ASTR 210 Fall 2025 — Homework set 7
50 points
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Solutions need to show all important intermediate calculations, diagrams, and explanations in addition to the final answer to receive full credit. Please check the legibility of homework solutions uploaded to the class website as we cannot grade or give credit for illegible or unreadable work. Units do not need to be specified if an expression or equation is requested; for numerical calculations please use the specified units for the answer, or if not specified, SI or cgs units. Please use Table A.1 for the value of physical constants and Table A.2 for the value of astronomical constants, unless otherwise specified in the problem. Please use the correct number of significant figures.

7.1 Exoplanets

The host star in an exoplanet system has a stellar mass $M_A = 1.09$ $M_\odot$ and a stellar radius $R_A = 0.980$ $R_\odot$. The exoplanet has an orbital period P = 4.727 days and a mass $M_B = 3.2$ $M_\oplus$; it causes a reduction in stellar flux $\delta F/F = 2.2 \times 10^{-4}$. Assume the exoplanet's orbit is circular. From these data, calculate

(a) the exoplanet's orbital semi-major axis in AU [4 pts];

(b) the exoplanet's radius R_B in Earth Radii [4 pts];

(c) the velocity of the host star around the center of mass of the system [4 pts]; and

(d) the expected maximum duration of the transit (1st contact to 4th contact), if the system is perfectly aligned. [4 pts]

7.2 Stellar and protoplanetary disk radii

A young star system is observed to contain one component with a blackbody temperature of 3000 K and a total luminosity of 1.1×10^{26} W, plus another component with a blackbody temperature of 32 K and a total luminosity of 5.2×10^{25} W.

(a) What are the radii of those two components, assuming they're spherical? [3 pts each, 6 total]

(b) Compare their sizes to those of objects and/or orbits in our own solar system. [2 pts each, 4 total]

7.3 Binary stars

Suppose you are studying a visual binary star; the maximum separation between the two components of the binary is $6.0''$, and their orbital period is 80 yr. The annual parallax of the system is $0.4''$. Assume the stellar orbits are circular.

(a) What is the total mass of the binary system? [5 pts]

(b) Why can't you infer the masses of the two individual components with the information you have now? Put another way, what additional information would allow you to decompose the total mass into the two individual masses? A sentence or two should be adequate; you may include an equation if you like, but that's not necessary. [4 pts]

7.4 Stellar masses

A double-lined spectroscopic binary star is observed to have radial velocities with amplitudes $v_A \sin i = 108$ km s^{-1} and $v_B \sin i = 111$ km s^{-1}. The orbital period is $P = 3.96$ days.

(a) Find the ratio of the stars' masses, M_A/M_B. [3 pts]

(b) Assuming that the binary orbits are edge-on ($i = 90°$), what is the combined mass $M_A + M_B$ of the two stars? [7 pts]

(c) What are the individual masses M_A and M_B? [5 pts]