PHY305A
Mid Sem Exam

time: 2 hours

max. marks 80

Instructions:
1. 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.
2. Please answer all parts of a question adjacent to one another. We will grade an answer only at the first place where it appears in the answer sheet.

1a. A star has 2 times the flux of the reference star (such as Vega) in B filter and half the flux of the reference star in V filter. Using the magnitude scheme in which all magnitudes of the reference star are 0, find $B-V$ for the star.

1b. The apparent bolometric magnitudes of two stars (1 and 2) are related by $m_1 = m_2 + 5$. Their surface temperatures T_1 and T_2 are related by $T_2 = 4T_1$. Find the relationship between their angular diameters. Assume that the stars emit as perfect blackbodies.

1c. Starting with the formula for specific intensity B_ν

$$B_\nu = \frac{2h\nu^3/c^2}{e^{h\nu/kT} - 1}$$

determine the expression for B_λ where the symbols have their standard meaning.

(marks 3+6+3)

2a. Write down the relationship between the sidereal day and the solar day.

2b. In deriving the relationship between the sidereal day and the solar day we assumed that rotation axis of the Earth is parallel to its axis of revolution. If we do not make this assumption, will the relationship change? Give a brief explanation for your answer.

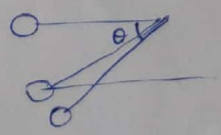
2c. Determine the angular deflection of a star due to the atmosphere assuming the plane parallel model of the atmosphere.

2d. What is the theoretical limit on the resolution of any instrument. What is the physical reason for this limit?

(marks 2+4+4+2)

3a. Make a sketch of the HR diagram with $B-V$ on the x-axis and M_V on the y-axis with the range of $B-V \in [-0.5 : 2]$ and that of $M_V \in [15 : -10]$. Clearly label the main branches of stars on this diagram.

3b. Approximately show the position of (i) Sun, (ii) Betelgeuse and (iii) a B0V type star on the HR diagram drawn in (3a).



O B A F G K M

3c. Explain why most of the stars in the HR diagram lie along a particular branch of the diagram.

(marks 5+4+3)

4a. Consider Hydrogen atoms and ions in a stellar atmosphere. Express N_2/N_{total} in terms N_2/N_1 and N_{II}/N_1 where the notation has its standard meaning.

4b. The Balmer lines of H are very weak in the solar spectrum. Suppose we observed the Lyman lines in the solar spectrum instead of the Balmer lines. What would be the relative strength of these lines? Briefly explain your answer.

4c. Make a rough sketch of the observed strength of H Balmer lines and CaII lines in stellar spectra from O5 to M7 type stars. O B A F G K M

4d. Approximately what is the effective wavelength of the U and V filters. 390 - 780 nm.

4e. Approximately what is the effective temperature of a star which has $B - V = 0$.

(marks 3+3+3+2+1)

5a. Name the star with largest proper motion. Approximately what is the observed angular speed (in arcseconds per year) of this star?

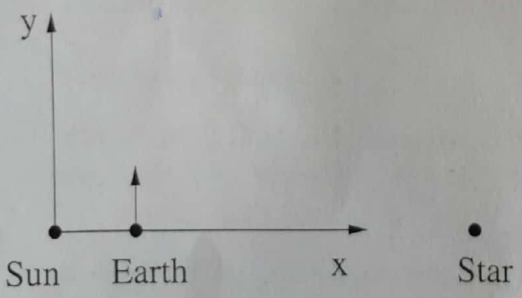
5b. Consider a star which lies in the ecliptic plane. Assume that its annual parallax is 0.5" arcsecs.

(i) What is the distance of this star from Earth in parsec units and in Km, given that 1 AU $= 1.496 \times 10^8$ Km.

(ii) Assume that the star has proper motion equal to 1" per year. Determine the transverse speed of the star i.e. the linear speed arising due to the proper motion.

(iii) Let the angular velocity of the star also lie in the ecliptic plane. Assume that at time $t = 0$ the star is at the location shown in the figure below with its velocity vector (neglect radial velocity) parallel to the velocity vector of Earth due its revolution around the Sun (neglect rotation of Earth). Determine the motion of the star as seen by an observer on Earth. Plot the y-component of the position of the star as a function of time as seen by Earth based observer.

(marks 2+3+2+7)



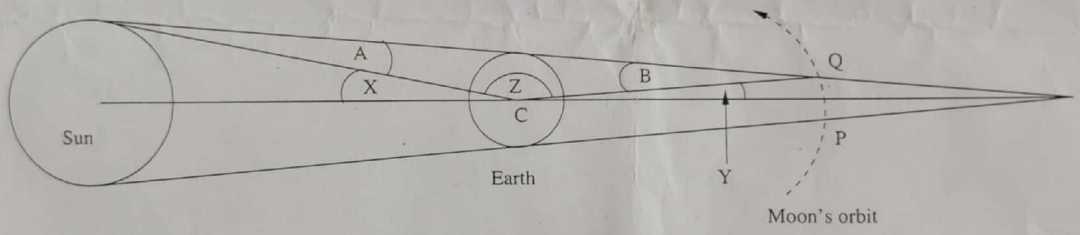
6a. Define vernal equinox.

6b. Consider an observer located at the equator. She uses the direction towards north (parallel to Earth's rotation axis) as the z-axis and the local normal as the y-axis. Determine the transformation between this coordinate system (a, A) and the equatorial coordinate system (δ, α) at some time t. Assume that at initial time $t = 0$, the x-axis makes an angle ϕ_0 with the vernal equinox. Here a is the latitude and A the azimuthal coordinate in the local coordinate system. (In this problem you can ignore the revolution of Earth.)

(marks 2+6)

7a. Consider a radio telescope consisting of two antenna. The baseline has length 1 Km and is oriented in the east-west direction on the equatorial plane. It is observing a star which also lies in this plane. As the Earth rotates the orientation of the baseline changes. Ignore the effect of revolution of Earth. When the star is directly overhead, the path difference between the two antennas is zero. Find the path difference one hour later.

7b. The diagram shows the Sun, Earth and Moon as the Moon passes through the Earth's shadow. Let R_S, R_E and R_M be the radii of the Sun, Earth and the Moon respectively. Let r_S be the Earth-Sun distance and r_M the Earth-Moon distance. Given that $X+Y = A + B$ obtain a relationship between R_M, R_E and R_{sh} where R_{sh} is the radius of the Earth's shadow on the Moon. Hence express R_E/R_M in terms of the angle Y. You may make suitable assumptions and approximations.



(marks 4+6)