AST 207 Test 2 Answers 21 October 2009

You may use one sheet of notes. You may not use books or additional notes.

Do the easy questions first. Then go back to the harder ones.

Name	
PID	
1	/ 15
2	/ 7
3	/ 4
4	/ 4
Total	/ 30

Star	App mag	Abs mag	Spectral type	Distance (pc)
Sun	–26.74	4.83	G2	5×10^{-6}
Sirius A	–1.45	1.41	A1	2.7
Sirius B	8.7	11.6	A	2.7
Canopus	–0.73	–4.7	F0	60
Rigel Kent.	–0.1	4.3	G2	1.33
Arcturus	–0.6	–0.2	K0	11
Vega	0.04	0.5	A0	8.1
Capella	0.08	–0.6	G8	14
Rigel	0.11	–7.0	B8	93
Procyon	0.35	2.65	F5	3.5
Betelgeuse	0.8	–6	M2	200
Achernar	0.48	–2.2	B5	39
Hadar	0.60	–5.0	B1	120
Altair	0.77		A7	5.0
Aldebaran	0.85	–0.7	K5	21
Acrux	0.9	–3.5	B2	80
Spica	0.96	–3.4	B1	80
Antares	1.0	–4.7	M1	130
Fomalhaut	1.16	1.9	A3	7.0
Pollux	1.15	0.95	K0	11
Deneb	1.25	–7.3	A2	500
Mimosa	1.26	–4.7	B0	150
61 Cygni	5.2	7.6	K5	3.5

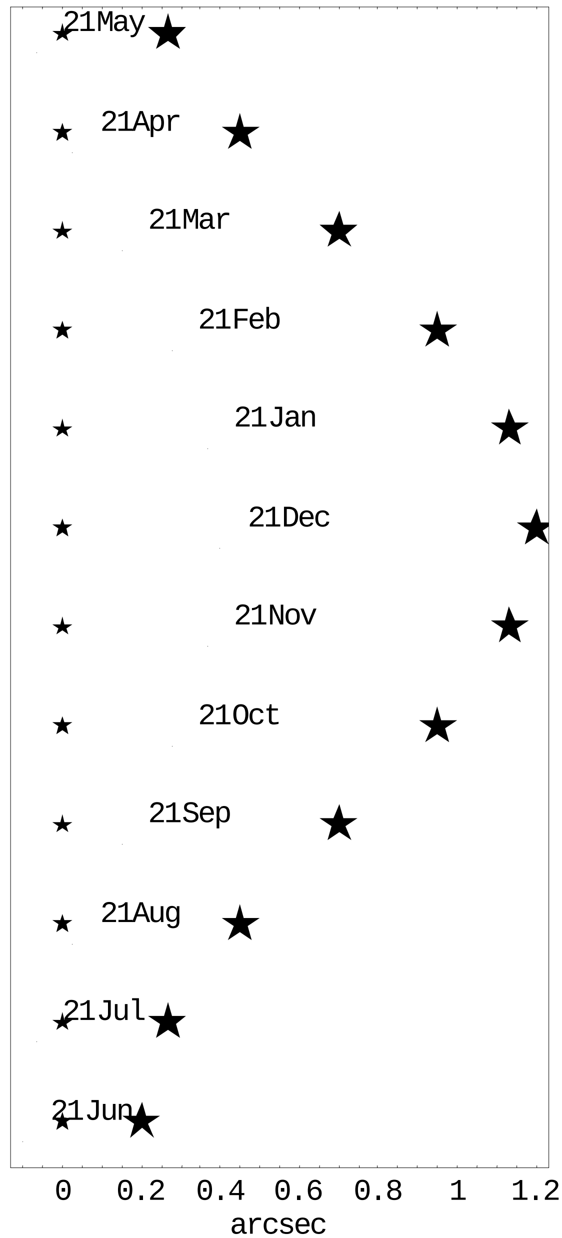

Figure 1 Observations of a nearby star (large symbol) and a distant star (small symbol) over the course of a year. The pictures are offset vertically. The horizontal spacing is shown accurately. East is to the left.

1. For these questions, you need to separate the key ideas from the details. Extraneous details will count against you. Write brief answers using a few complete sentences.

    a. (3 pts.) What prevented Hipparchus from measuring distances to the nearest stars?

    Bessel, Struve, & Henderson, who did measure the distances to 3 stars, had (1) telescopes and (2) a longer baseline. The longer baseline, the earth-sun distance, meant the AU had to be measured.

    b. (3 pts.) Suppose we set up a telescope on Mars to measure the distances to stars. Would the parallactic shifts be larger or smaller than they are on Earth? Explain your reasoning.

    "The parallactic shift would be greater than on Earth, because Mars has a larger orbit than Earth, making a larger baseline."—D. Jaeger

    "…For example, angle=baseline/distance. Earth's baseline is 1AU, and say Mars' baseline is 1.5AU, and the distance from each of them is the same, 3.5[pc]. Angle from earth is 1/3.5. Angle from Mars=1.5/3.5."—C. Oakley.

    Many answered that the parallax is different because Mars or closer or farther from the star. The change in distance is insignificant: The nearest stars are about a parsec, which is 200,000AU.

    c. (3 pts.) How is it possible that a bigger star is less luminous than a smaller one?

    A bigger, cooler star may be less luminous than a smaller, hotter one.

    d. (3 pts.) Why was finding Sirius B's temperature crucial to the discovery of white dwarfs?

    "Finding that Sirius B's temperature was very similar to Sirius A's temperature left only one explanation for the differences in their luminosities; Sirius B must be much smaller."—A. League

    e. (3 pts.) Both the apparent and absolute magnitudes of Vega were known in 1900, but only the apparent magnitude was known in 1800. Explain why.

    "In 1800 astronomers could tell how bright stars were from earth (apparent magnitude), but it wasn't until the 1830's when Henderson, Bessel, and Struve got the first distances to stars. This allowed astronomers to put all stars on a level playing field and tell how bright they would be if they were at a set distance [of 10pc].''—B. Cox.

2. Imagine aliens on a planet A that orbits the star Hadar at a distance of 1 AU. (See the table on the front sheet.)

    a. (1 pt.) Would the aliens observe Hadar to be redder or bluer than the Sun?

    Since the spectral class of Hadar is B, which is hotter than G, that of the sun, Hadar is bluer.

    b. (3 pts.) For the aliens on planet A, how much brighter or fainter would Hadar be compared with the Sun as seen by us?

    Since we are viewing the sun, and the aliens are viewing Hadar both from 1AU, compare the absolute magnitudes. Hadar is 9.83 mag more luminous than the sun. The aliens see Hadar as 8600 times (3.93 factors of 10) brighter than we see the sun.

c. (3 pts.) Aliens on another planet B, which also orbits Hadar, see Hadar to be exactly as bright as we see the Sun. What is the distance between planet B and Hadar?

On planet B, Hadar must be 8600 times fainter than it is on planet A. Since flux is proportional to $(\text{distance})^{-2}$, the distance is $\sqrt{8600}$ AU = 92 AU.

3. A star orbits Sag A in an elliptical orbit with a period of 14 yr. The semi major axis of the orbit is 1000 AU. (3 pts.) Show how to find the mass of Sag A. (1 pt.) Give the numerical answer for the mass. (It is easiest to express the mass in solar mass, rather than in kg.)

Use Newton's version of Kepler's Third Law: $P^2=R^3/M$, where the period P is in years, the semi major axis R is in AU, and the mass M in solar masses.

$$M = R^3/P^2 = 1000^3/14^2 = 5\times10^6\ M_{sun}.$$

4. We have made observations of a star and a very distant star to measure the distance of the nearby star. On June 21, the nearby star is 0.2 arcsec from the bright one. On July 21, the nearby star is 0.27 arcsec from the bright one. The other observations are shown in Figure 1 on the front sheet.

a. (3 pts.) Explain how to calculate the distance to the nearby star. (1 pt.) Express the distance in parsec.

Pick the two dates 6/21 and 12/21, for which the shift between the nearby star and the distant star is 0.2arcsec, the smallest, and 1.2arcsec, the largest. Between these two observations, the baseline is 2AU. The distance D to the nearby star is

D = Baseline/Angle = 2AU/(1arcsec) = 2 parsec.

Alternatively, pick 9/21 and 12/21 as shown in the diagram. Then

D = Baseline/Angle = 1AU/(0.5arcsec) = 2 parsec.