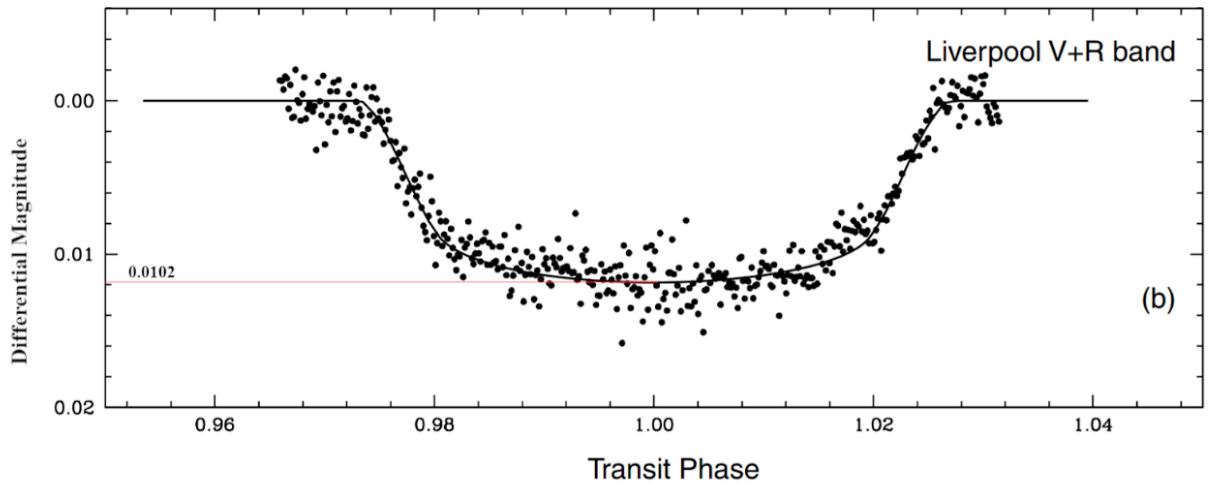
II. Long Questions

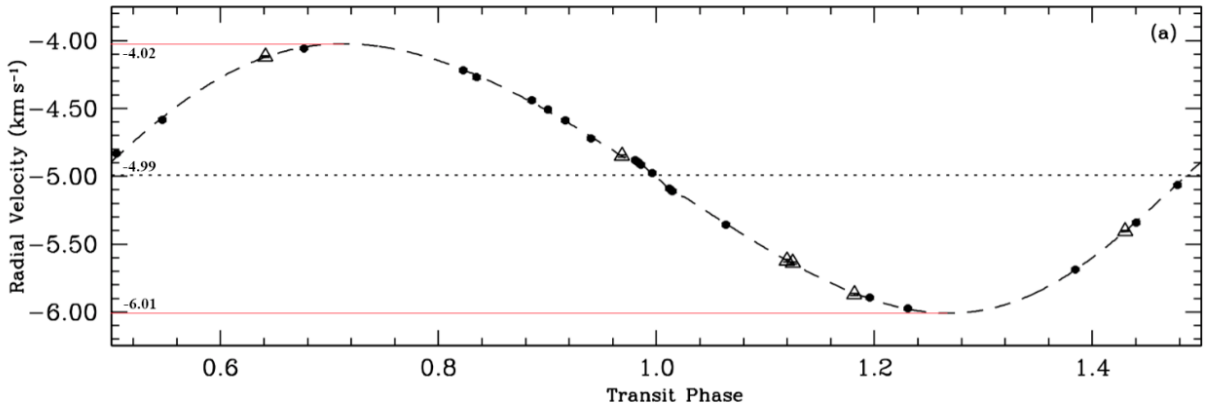
1. [15 pt] In 2008, while observing WASP-14, a main sequence star of mass 1.211 $M_\odot$ and radius 1.306 $R_\odot$, an exoplanet called WASP-14b was discovered via the transit method. Photometry as well as radial velocity data are shown in the figures. Transits occur once every 2.243753 days. The radial velocity of the center of mass of WASP-14 and its planet is -4.99 km/s. Fitting of the radial velocity curve indicates that the argument of periastron of the orbit of WASP-14b is 254.9°.

(a) [5 pt] Determine the length of the semi-major axis of the orbit of WASP-14b.

(b) [5 pt] Determine the density of WASP-14b.

(c) [5 pt] Determine the eccentricity of the orbit of WASP-14b.





2. [15 pt] The star Sualocin (RA: 20^h 39.6^m, Dec: 15° 54.7', absolute magnitude: -0.4) is about 78 pc away from our solar system, and the star Rotanev (RA: 20^h 37.5^m, Dec: 14° 35.7', absolute magnitude: 1.6) is about 31 pc away. An alien astronomer is on a planet with Earth's mass and radius orbiting Rotanev. The planet has a uniform albedo of 0.3.

(a) [4 pt] What is the angular distance between Sualocin and Rotanev?

(b) [3 pt] What is the distance between these stars in parsecs?

(c) [3 pt] On the alien's planet, what is the angular separation in the sky between Sualocin and our Sun?

(d) [5 pt] How much greater is the flux received by the planet from Sualocin than that received from our Sun?

3. [15 pt] Suppose that at some time in the very recent past all the hydrogen and helium (baryon density $\rho_b = 4.2 \times 10^{-31}$ g/cm^3, about 75% hydrogen (=1 baryon) by mass and 25% helium (=4 baryons) by mass) in the universe had been instantly fused into iron in stars, and the released energy thermalized into black body radiation. (Note that the binding energy per nucleon of $^{56}_{26}$Fe is 8.8 MeV and that of $^{4}_{2}$He is 7.1 MeV.)

(a) [5 pt] Calculate the current temperature of this black body radiation.

(b) [5 pt] At what wavelength would the black body spectrum peak, and what region of the electromagnetic spectrum would this be?

(c) [5 pt] The mean bolometric luminosity per unit volume emitted by stars in the universe today is about $3 \times 10^8\ L_\odot/\mathrm{Mpc}^3$. How long would it takes stars at this rate to fuse all the hydrogen and helium in the universe? Compare to the present age of the universe.