trigonometric parallax) to be 2 pc. The distant astronomer says that you are wrong; the distance is only 1 pc. What is the problem?

2.17. As we determine the astronomical unit more accurately, how does the relationship between the AU and the parsec change?

Problems

2.1. What magnitude difference corresponds to a factor of ten change in energy flux?

2.2. One star is observed to have $m = -1$ and another has $m = +1$. What is the ratio of energy fluxes from the two stars?

2.3. The apparent magnitude of the Sun is -26.8. How much brighter does the Sun appear than the brightest star, which has $m = -1$?

2.4. (a) What is the distance modulus of the Sun? (b) What is the Sun's absolute magnitude?

2.5. Suppose two objects have energy fluxes, f and $f + \Delta f$, where $\Delta f \ll f$. Derive an approximate expression for the magnitude difference Δm between these objects. Your expression should have Δm proportional to Δf. (Hint: Use the fact that $\ln(1 + x) \cong x$ when $x \ll 1$.)

2.6. Show that our definition of magnitudes has the following property: If we have three stars with energy fluxes, f_1, f_2 and f_3, and we define

$$m_2 - m_1 = 2.5 \log_{10}(f_1/f_2)$$

$$m_3 - m_2 = 2.5 \log_{10}(f_2/f_3)$$

then

$$m_3 - m_1 = 2.5 \log_{10}(f_1/f_3)$$

2.7. Suppose we measure the speed of light in a laboratory, with the light traveling a path of 10 m. How accurately do you have to time the light travel time to measure c to eight significant figures?

2.8. Let λ_1 and $\lambda_2(\nu_1, \nu_2)$ be the wavelength (frequency) limits of the visible part of the spectrum. Compare $(\lambda_1 - \lambda_2)/(\lambda_1 + \lambda_2)$ with $(\nu_1 - \nu_2)/(\nu_1 + \nu_2)$. Comment on the significance.

2.9. (a) Calculate the frequencies corresponding to the wavelengths 500.00 nm and 500.10 nm. Use these to check the accuracy of equation (2.10a). (b) Repeat the process for the second wavelength being 501.00 nm and 510.00 nm. What do you conclude?

*2.10. (a) Use equation (2.9) to derive ν_{max}, the frequency at which $I(\nu, T)$ peaks. Convert this ν_{max} into a wavelength λ_{max}. (b) Use equation (2.10c) to find the wavelength at which it peaks. (c) How do the results in (a) and (b) compare?

2.11. For a 300 K blackbody, over what wavelength range would you expect the Rayleigh–Jeans law to be a good approximation?

2.12. Derive an approximation for the Planck function valid for high frequencies ($h\nu \gg kT$).

2.13. As we will see in Chapter 21, the universe is filled with blackbody radiation at a temperature of 2.7 K. (a) At what wavelength does the spectrum of that radiation peak? (b) What part of the electromagnetic spectrum is this?

2.14. (a) We observe the blackbody spectrum from a star to peak at 400 nm. What is the temperature of the star? (b) What about one that peaks at 450 nm?

2.15. Derive an expression for the shift $\Delta\lambda$ in the peak wavelength of the Planck function for a blackbody of temperature T, corresponding to a small shift in temperature, ΔT.

2.16. Calculate the energy per square centimeter per second reaching the Earth from the Sun.

2.17. How does the absolute magnitude of a star vary with the size of the star (assuming the temperature stays constant)?

2.18. (a) What is the energy of a photon in the middle of the visible spectrum ($\lambda = 550$ nm)? (b) Approximately how many photons per second are emitted by (i) a 100 W light bulb, (ii) the Sun?

2.19. If we double the temperature of a blackbody, by how much must we decrease the surface area to keep the luminosity constant?

*An asterisk denotes a harder Problem or Question. The convention continues throughout the book.

(assuming the radius stays constant)? (b) Does the absolute visual magnitude vary in the same way?

*2.21. For a star of radius R, whose radiation follows a blackbody spectrum at temperature T, derive an expression for the bolometric correction.

2.22. Suppose we observe the intensity of a blackbody, I_0, in a narrow frequency range centered at ν_0. Find an expression for T, the temperature of the blackbody in terms of I_0 and ν_0. (a) First do it in the Rayleigh–Jeans limit and (b) in the general case.

*2.23. Suppose we receive light from a star for which the received energy flux is given by the function $f(\lambda)$. Suppose we observe the star through a filter for which the fraction of light transmitted is $t(\lambda)$. Derive an expression for the total energy detected from the star. (Hint: Start by thinking of the energy detected in a small wavelength range.)

2.24. What is the distance to a star whose parallax is 0.1 arc sec?

2.25. Derive an expression for the distance of an object as a function of the parallax angle seen by your eyes?

2.26. (a) If we can measure parallaxes as small as 0.1 arc sec, what is the greatest distance that

Computer problems

2.1. Make a fourth column for Table 2.1, showing the range of photon frequencies for each part of the spectrum. Make a fifth column showing the range of photon energies for each part of the spectrum. Make a sixth column showing the temperatures that blackbodies would have to peak at the wavelengths corresponding to the boundaries between the parts of the spectrum

2.2. Make a graph of the magnitude difference $M_B - M_V$ as a function of temperature for a temperature range of 3000 K to 30 000 K. To simplify the calcu-