18

PHY305A
Quiz 1

time: 50 minutes
Name: Sahil Dhull

max. marks 30
Roll number: 160607

Calculators and mobiles are not allowed. You may leave your final answer in the form of a numerical expression. However all numerical substitutions must be done and you are required to simplify the final result as much as possible.

1. Using Stellarium determine the name of the brightest star in the constellation Bootes. (marks 2)

2. Using Stellarium name the constellation on the eastern and the western horizon in the night sky today at Kanpur at 4 AM. (marks 3)

3. Using Stellarium determine the next date when you will observe the retrograde motion of the planet Venus assuming you are above the atmosphere and able to observe in all directions. For this exercise eliminate the ground and the atmosphere so that you are able to view stars in all directions at all times. (marks 7)

4. The transformation between ecliptic (β, λ) and equatorial coordinates (δ, α) is given by

$$\cos\beta\cos\lambda = \cos\delta\cos\alpha\,,$$

$$\cos\beta\sin\lambda = \cos\mu\cos\delta\sin\alpha + \sin\mu\sin\delta\,,$$

$$\sin\beta = -\sin\mu\cos\delta\sin\alpha + \cos\mu\sin\delta\,.$$

Determine the inverse transformation, i.e. the transformation between equatorial and ecliptic coordinates.

(marks 4)

μ is the angle between ecliptic and equatorial pole.

Going from equatorial to ecliptic, we have to rotate about x-axis by μ counter-clockwise.

Hence going from ecliptic to equatorial, it will be μ clockwise.

Hence

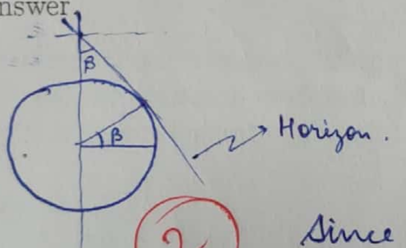
$$\cos\delta\cos\alpha = \cos\beta\cos\lambda$$
$$\cos\delta\sin\alpha = \cos\mu\cos\beta\sin\lambda - \sin\mu\sin\beta$$
$$\sin\delta = \sin\mu\cos\beta\sin\lambda + \cos\mu\sin\beta$$

4

4. Consider an observer at latitude β. Determine the range of declinations of stars which always remain below the horizon for this observer. Give a clear explanation of your answer.

(marks 4)

4



The horizon plane, when rotated about rotation axis will result in a conical surface.

2

Since observer can't see stars below Horizon plane, So all the stars that lie inside this cone will not be visible ever.

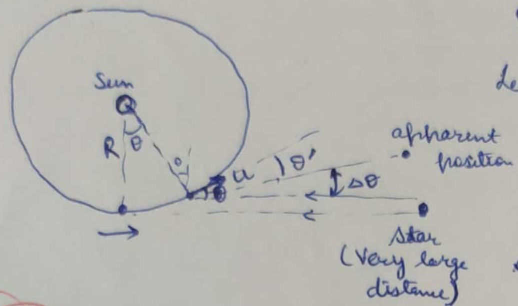
So, the range of declination is from $-(\frac{\pi}{2}-\beta)$ to $-\frac{\pi}{2}$

$\Rightarrow$ $\beta-\frac{\pi}{2}$ to $-\frac{\pi}{2}$

2

5. Let the orbital speed of Earth around the Sun be u. Consider a star which lies in the ecliptic plane. Assume that at time $t = 0$ the velocity vector of Earth is parallel to the direction of the star. Determine the shift of the star's position vector due to aberration one month later. (Ignore Earth's rotation)

(marks 4)



θ is the actual position of star

Let θ' be the apparent position due to aberation.

We know $\tan\theta' = \dfrac{\sin\theta}{\cos\theta + \frac{u}{c}}$ 1

Since time = 1 month, $\theta = \frac{2\pi}{12} \times 1 = \frac{\pi}{6} = 30°$

4

$\Rightarrow \tan\theta' = \dfrac{1/2}{\frac{\sqrt{3}}{2} + \frac{u}{c}} \Rightarrow \theta' = \tan^{-1}\left(\dfrac{c}{\sqrt{3}c + 2u}\right)$ 1

Shift of star's position vector $= \left(\theta - \tan^{-1}\left(\dfrac{c}{\sqrt{3}c+2u}\right)\right)$ towards east

2

$= \left[\dfrac{\pi}{6} - \tan^{-1}\left(\dfrac{c}{\sqrt{3}c+2u}\right)\right]$ towards east.

6. Assume that a star is a blackbody radiator with surface temperature T and radius R. The intensity of blackbody radiation at this temperature is

$$B = \frac{\sigma T^4}{\pi}$$

(a) Write down the general formula for flux density as an integral over the intensity.
(b) Using this formula, determine the flux density at the surface of the star.

(marks 2+4)

(a) $F = \int d\Omega \cos\theta \, I$, where θ is the polar angle (w.r.t. area vector)
Ω is the solid angle
& I is the intensity.

2

(b) $F_s = \int d\Omega \cos\theta \, I = \int d\Omega \cos\theta \, B$, $I = B$.

Since radiations are coming from lower half in all directions

$F_s = \int_0^{2\pi} d\phi \int_0^{\pi/2} d\cos\theta \cos\theta \, B = 2\pi B \left[\dfrac{\cos^2\theta}{2}\right]_0^{\pi/2} = \pi B$

$\Rightarrow F_s = \sigma T^4$

4

12

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1. Using Stellarium determine the name of the brightest star in the constellation Bootes. (marks 2)

Brightest star → Arcturus

2. Using Stellarium name the constellation on the eastern and the western horizon in the night sky today at Kanpur at 4 AM. (marks 3)

Western Horizon - Delphinus, Equuleus, Aquarius

Eastern Horizon - Cancer, Canis Minor, Monoceros

3. Using Stellarium determine the next date when you will observe the retrograde motion of the planet Venus assuming you are above the atmosphere and able to observe in all directions. For this exercise eliminate the ground and the atmosphere so that you are able to view stars in all directions at all times. (marks 7)

Starts at - May 2020

Ends in - July 2020