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**ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27**
**M.Sc. PHYSICS - IV SEMESTER**
**SEMESTER EXAMINATION: APRIL 2018**
**PHDE 0417 - ASTROPHYSICS**

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

**This question paper has 3 printed pages and 2 parts**

## PART A

**Answer any FIVE full questions.** **MAX. MARKS 5x10=50**

1.
   (a) Explain distance measurement using parallax. (**4 Marks**)
   (b) Can we measure the distance of a galaxy using parallax method? If yes, explain how; if not, explain why. (**6 Marks**)

2. Explain in a few sentences (not more than 5) the following:
   (a) What are the broad types of galaxies seen in the universe? (**1 Marks**)
   (b) What is the current model for evolution of galaxies? (**2 Marks**)
   (c) What are Active Galaxies? List the different types of Active Galaxies. (**2 Marks**)
   (d) Giant Elliptical galaxies appear redder than Spiral galaxies. What can you infer from such an observation? (**3 Marks**)
   (e) What are quasars? (**2 Marks**)

3. Write down the equations representing stellar structure. How many unknowns are there in the equations? In order to simultaneously solve these equations, what are the other equations one needs to know in addition?

4. Derive the Planck Radiation Law and from it deduce the Stefan-Boltzmann Law

5. Show that the brightness of an extended object is the same as that of the image in an imaging system. Discuss the effect of the eye-piece on the apparent brightness of the object.

6.

(a) State Kepler's Laws. (**3 Marks**)

(b) For an object moving in a circular orbit, show that angular momentum is a constant of motion (**3 Marks**)

(c) Using (b) prove Kepler's 2$^{nd}$ Law. (**4 Marks**)

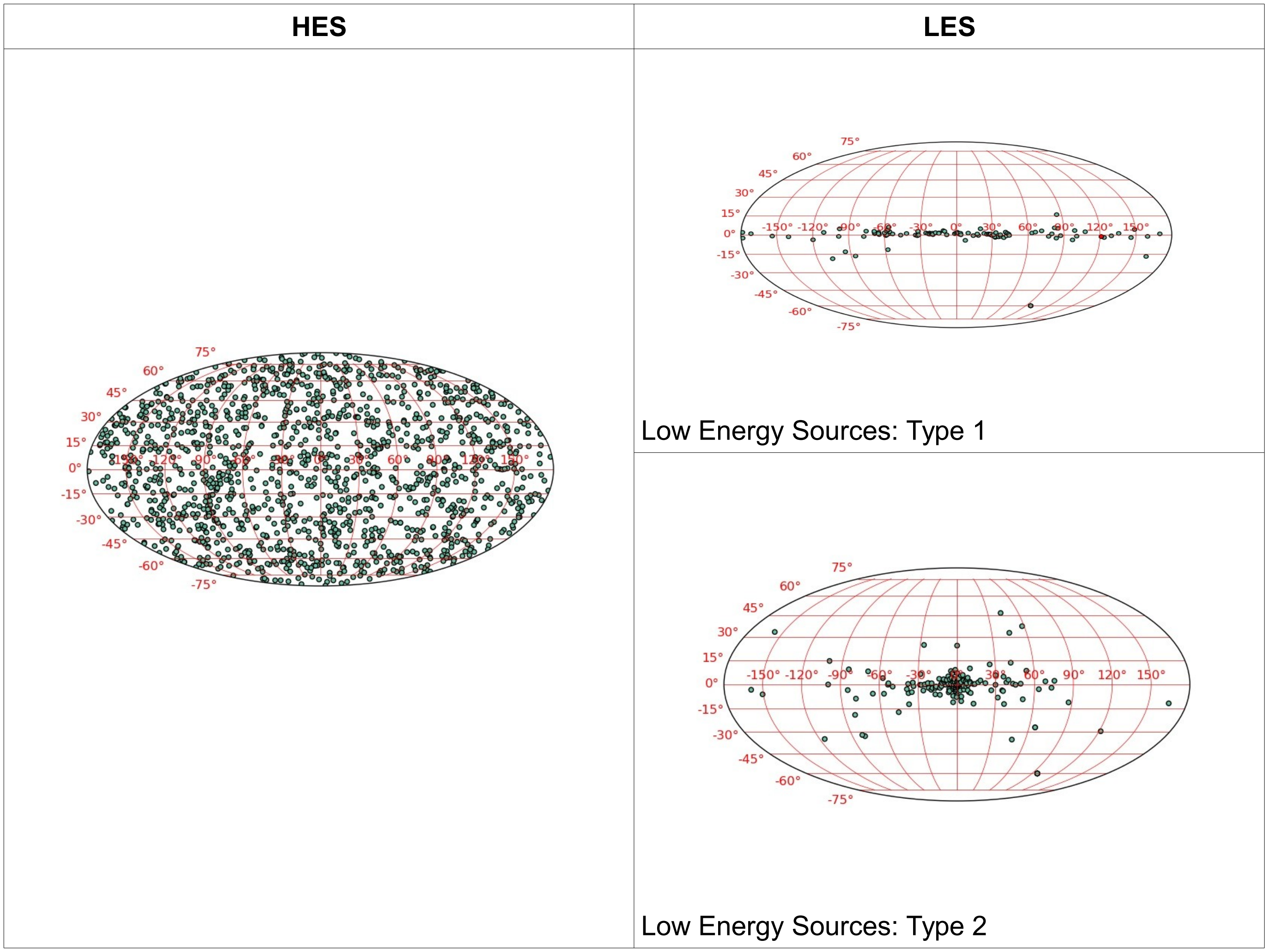


Fig. 1 All sky (galactic) map of the HES and LES1 and LES2 sources.

7. In a hypothetical world, astronomers detect some new types of astronomical sources. As part of the classification process (prevalent in all branches of science), the astronomers plotted the positions of these new sources called HES (High Energy Sources). They compared the positions with another type of sources called Low Energy Sources (LES) that come as two types again: LES1 and LES2. The positions of these objects in galactic coordinates are shown in Fig. 1.

(a) Explain as to what you can infer from these plots. (**4 Marks**)

(b) Can you make estimates on the energies of HESs by placing them at assumed points based (100 AU, 1 kpc and 100 Mpc) on the graph below? Why do you need to keep them at such distances? (**6 Marks**)

**<u>PART B</u>** **<u>MAX. MARKS 4x5=20</u>**

**Answer any <u>FOUR</u> full questions.**

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

8. The satellite *Hipparcos* launched in 1989 was to accurately measure the parallax of stars; and it has indeed provided the most accurate data (used even now). A successor to *Hipparcos* is the *Gaia* satellite launched in 2013. The smallest parallax discovered by *Hipparcos* is 0.002". What is the distance of this star in light years?

9. Globular clusters contain typically $10^5-10^6$ stars. They are very tightly bound systems such that there typical sizes are about $2\,\mathrm{pc}$ across. What is the typical inter-stellar distance within globular clusters? How does it compare with the distance between sun and Proxima Centauri?

10. Assuming Earth's central density to be $\rho_c=10\ \mathrm{g\ cm^{-3}}$ and that the density varies linearly from the center outward: $\rho=\rho_c\left(1-\frac{r}{R_{\mathrm{Earth}}}\right)$. The variation of mass is given as $\frac{dm}{dr}=4\pi r^2\rho$. The list of constants above gives the mass of Earth – for this mass, what would the computed $R_{\mathrm{Earth}}$ be? How does this compare with the actual value of $6371\,\mathrm{km}$ ?

11. Sun has a luminosity of $L_{\odot}=3.828\times10^{33}\,\mathrm{erg\ s^{-1}}$. The Sun-Jupiter distance is $d_{\mathrm{SJ}}=7.785\times10^{8}\,\mathrm{km}$ and radius of Jupiter is: $R_{\mathrm{J}}=6.9911\times10^{4}\,\mathrm{km}$.
    (a) What is the solar power (energy per unit time) incident on Jupiter? (**2 Marks**)
    (b) Jupiter has an albedo (ratio of reflected flux over incident flux, i.e.: $A=\frac{F_{\mathrm{reflected}}}{F_{\mathrm{incident}}}$ ) $A_{\mathrm{J}}=0.52$. Calculate the solar power absorbed by Jupiter. (**3 Marks**)

12. The p-p reaction may be summarized as: $4\,{}^1H \rightarrow {}^4He+2e^{+}+2\nu+2\gamma+\mathrm{Energy}$. Given that mass of ${}^4He$ is $6.6447\times10^{-27}\,\mathrm{kg}$ find the Q-value (efficiency) of the reaction.

13.
    (a) The Double Double star epsilon Lyrae has an angular separation of $2.3\,\mathrm{arcsec}$ (for $\varepsilon_2$), (It is $2.6\,\mathrm{arcsec}$ for $\varepsilon_1$ ) what is the minimum aperture one would need in order to resolve the star system into individual stars? (**3 Marks**)
    (b) What is the limiting magnitude for the Thirty Meter Telescope (TMT). (**2 Marks**)