Useful constants:

$G = 6.67 \times 10^{-11}\ m^{-3}\ kg^{-1}\ s^{-2}$

$k_B = 1.38 \times 10^{-23}\ J/K$

$\sigma = 5.67 \times 10^{-8}\ W\ m^{-2}\ K^{-4}$

$M_\odot = 1.99 \times 10^{30}\ kg$

$R_\odot = 6.96 \times 10^{8}\ m$

$L_\odot = 3.86 \times 10^{26}\ W$

$1\ A.U. = 1.5 \times 10^{11}\ m$

$\mu_o = 4\pi \times 10^{-7}\ NA^{-2}$

$m_H = 1.67 \times 10^{-27}\ kg$

[This question paper contains 8 printed pages.]

05.01.2024(M)

Your Roll No.....

Sr. No. of Question Paper : 4597 **G**

Unique Paper Code : 32227506

Name of the Paper : Astronomy & Astrophysics

Name of the Course : **B.Sc. (Hons.) Physics – DSE**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** of the following : (5×3)

(a) The Sun is a G2V star, while star 'HD 13189' is a K2II star. Explain, what is meant by these classification terms.

(b) The James Webb space telescope has an aperture of diameter 6.5 m. At a wavelength of 1 μm, what will be its angular resolution in arc seconds. Will it be able to resolve the great red spot which spread 10,000 km across on the planet Jupiter. Assume v that Jupiter is at a distance of 5 A.U.

(c) What is the Sun's hour angle at the following local times : 8:15 p.m, 8:15 a.m. & at noon.

(d) If a star ($\delta = +45°$) is on the celestial meridian 9° south of the zenith, what is your latitude?

(e) Explain the significance of Oort's constant A and B.

Sketch the density distribution $\rho(r)$ as a function of r. Calculate the mass enclosed, M(r), within the distance r. Obtain the rotational velocity as implied by this mass distribution. Describe one key observation that suggest the presence of dark matter in the milky way galaxy.

(b) How many times the sun would have revolved around the centre of the milkyway if it is rotating in a circular orbit with a velocity 250 km/s at a distance of 8.5 kpc from the galactic centre? (Assume the age of the sun to be 4.6×10^9 years) (10,5)

7. (a) Using Newtonian cosmology, Derive first Friedmann equation and hence explain the concept of open, flat and closed universe.

(b) How far from the Solar System would a galaxy with a redshift of z = 0.035 be ? (Assume $H_0 = 70$ km/s/Mpc) (10,5)

P.T.O.

5. (a) Show that in a perfecting conducting fluid (say a gas of free electrons), the magnetic flux through any closed loop moving with the fluid is constant with time. (The magnetic field lines are "frozen" into the field).

(b) Assume that the number density of particles in photosphere is constant everywhere, but the magnetic field inside sunspot (B_{in} = 0.1 T) is much stronger than outside (B_{out} = 0.005 T). If the temperature inside the sunspot is T_{in} = 4000 K while the temperature outside is T_{out} = 6000 K, estimate the number density of plasma particles in the photosphere. (10,5)

6. (a) Assume that dark matter in the galaxy has a density distribution which varies with distance r as : $\rho(r) = \rho_0(r_0/r)$, where ρ_0 and r_0 are constants.

(f) State two properties which a good *standard candle* distance indicator should possess.

2. (a) A binary star system consist of two components star A and star B. Assume that the orbit is circular and we see the system edge on.

(i) Star A is observed to have a parallax of 0.07". How far is the system.

(ii) The maximum angular separation of stars A and star B is 0.75". What is the actual separation (in A.U.) of the two stars.

(iii) The orbital period of the system is 12 years. What is the total mass of the system (in solar unit)?

(iv) Both stars can be observed spectroscopically and the maximum Doppler shift of spectral lines from starB is found to be 1.5 times

larger than the maximum shift for star A. What is the ratio of masses m_A / m_B? Hence find the individual stellar masses m_A and m_B.

(b) How many main-sequence stars with $m_V = 20$ equal the brightness of a single giant with $m_V = 12.5$?

(10,5)

3. (a) Explain the universal equatorial coordinate system for determining the position of astronomical objects with appropriate diagram. Write two advantages and disadvantages each for this coordinate system.

(b) Define circumpolar stars. With the help of a suitable diagram show that the condition for a star to be circumpolar is $\delta > 90 - \varphi$, where δ is the declination and φ is the latitude of the observing site. (10,5)

4. (a) Consider a system consist of N stars bounded by gravitational force. Show that for such system the time-averaged kinetic energy $\langle T \rangle$ and the time-averaged potential energy $\langle U \rangle$ satisfy the $2\langle T \rangle + \langle U \rangle = 0$ in a steady equilibrium state and the average is obtained by integrating over a sufficiently long time τ and dividing all the terms by τ.

(b) Consider a spherical gas cloud, having a mass of $M = 10^6 M_\odot$, a radius of R = 50 pc and an average temperature of T = 10 K. For simplicity , assume that the gas cloud consists of hydrogen only. Using order of magnitude arguments, assess whether the cloud is in virial equilibrium or not. If it is not, what would happen to the cloud?

(10,5)

P.T.O.