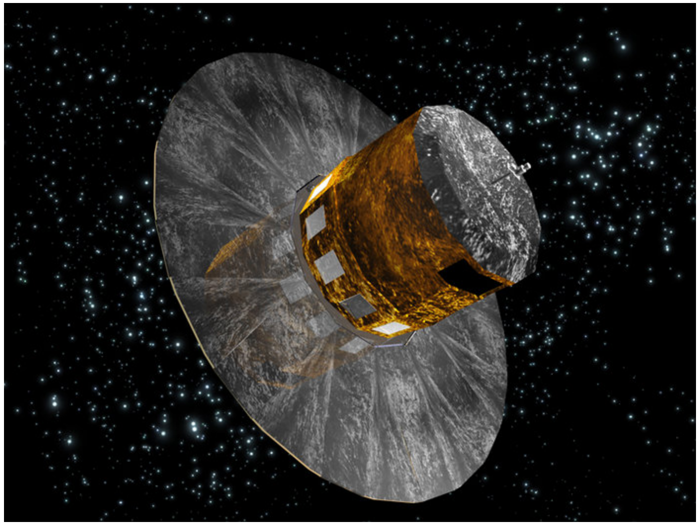
Parallax

- Parallax measurements from the Earth in the optical are limited by seeing.
- Best available measurements come from the European Space Agency (ESA) Hipparcos satellite that measured positions of 10^5 stars to 1 milliarcsec accuracy.
- ESA just launched the Gaia satellite to measure positions of all stars brighter than 15^{th} mag to 0.024 milliarcsec, typically 70 measurements over 5 years.
- Gaia will provide less accurate measurements down to 20^{th} mag for 10^9 objects, making a 3d map of Milky Way.
- Can measure parallax in radio (VLBI) to ~ 0.1 milliarcsec, only a few dozen objects done.

Hipparcos



Gaia



Luminosity, Temperature, and Radius

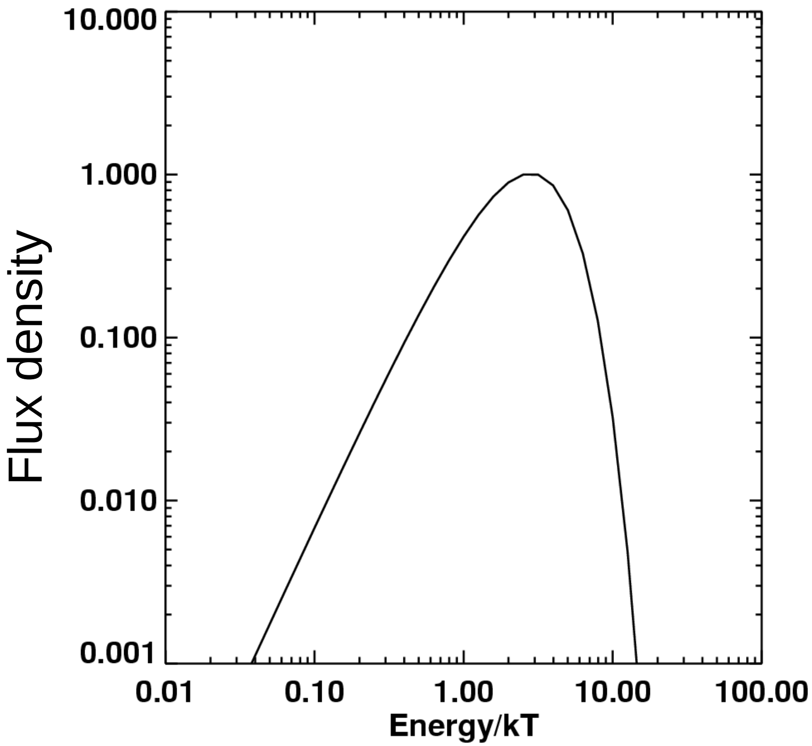
- Bolometric luminosity, *L*, measured flux, *f*, and distance, *d*, are related:

$$L = 4\pi f d^2$$

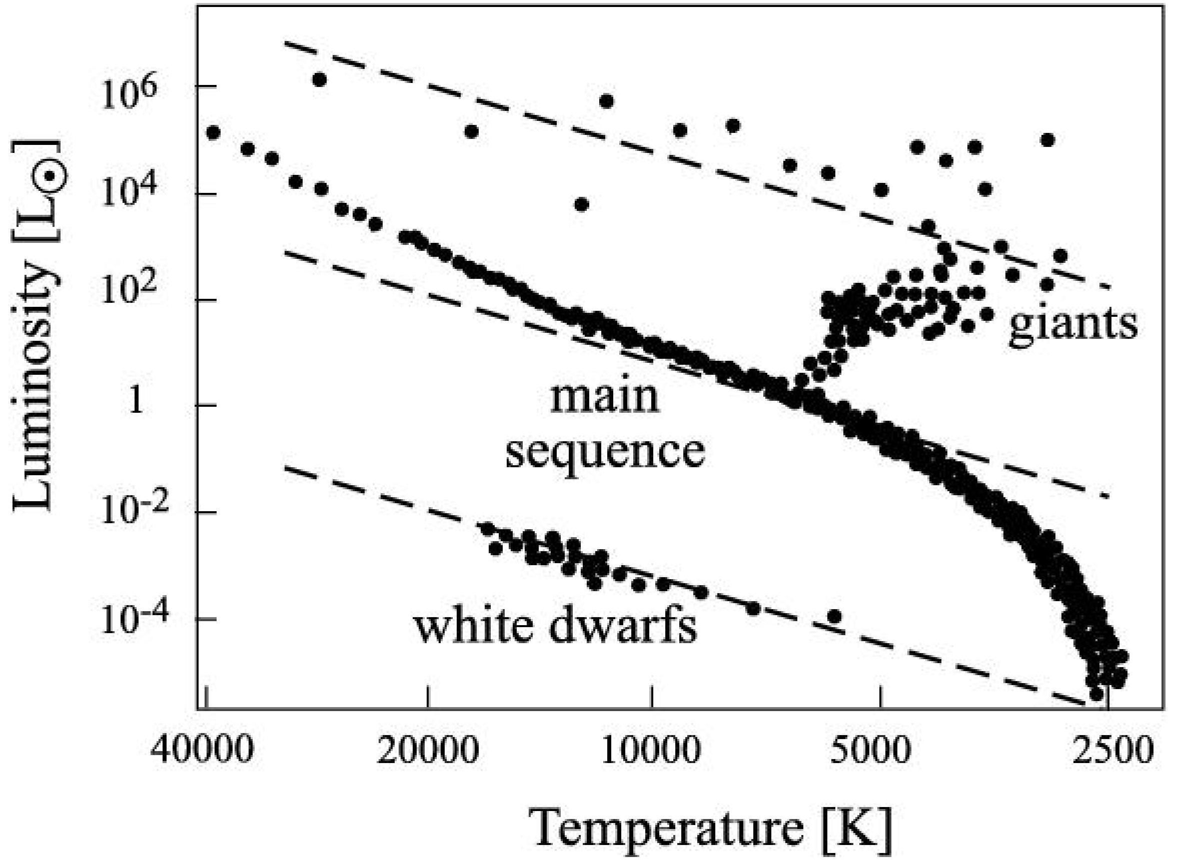
- Stefan-Boltzman law relates bolometric luminosity, surface area, and temperature (sometimes called the effective temperature):

$$L = 4\pi r_*^2 \sigma T^4$$

- Note that is it basically impossible to measure flux over all wavelengths, as would be required to make the first equation correct. Instead, one typically makes a measurement in one or a few bands and then makes a 'bolometric correction' – one assumes a blackbody (or other) spectra shape to estimate the bolometric flux from the measurement(s).



Hertzsprung-Russell Diagram



- Hertzsprung-Russell diagram is plot of luminosity versus temperature for stars.
  - Dashed lines are constant radius $L \propto T^4$., $0.01R_\odot$, $R_\odot$, $100R_\odot$.
- Stars in different evolutionary phases appear in different regions on the HR diagram.
- **Main sequence** are stars burning hydrogen in their core.
  - Hotter main sequence stars have larger radii.
  - Hotter main sequence stars are more massive.
  - Luminosity class V.
- Giant stars have radii ~100x larger than main sequence, are cooler.
  - Luminosity classes I to IV.
- White dwarfs have radii ~100x smaller than main sequence, are hotter.

Homework

- For next class:
  - Problems 2-2, 2-3