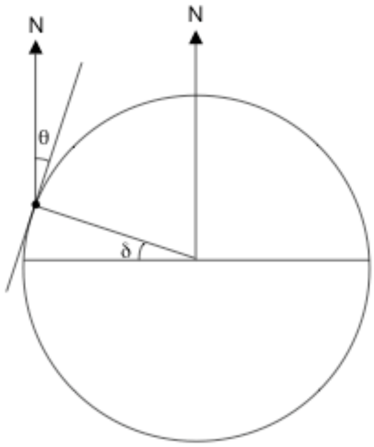
Year 1 Introduction to Astrophysics

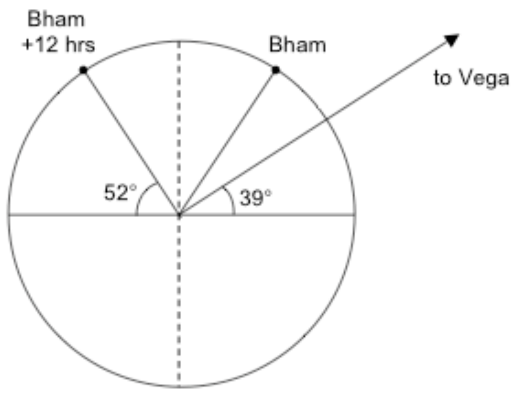
Practice problems 1 - Solutions

1. (a)



If the observer (marked by black dot) is at latitude δ, then the angle of the N direction above the horizon must also be δ. Consider angles in triangles on the left to see this.

(b)



Minimum distance of Vega from zenith = 52-39=13 deg (on right).

12 hours later (on left) Vega will be a *maximum* distance of 180-52-39=89 deg from the zenith at Birmingham. Hence min and max altitudes of the star above the horizon are 1 deg and 77 deg.

2. The sun is at RA=0h on March 21st, and moves 2hr per month (hence a full 24 hr in a year) towards increasing RA. We want the sun opposite in the sky to M33, hence we should observe about 7 months after the vernal equinox (i.e. in October), when it will be around RA=14h.
   The galaxy is in the North (positive declination), so a N.hemisphere observatory should be used.
   M33 will cross the meridian (and hence be highest in the sky) when the LST is equal to the RA of the object – i.e. at LST=1h34m.

3. (a) The diameter is 10/2000=0.005 radian. Multiplying by 206265, this is equivalent to 1031 arcsec.

(b) Parallax in arcsec is just the inverse of the distance in pc, so the star cluster has $p=1/d$=1/2000=0.0005 arcsec, or 0.5 mas.

(c) The solid angle covered is the area covered by the cluster divided by the square of its distance (where the units must be the same for area and distance squared, so they cancel).
Hence $\Omega = \pi r^2/d^2 = \pi \times 5^2 / 2000^2 = 1.96 \times 10^{-5}$ sr.

4. Using $L=4\pi R^2\sigma T^4$, we obtain (converting everything to SI units) $L_{\mathrm{Rigel}}=2.48\times10^{31}$ W=63,490 $L_\odot$.

5. The Cepheid is 4 orders of magnitude more luminous than the Sun, and so its absolute magnitude must be 4 x 2.5 =10 mag brighter. Hence it must have M_V = 4.83-10 = -5.17.
Its distance modulus is therefore m-M = 24.83 + 5.17 = 30.
Since m-M = 5 log (d/10 pc), it follows that d=10 Mpc.

6. Rigel is bluer by 0.69 mag, hence if a sun-like star had the same magnitude as Rigel in the B band, then it would be 0.69 mag brighter than Rigel in V. Since (lecture 3) $F_1/F_2 = 10^{-(m1-m2)/2.5}$, this corresponds to a factor $10^{0.69/2.5}$ = 1.89 in V band flux.

7. (a) Assuming that the galaxy moves with the Hubble expansion, we get H_0 = (75000 km/s)/(1200 Mpc) = 62.5 km s^{-1} Mpc^{-1}.

(b) The Hubble time is just $1/H_0$. Converting H_0 into units of s^{-1}, we get
$H_0 = 62.5/3.1\times10^{19} = 2.0\times10^{-18}$ s^{-1}.
So $t_H = 1/H_0 = 5\times10^{17}$ s = 1.6×10^{10} yr.

(c) Assuming that light simply travels through the Universe at the speed of light to reach us in the time since the Big Bang, and that the age of the Universe is t_H , neither of which is quite true, the radius of the observable Universe is simply
$R = c\, t_H = 3\times10^8 \times 5\times10^{17} = 1.5\times10^{26}$ m = 4839 Mpc.

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