Short Problems

Problem 1 [6]
A comet has an orbital period of 300 years. If at perihelion, the comet is 0.05 AU from the Sun, what is the aphelion distance? Determine the orbital velocity of the comet at its closest approach to the Sun.

Problem 2 [6]
What is the maximum distance at which the E-ELT (with a 39.3 m diameter primary mirror) could detect an Earth-like planet around a Sun-like star in the L-band (3.0 - 4.0 microns)?

Problem 3 [6]
A star displays a variation in radial velocity with a period of 297 days. The radial velocity curve has a maximum of 1289 m/s above baseline and a minimum of 373 m/s below baseline. If the variation is due to the presence of a planet, determine the eccentricity of the planet.

Problem 4 [6]
What physical factors cause some nebulae to display dark spectra with bright emission lines while others display bright spectra with dark absorption lines? Explain your reasoning with a diagram of each case for full credit.

Problem 5 [6]
Prove that a Lagrange point exists at the vertex of the equilateral triangle whose base is the line between the primary and secondary body.

Problem 6 [6]
The Sun has an effective temperature of 5778 K. If the spectral radiance is given by Planck's Law, $B_\lambda(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$, and the Sun's V-band magnitude is -26.7, determine the Sun's apparent magnitude in the L band (centered on 3.5 microns).

Problem 7 [6]
Alpha Centauri is a binary system located 4.37 ly from Earth with a total apparent magnitude of -0.27. If Alpha Centauri A and B have temperatures of 5790 and 5260 K, respectively, and radii of 1.227 and 0.865 solar radii, respectively, find the apparent magnitude of Alpha Centauri A and B individually.

Problem 8 [6]
Muons are subatomic particles similar to electrons with a mass of 105.7 MeV/c^2 and lifetime of 2.2 microseconds produced by cosmic ray collisions in the upper atmosphere (approximately 20 km above the Earths surface). If the muons are produced with a velocity of 0.998c, and 10,000 muons/m^2/minute are observed at sea level, what is the muon flux when the muons are created?

Problem 9 [6]

A star is observed with UBV magnitudes $m_u = 16.31$, $m_b = 14.52$, $m_v = 13.76$. Spectral analysis gives $M_b ol = 7.31$, BC = -1.02, $(U - B)_0 = 1.222$. Determine the distance to the star.

Problem 10 [6]

A binary star system has a primary eclipse lasting 1 hour 19.2 minutes in total, with minimum brightness lasting 44.16 minutes. Determine the ratio of the radius of the larger star to the smaller star.

Problem 11 [6]

An eclipsing binary system has a magnitude $m_p = 14.2$ during the primary transit and $m_s = 13.7$ during the secondary transit. Find the normal (non-eclipsed) apparent magnitude of the system?

Problem 12 [6]

A star has a radius $R_* = 0.897 \pm 0.091 R_{sun}$. An orbiting exoplanet causes a 0.37 percent dip in brightness. Calculate the size of the planet in solar radii, including error bounds.