Register Number:
DATE:

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

M.Sc. PHYSICS - IV SEMESTER

SEMESTER EXAMINATION: APRIL 2019

PHDE 0417 - ASTROPHYSICS

Time- 2 1/2 hrs. **Max Marks-70**

This question paper has 4 printed pages and 2 parts

PART A

Answer any FIVE full questions. **(5x10=50)**

1.
   (a) What are “Goldilocks Zones” in relation to planet formation? What is the typical distance scale range where Goldilocks Zones occur? Can planets be found outside of their stellar systems?
   (b) What are the key differences between Planetary Nebulae and Supernova Remnants? Which of the two do we see more often? Explain. **(5+5)**
2.
   (a) The all sky maps of two types of astronomical sources are as shown in Fig. 1(a) and Fig. 1(b): What can you infer from the two figures about the positions of these sources with respect to earth?
   (b) The SDSS archive gives a quasar spectrum as shown in Fig. 2. The Lyman α emission line is observed to be located at $3996.686\ \text{Å}$. The lab wavelength of the line is: $1215.673\ \text{Å}$. Estimate the distance to the quasar. Assume the value of Hubble constant to be $68\ \mathrm{km\,s^{-1}Mpc^{-1}}$. **(5+5)**

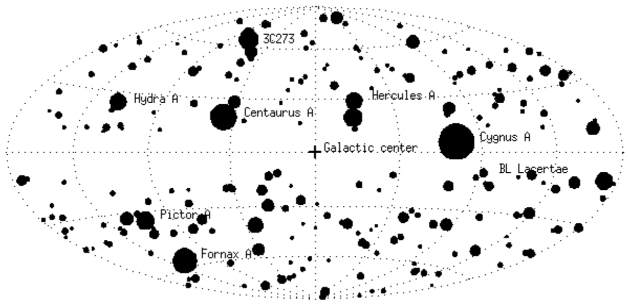

Fig. 1(a): Bright Radio Sources

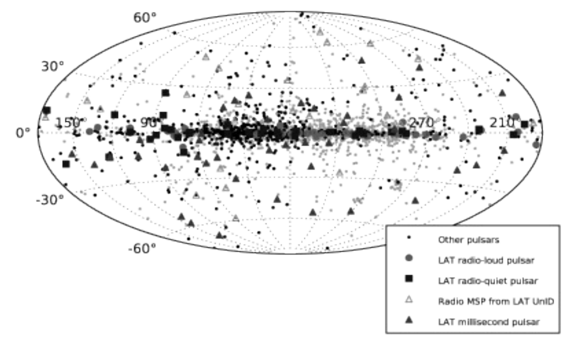

Fig. 1(b): Pulsars

3.

(a) Using a sketch, explain gravitational lensing.

(b) How does the theoretically expected rotation curve of galaxies compare with that obtained from observations?

(c) How does gravitational lensing support the departure of observational rotation curves varying from the theoretically expected ones? (**3+4+3**)

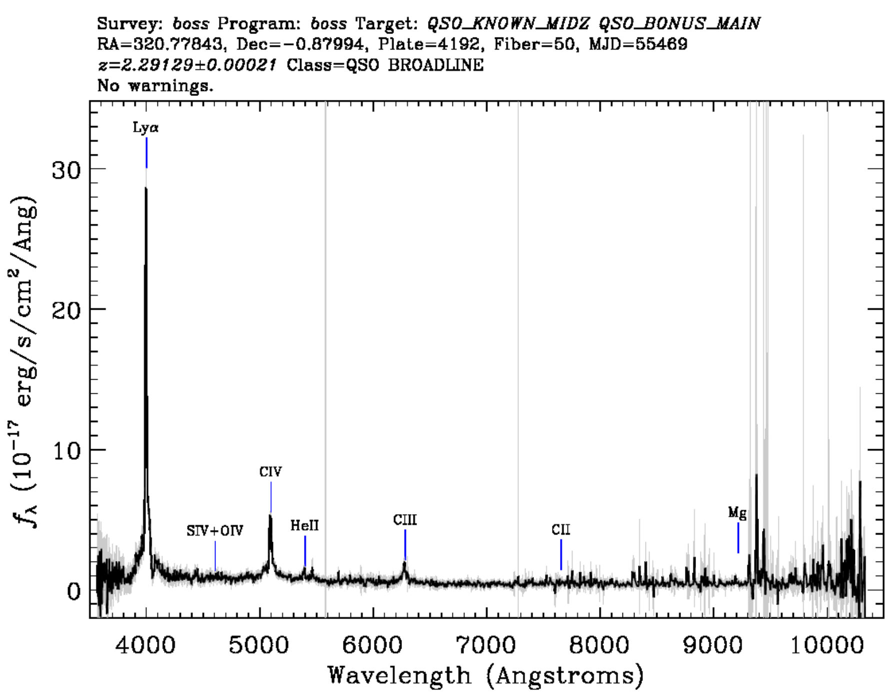

Fig. 2: Quasar Spectrum

4. What are quasars? From seeing that the variability of the quasars are of the order of months, what can you infer about the size of the central object (provide reasoning based on simple physics)? (**4+6**)

5. What are gamma ray bursts (GRBs)? List four observational aspects of GRBs. (**2+8**)

6. Relative magnitude is defined as: $m_A - m_B = -2.5 \log\left(\frac{I_A}{I_B}\right)$. Explain the term "Light Grasp" of a telescope. With this, work out a relation for the limiting magnitude of the telescope. You may treat the human eye to have a diameter of 7 mm . (**2+8**)

7. The net flux is defined as: $F = \int\int I_\nu \, d\Omega \, d\nu$ where I_ν is the specific intensity, with ν being the frequency and Ω the solid angle. Consider a sphere that is emitting with uniform brightness (i.e. all rays leaving the surface have equal brightness B or specific intensity I where $I = \int I_\nu \, d\nu$) as shown in Fig. 3. Show that F is inversely proportional to the square of the distance r .

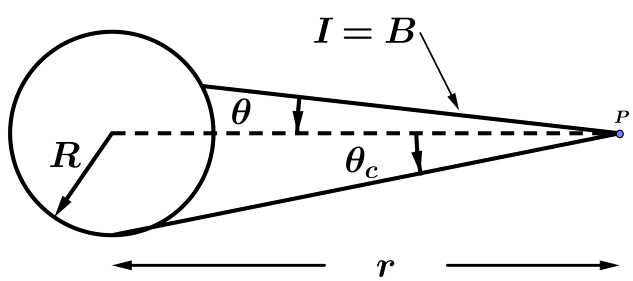

Fig. 3: Uniformly emitting Sphere.

PART B

Answer any <u>FOUR</u> full questions. (**<u>4x5=20</u>**)

[Constants: h=6.6x10^{-34} J s (Planck's constant), 1eV = 1.6x10^{-19} J (electron volt to Joules), c=2.99x10^{8} m/s (speed of light), 1Å = 1x10^{-10}m (Angstrom to meters), e = 1.6x10^{-19} C (electronic charge), m_{proton}=1.673x10^{-27}kg (mass of proton), $m_{electron}$=9.109x10^{-31}kg (mass of electron), G=6.674x10^{-11}m^{3}kg^{-1}s^{-2} (Gravitational constant), $M_\odot$=1.9891x10^{30} kg (Solar mass), $R_\odot$=6.9x10^{8} m, σ = 5.67x10^{-8} W m^{-2} K^{-4} (Stefan-Boltzmann constant), M_{Earth}=5.97x10^{27}kg (Mass of Earth), $D_{earth\text{-}sun}$=1.49x10^{11}m (Earth-Sun distance), 1 inch = 2.54 cm, 1AU = 1.496x10^{11} m, 1 ly= 9.461x10^{15} m, 1 pc= 3.086x10^{16}m]

8. The parallax angle subtended at the sun by Proxima Centauri is seen to be $0.75''$. What is its distance from our solar system in parsecs?.
9. Pluto has a diameter of about $2300\ \mathrm{km}$ and an eccentric orbit around the Sun, with the perigee at $4.4\times10^{9}\ \mathrm{km}$ and apogee at $7.3\times10^{9}\ \mathrm{km}$. What is the difference in variation in solid angles at the apogee and perigee in terms of the mean solid angle that Pluto subtends at the Sun
10. Given that the solar constant on Earth is $1.361\,\mathrm{kW\,m^{-2}}$ and the distance of Mars from sun is $1.5\,\mathrm{AU}$ what is the solar constant as measured on Mars?

11. The BATSE (Burst And Transient Source Experiment) onboard the Compton Gamma Ray Observatory (CGRO) data indicate a fluence of $10^{-7}\ \mathrm{ergs\,cm^{-2}\ s^{-1}}$ for GRBs. If we place the source at $100\ \mathrm{AU}$ (Oort cloud), or at $1\ \mathrm{kpc}$ (Galactic halo) or at $1\ \mathrm{Gpc}$ (cosmological distances) how much energy would this mean at each of the sources?
12. In the paper by Vera Rubin (1972), it was observed that M31 (Andromeda) Galaxy had a rotational velocity of $275\ \mathrm{km\,s^{-1}}$ at about $1\ \mathrm{kpc}$. Assuming Kepler rotation rate at that point, what would the mass of the central object be?
13. From basic parameters (like its mass and radius), estimate the central pressure in the Sun.