Register Number:
DATE:

ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27

M.Sc. PHYSICS - IV SEMESTER

SEMESTER EXAMINATION- APRIL 2017

PH 0416: ASTROPHYSICS

Time: 2.5 hrs. **Maximum Marks: 70**

This question paper has 3 printed pages and 2 parts

PART A **MAX. MARKS 5x10=50**

Answer any FIVE full questions.

1. With an appropriate ray diagram derive the expression for plate scale of a telescope. Express the plate scale in terms of arc-seconds (**10 Marks**)

2. The expression for the power radiated by a relativistically moving charged particle (relativistic Larmor formula): $P=\frac{2}{3}\gamma^4\frac{e^2a^2}{c^3}$. Show that the average power (over the pitch angles) radiated by an electron moving relativistically in a magnetic field of intensity B is given by $\langle P\rangle=\left(\frac{2}{3}\right)^2 r_0^2\frac{v^2}{c}\gamma^2B^2$ (**10 Marks**)

3. The radiative transfer equation is given as: $\frac{dI_\nu}{ds}=-\alpha_\nu I_\nu+j_\nu$ where I_ν is the specific intensity.
   a) Define specific intensity of a source (**1 Mark**)
   b) Describe the various terms in the radiative transfer equation (**1 Mark**)
   c) Define optical depth (**1 Mark**)
   d) The general solution to the radiative transfer equation is given as: $I_\nu(\tau)=I_\nu(0)+\int_0^\tau e^{-(\tau-\tau')}S_\nu(\tau')d\tau'$
      - Describe the various terms in the above equation (**2 Marks**)
      - Under what conditions can you derive Kirchoff's Law: $I_\nu=S_\nu$ (assume a constant value for S_ν). (**5 Marks**)

4.
   a) Write down the equation of motion of a gas element inside a star (**6 Marks**)
   b) Using this, obtain the free fall dynamical time scale of a star. What is this time scale for our Sun? (**2 Marks**)
   c) What is the physical significance of this timescale (in comparison with the lifetime of the Sun)? (**2 Marks**)

5.
   a) How can we scientifically infer the color of a star? (**5 Marks**)
   b) What is the significance of color-color diagrams for populations of stars? (**3 Marks**)
   c) How do color-color diagrams differ from color-magnitude diagrams? For what populations of stars are color-magnitude diagrams important. (**2 Marks**)

6. Describe the constituents of the Interstellar Medium. What are the radiation mechanisms for each of these constituents. (**10 Marks**)

7. Write short notes on:
   a) cluster of galaxies (**2 Marks**)
   b) gravitational lensing (**2 Marks**)
   c) dark matter (**2 Marks**)
   d) how each of these (a), (b) and (c) are inter-related. (**4 Marks**)

PART B **MAX. MARKS 4x5=20**

Answer any FOUR full questions.

[Constants: $h=6.6\times10^{-34}$ J s (Planck's constant), $1eV = 1.6\times10^{-19}$ J (electron volt to Joules), $c=2.99\times10^{8}$ m/s (speed of light), $1Å = 1\times10^{-10}$m (Angstrom to meters), $e = 1.6\times10^{-19}$ C (electronic charge), $m_{proton}=1.673\times10^{-27}$kg (mass of proton), $m_{electron}=9.109\times10^{-31}$kg (mass of electron), $G=6.674\times10^{-11}m^3kg^{-1}s^{-2}$ (Gravitational constant), $M_\odot=1.9891\times10^{30}$ kg (Solar mass), $R_\odot=6.9\times10^{8}$ m, $\sigma = 5.67\times10^{-8}$ W m^{-2} K^{-4} (Stefan-Boltzmann constant), $M_{Earth}=5.97\times10^{27}$kg (Mass of Earth), $D_{earth\text{-}sun}=1.49\times10^{11}$m (Earth-Sun distance), 1 inch = 2.54 cm]

8. An amateur astronomer has an 8 inch telescope with a focal ratio of f/5.
   a) What is the theoretical resolution of the telescope (assume a wavelength of 550 nm)? You answer should be in arc-seconds. (**1 Mark**)
   b) Compute the plate scale of the telescope. (**2 Marks**)
   c) If the telescope were functioning at the theoretical resolution limit, for an extended object subtending this limit resolution angle, what would its dimensions be on the image plane (i.e. work out the arc-seconds per millimeter on the CCD). (**2 Marks**)

9. The stars Rigel and βCanis Majoris have the same effective temperature, 12000K. Their absolute magnitudes are respectively -6.77 and -1.33.
   a) Calculate their luminosities in solar units (**2 Marks**)
   b) Calculate the ratio of their radii. (**3 Marks**)

10. The Sun has a Magnetic field of intensity 1 Gauss. If the Sun were to become (collapse into) a white dwarf (radius = 1000 km), in a distant future what would it's magnetic field intensity be if we were to conserve the magnetic field intensity during the collapse. (**5 Marks**)

11. Estimate the central pressure in the sun. (**5 Marks**)

12. A quasar has a total luminosity of $3.827\,x\,10^{45}$ ergs s^{-1}. If 10% of the rest mass it accretes gets converted to energy, at what rate does it accrete gas? Convert this rate to solar masses per year. (**5 Marks**)

13. A galaxy cluster consists of hundreds of thousands of galaxies bound together by gravity (much like a galaxy consists of billions of stars bound together by gravity).
   a) One method of estimating the mass of a galaxy cluster is by assuming that all of the mass is through the visible light that we observe. The Coma cluster contains $N_{Gal}=800$ galaxies having an average mass of $M_{Star}\approx 10^{9} M_{\odot}$. Make an estimate of the mass of the galaxy. (**1 Mark**)
   b) The second method involves calculating the dynamical mass using Virial Theorem ($2\langle T\rangle=\langle V\rangle$) . Assume that the Coma cluster is in "Virial" equilibirum. Let the average radius of the cluster (inferred from observations) be $\langle R\rangle\approx 0.3$ Mpc ($1\,pc=3.086\,x\,10^{18}\,cm$) and the radial velocity be $\langle v\rangle=1000\,km\,s^{-1}$. What is the mass of the cluster? (**2 Marks**)
   c) What do you think is the reason for the discrepancy between the two results you obtained for the mass. (**1 Mark**)