Radio Astronomy [AA 474/674]

Assignment 1

Date: 04.01.2021 Deadline: 11.01.2021

1. a) An observer is located at latitude 38 ° N and longitude 79 ° W. Calculate the altitude of Polaris (the altitude of the north celestial pole), the altitude of the south celestial pole and the altitude of the celestial equator for this observer.
   b) Rework the previous problem in a) for an observer located at latitude 38 ° S and longitude 30° E. How do the results compare?

2. The most northerly star of the Southern Cross, γ Crucis, has declination -57°. At what latitude will it just be visible? At what latitude will it pass directly overhead? At what latitudes will it never set?

3. The synodic period (S) of a planet is defined as the time for a planet to appear in the same place in the sky relative to the stars (in the same constellation) **as seen from the earth**. This is as seen from Earth, and involves the motion of the Earth. The sidereal period (P) is defined as the time for a planet to go once around the Sun (with respect to the stars). This period is independent of where we are and does not depend on the motion of the Earth. Find the relationship between sidereal and synodic period for inferior (inner) planets.

   $$1/S = 1/P - 1/E$$

   [Hint: Compare the angular velocities in each case]
   Find the corresponding relation for superior planets.

4. a) Prove that specific intensity in distance-independent.
   b) The surface brightness of a galaxy at a distance d is I_0 mag arcsec^{-2} . I_0 corresponds to the total galaxy flux per arcsec^{-2} . Assume that the galaxy is made up of stars of absolute magnitude M. Show that the number of stars contained within 1 arc second square patch of the image of this Galaxy is given by

   $$N = \left(\frac{d}{10pc}\right)^2 10^{0.4(M-I0)}$$

5. The latitude of Indore is 22.7196° N and 75.8577° E. The LST at Indore on January 27, 2020 at 9PM (IST, local time) is 4.93 Hrs. The star Betelgeuse is a bright supergiant star which will explode following a supernova in the (near?) future. Recently it generated a lot of interest as it has been consistently dimming since December 2019 indicating significant implication about its fate. This dimming in intensity of the star is more deeper, fatster and longer than any previous behaviour observed from this variable star. Calculate the altitude and azimuth of Betelgeuse (**RA** = 05h 55m 10.3s, **Dec** = +07° 24' 25") as measured from Indore at that time.

6. We have a digital camera with a CCD chip 1024 X 1024 pixels, sensitive to optical light (0.55nm). The Chip dimension is 2 cm X 2 cm. We want to use this CCD for astronomical observations. What should be the focal length id we want to ensure that a the corresponding telescope creates a the image of a star (point source) as a blob of 2 X 2 pixels on the CCD?

7. Confirm that the Lick 3-m telescope has plate scale of ∼14 ” /mm, given its focal length of 15.2 m. What is the focal ratio R of this telescope? A detectable image of a distant star (i.e., a point source) can be obtained on film at the focus of the telescope in an exposure of duration T if the

flux density (W m^{-2}) at the telescope is F. The circular image size is 1" in radius due to variable atmospheric refraction. How long does it take to detect a uniformly bright nebula of angular radius 2' if its total flux is 1000 F?

8. (a) What is the difference of magnitudes for two stars if one is a million times "brighter" than the other? (b) The original Palomar Observatory Sky Survey photographic plates reach to a magnitude of about m = 21. Compared to the brightest stars, $m \approx 0$, how "faint" are the 21st magnitude stars, i.e., what is the ratio of fluxes? Repeat for the Hubble Space Telescope (HST) which can reach to $m_V \approx 28$. (c) The bright star Sirius (type A1 V) has $m_V = -1.44$ and is at distance 8.8 LY. Would Sirius be visible to the HST if it were in our sister galaxy Andromeda at distance 2.5 MLY? (d) Would a star identical to the sun (absolute magnitude $M_V = 4.82$) in Andromeda be visible to the HST?

9. When the moon is full, its magnitude (summed over its entire surface) is V = −12.7. The diameter of the moon is about 30'. (a) The resolution of the human eye is ~1'. What is the magnitude of the moon per square arcminute? (b) What is the magnitude per square arcsecond; the resolution of a ground-based optical telescope? (c) What is the surface brightness of the moon?