Stellar Properties

1. Distance (nearby stars) (17.1)
2. Luminosity/ Absolute mag. (17.2)
   Apparent brightness/appar. mag. (17.2)
3. Surface Temp./Core Temp. (17.3)
4. Spectral Type & color (17.3)
5. Size (radius) (17.4)
6. Luminosity Class (17.6, p.456)
7. Mass (17.7,17.8)
8. Radial & Tangential velocity (17.1)
9. Composition (17.3)
10. Distance (far away stars) (17.6)
11. Lifetime & age (17.8)
12. Position on H-R diagram (17.5)

EXERCISE

In groups of 2-3, figure out the following for each property listed to the left:

a) Value for the Sun
b) Range of values for other stars
c) How its measured
d) Theory behind interpretation of measurement.

1. Distances to nearby stars

a) Value for Sun.*

93,000,000 miles or 150,000,000 km.

This is only 1.5 X 10^{-5} LY.

b) Range of values for other stars.

Closest: 4.3 LY for Proxima Centauri. (4.22 LY)

Farthest: Stars exist in galaxies which have distances out to the edge of the observable universe (about 10,000,000,000 LY).

However, the technique of "Stellar Parallax" is limited by the resolution of our imagers. It can only be measured out to 200 pc (600 LY) from the ground, The Hipparcos satellite "measured parallaxes to over 200 pc, encompassing over a million stars." Hipparcos measured 118,000 stars with a median precision of +-1 mas corresponding distances to 3300 LY, another million stars were measured with lower precision.

c) How its measured

Image a star (on film or CCD) at least two times from two positions as far apart as possible. The more images at different positions, the better. A nearby star will appear to move relative to background stars (or an absolute coordinate system).

d) Theory behind interpretation of measurement.

The theory is simple geometry, not physics. $D = 1/\pi$ where D is distance (in parsecs) and π is the parallax angle (in arcseconds).

* green text means information from Astronomy Today 5th Ed.

2. Luminosity and Absolute Magnitude

a) Values for the Sun

L=3.9x10^{26} W = 1 Lsun

Msun = 4.83 (=apparent mag of Sun if placed at d=10pc)

b) Range of values for other stars

M-type stars have the lowest L among main sequence stars, L ~ .005 Lsun

O-type stars have the largest L among main sequence stars, L ~ 10^5 Lsun

Non-main sequence stars can be fainter (white dwarfs, neutron stars) and brighter (blue supergiants, novae, supernovae).

c) How its measured

Use photometry to get the apparent brightness (flux or *m*), then get a distance from parallax. Solve for distance (see equation below).

OR take a spectrum which gives the spectral type and luminosity class. This allows one to roughly locate the star on the H-R diagram. Read off *L*.

d) Theory behind interpretation of measurement.

Luminosity is the total amount of light energy leaving the object – in all directions! To find *L*, measure the flux at a distance, *d*, and then multiply the flux by the surface area of a sphere of radius *d*.

$$L = 4\pi d^2 (flux)$$

Apparent brightness / apparent magnitude

a) Values for the Sun
m = -26.7
b) Range of values for other stars
Sun is brightest (-26.7), we can observe others as faint as m=+30.0.
Next brightest star is -1.5 (Sirius).
Planets can appear even brighter, and the Moon is -12.5.
c) How its measured
Use photometry to get a flux (counts per second). Apparent magnitude is then given by m = -2.5 log (flux/reference flux).

d) Theory behind interpretation of measurement.
The counts that we receive in a detector tell us the intensity or flux of photons at the Earth.

Surface and core temperature

a) Values for the Sun

Tcore= 15x10^6 K

Tsurface= 5800 K

b) Range of values for other stars

Tsurface ranges from 3000 to 50000 K for main sequence stars.

Tcore ranges from 0.6x10^6 to 50x10^6 K (for 50Msun star). Exotic stars higher

c) How its measured

Tsurf: a) use multi-color photometry (ie. image through color filters). The colors correlate with surface temperature (blue=hot, red=cool). b) take a spectrum and measure the strengths of many different absorption lines.

Tcore: MANY observables used: radius, surface temp, surface density, total mass (from planet orbits), total luminosity. This information is fed into a computer that uses laws of physics to make a stellar model. The model will include temperature at the core.

d) Theory behind interpretation of measurement.

Tsurf: a) blackbody law – for a blackbody, each temperature produces a unique continuous spectrum with a unique peak wavelength (λmax). The shape of this spectrum across the filter bandwidths determines the colors measured. b) atomic physics – the strength of absorption lines created by a given element depend on the gas temperature.

Tcore: structural equations (like hydrostatic equilibrium), and nuclear physics