Department of Physics
1st Year Examples 2005/2006
Term 2, Week 20–24

THE UNIVERSITY OF WARWICK

PX144: Introduction to Astronomy

Academic Week 23/Term Week 19: Stars

Question 1: *Stars: Distances*

a) Parallaxes can also be used to determine distances within our Solar System. The Moon has a distance of 380000 km from the center of the Earth. What is its parallax angle with respect to the Earth's radius ($r_{\text{Earth}} = 6378$ km)? What is the error introduced by using the small angle approximation with respect to the exact computation?

b) In 1838, Bessel determined the distance of the star 61 Cygni to 3.16 pc, while the modern distance determination yields 3.40 pc. Estimate the error in arcseconds of Bessel's measurement.

c) What is the distance modulus and distance (in parsecs) of a star whose absolute magnitude is +6.0 and whose apparent magnitude is +16.0?

Question 2: *Stars: Magnitudes*
The aim of this question is to get you acquainted with the major observational properties of stars, including the somewhat arcane units used in astronomy.

a) *Magnitudes, Luminosities:* With an apparent magnitude of $m = -1.5$ mag, Sirius is the brightest star in the sky. You have all seen it south of the very prominent constellation Orion. Sirius is at a distance of $d = 8.6$ light years, i.e., it is very close to us. Close to Sirius in the shoulder of Orion sits Betelgeuse, which – while still bright – appears much fainter to us than Sirius. At a distance of 490 light years, Betelgeuse has an apparent magnitude of $m = 0.8$ mag (note that Betelgeuse is a variable star and you might find different magnitudes when browsing around – please use the values given here!). Compute the absolute magnitudes of Sirius and Betelgeuse and compare the luminosities of the two stars.

b) *Zeilik & Gregory, Problem 11-10:* A certain globular cluster has a total of 10^4 stars; 100 of them have an absolute magnitude of $M = 0.0$, and the rest have $M = +5.0$. What is the integrated visual magnitude of the cluster? (*Hint:* As magnitudes are logarithmic units, it is not possible to obtain the magnitude of a binary system by adding the magnitudes of its components. Instead, one has to first convert the magnitudes into fluxes, add the fluxes, and convert the resulting flux back to magnitudes.)

Question 3: *Stars: Properties in the HRD – This question will be marked for credit*
The Stefan-Boltzmann law implies that the total luminosity of a star is given by

$$L = 4\pi R^2 \sigma_{\text{SB}} T^4$$

provided that the star's spectrum is sufficiently close to that of a black body (this is usually – but not always – the case). For our Sun, $R_\odot = 700000$ km and $T_\odot = 5780$ K, furthermore its apparent magnitude on Earth is $m_\odot = -26.7$ mag.

a) Compute the absolute magnitude of the Sun, i.e., the magnitude the Sun would have if it were at a distance of 10 pc. 1 pc = 206264 AU.

b) Using the information given in the introduction and in the previous subquestion, derive an expression relating the absolute magnitude of a star to its radius and temperature. (*Hint:* Use the definition of the magnitude as a ratio of measured fluxes, applying it to the flux of the Sun and that of a star, both assumed at the same distance).

c) Red giants have temperatures of only 3000 K, so they are rather cold as stars go. Still, they are very luminous, with typical absolute magnitudes of $M = -5$ mag, so they sit in the top right corner of the Hertzsprung-Russell Diagram. Using the formula derived in the previous question, or using the Stefan-Boltzmann law, give an estimate of the typical size of a Red Giant. Will the Earth continue to exist once the Sun turns into a Red Giant 6 billion years from now?

Question 4: *Comments on this week's lectures*

In order to improve the teaching and to enable myself to react to problems you might have with the module, I would like to hear your opinion on my teaching as early as possible. I would appreciate it if you would voice any problems and criticisms as soon as possible, e.g., on the speed with which I talk about the subjects of the lectures, the overall difficulty level of the class and the homework, the quality and contents of the handouts, and so on.

Please write these comments on a separate sheet of paper and give them to me: Either put the paper on the lectern before class or put it in my "pigeon hole" in the mailboxes on the 5th floor of the physics building, close to the physics undergraduate office. Feel free to remain anonymous, if you deem this necessary. You can also ask questions or post comments by using the discussion board for this module at `http://forums.warwick.ac.uk/wf/browse/forum.jsp?fid=912` or by sending email to `j.wilms@warwick.ac.uk` (I will post answers to emailed questions on the discussion board, if they are of sufficient interest for others).