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

M.Sc. PHYSICS – IV SEMESTER

SEMESTER EXAMINATION: APRIL 2023

(Examination conducted in May 2023)

PHDE 0420: ASTROPHYSICS

(For current batch students only)

Time: 2 ½ Hours   **Max Marks: 70**

This question paper has 3 printed pages and 2 parts

PART A

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

1.
   (a) How does the Earth's atmosphere respond to the electromagnetic spectrum from space?
   (b) Which are the wavelength bands that reach Earth's surface?
   (c) What are the various types of galaxies (list only the main types)? Explain the distinguishing characteristics with figures.   [3+2+5]

2.
   (a) What are proplyds?
   (b) Explain the different stages of star formation.   [3+7]

3.
   (a) What are sunspots?
   (b) What are the various ways that the ISRO mission: ADITYA-L1 will study the Sun?   [3+7]

4. Can we observe well in the infra-red band on Earth's surface? If yes, explain why and give examples of telescopes that observe in this wavelength band; if no, explain how we could observe better and give examples, if any of telescopes that attempt to do so.

5.
   (a) Show that the number of Gamma Ray Burst sources is inversely proportional to the Fluence.
   (b) What is the degree of variation (is it an inverse square or inverse cube or some other degree)?
   (c) What is the observed relationship between the two quantities? (Draw a figure to illustrate)
      (d) What inference can we make from the similarities or differences between the observed relationship of these two quantities and that which is theoretically deduced?   [3+1+2+4]

6.
   (a) Calculate the linear orbital velocity of the Moon around Earth (take the Earth Moon distance to be 60 Earth Radii, mass of Moon 5.97×10^{27} kg).
   (b) If a giant compressing machine could compress Earth (refer to the constants in Part B to see the mass of Earth) so that the escape velocity of a test particle becomes equal to the speed of light, what would Earth's radius be equal to?
   (c) Will the linear orbital velocity of the Moon change if Earth's radius changes? If yes, why; if no, why not? [3+5+2]

   7. Show that when an extended object is imaged by a telescope, its brightness is conserved.

PART B

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

[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), R_{Earth}= 6378.1 km, $D_{earth-sun}$=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. A Rs. 5 coin has a diameter of 2.2 cm. How far away should the coin be held on a full moon night such that it exactly covers the moon? (Radius of moon is 1737.4 km, assume it to be located at 60 Earth radii).

 9. Proxima Centauri is located $4 \, \mathrm{ly}$ away from us. If a planet is orbiting Proxima Centauri at the same distance as that between Earth and Sun, what is the minimum diameter that the telescope must possess in order to resolve the two? Assume that we observe at a wavelength of $6000 \, \text{Å}$.

10.
   (a) Compute the solid angle of the Sun.
   (b) How many Suns would be needed to cover one entire hemispherical sky?
   (c) What would be the total energy received per square meter per second on Earth if there were that many Suns? [1+1+3]

11. A low pressure Sodium vapor lamp emits about 35 W of power. It has a cylindrical structure with a length of $1 \, \mathrm{foot}$ and a radius of $1 \, \mathrm{inch}$. It emits light having only two wavelengths namely $D_1 \, (5890 \, \text{Å})$ and $D_2 \, (5896 \, \text{Å})$ and experiments indicate that the normalized spectrum of the lamp will be made up of just these two lines as delta functions having the same height. What are the specific intensities at each wavelength for this lamp?

12. The Pinwheel Galaxy or Messier 101 when viewed through a telescope is, as seen in Fig. 1.
   (a) The redshift of this galaxy is inferred to be: 8.04×10^{-4} . Assuming Hubble's constant to be $73 \, \mathrm{km.s}^{-1}.\mathrm{Mpc}^{-1}$, infer the distance to the galaxy.
   (b) The size of the galaxy, from another experiment, is inferred to be $1.7 \times 10^5 \, \mathrm{ly}$. From this and the distance to the galaxy, compute the field of view of the telescope from the image (the black solid lines are the cross hairs seen through the eye-piece). [1+4]
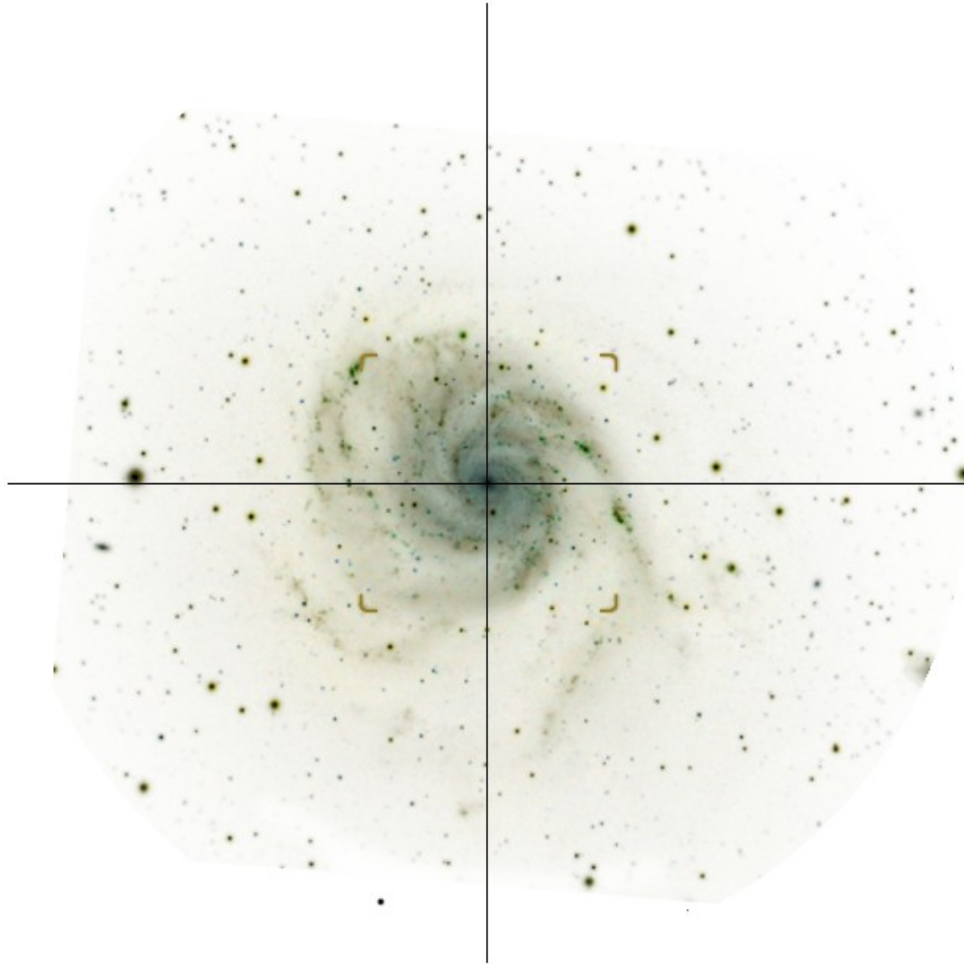
Fig. 1: See question 12

13. Two stars observed in (and downloaded from) SDSS have the following characteristics:

objID	ra	dec	u	g	r	i	z
1237660750333018127	66.30006483	22.68436567	18.28234	16.73006	16.0216	15.70814	15.554
1237660750333018136	66.30770828	22.69496033	24.1849	24.73498	25.02958	22.39127	21.8816

What color stars are these?