ASTR2013 Lab 2: Stars

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Before starting this, please ensure that you've completed the Jupyter notebook from week 1, or been asked to move on by your tutors.

1. (Based on 2.2 from textbook) We have in the previous tutorial plotted and integrated the blackbody flux versus wavelength. At a fixed wavelength of 550 nm, plot the blackbody flux versus temperature, for a range of temperatures matching typical stars. Also make this plot at 2200 nm (an infrared wavleength called the "K" band), and plot the ratio of these fluxes. What do you notice? Is this flux ratio most useful for determining temperature around 4000 K or 20,000 K?

2. (Question 2.4 from the textbook) The maximal radial velocities measured for the two components of a spectroscopic binary are 100 and 200 $\mathrm{km\,s^{-1}}$, with an orbital period of 2 days. The orbits are circular.

   (a) Find the mass ratio of the two stars.

   (b) Use Kepler's law to calculate the value of $M_1 \sin^3(i)$ and $M_2 \sin^3(i)$ for the two stars. Note that Kepler's law as given in the lecture slides, applied to circular orbits, can be modified to account for the orbital inclination by noting that velocity $v = v_{\mathrm{obs}} \sin(i)$ and $a = 2\pi v\tau$ for an orbital period τ, giving an alternate form:

   $$(M_1 + M_2)\sin^3(i) = \frac{\tau(|v_{1,\mathrm{obs}}| + |v_{2,\mathrm{obs}}|)^3}{2\pi G}, \tag{1}$$

   where $|v_{1,\mathrm{obs}}|$ and $|v_{2,\mathrm{obs}}|$ are the maximum radial velocities of the two stars with respect to the centre of mass velocity.

   (c) The mean value of $\sin^3(i)$ is $3\pi/16$. One of your tutors would be happy to show you why on the whiteboard, or you can try to integrate over solid angle yourself. What are the masses of the two stars, if $\sin^3(i)$ has its mean value?

3. Compute the dynamical timescale for the sun. Use Kepler's law to compute the orbital period of a satellite grazing the surface of the sun. What is the multiplicative factor between these timescales? Compute the freefall timescale according to the textbook formula. How does this differ? Before the sun ceases to burn nuclear fuel, it will become an asymptotic giant branch star with radius 1 au. What will its dynamical timescale be then? After the sun ceases to burn nuclear fuel, it will become a white dwarf with radius $\sim 1\,\mathrm{R_{earth}}$. What is its dynamical timescale at this point?

4. Given the sun's mass and radius, compute its approximate internal energy. The solar luminosity is `L_sun` in the `astropy.constants` module. What is its Kelvin-Helmholtz timescale? A 10 solar-mass main sequence star has approximately 10 times the solar radius and 10,000 times its luminosity. What is its Kelvin-Helmholtz timescale?