

ASTRONOMY 2 — Overview of the Universe
First Practice Problem Set

1. Calculate the number of stars per unit volume in a certain elliptical galaxy. The number of stars in the elliptical galaxy is 10^{11} , and the galaxy can be approximated as a sphere of radius $r = 15$ kpc. Recall that the volume of a sphere is given by $V = 4\pi r^3/3$, $\pi = 3.14$, and $1 \text{ kpc} = 3.09 \times 10^{21} \text{ cm}$.

2. Recall that Kepler's Third Law can be written as $M = Kv^2R$ where $K = 1.5 \times 10^7 \text{ g s}^2/\text{cm}^3$; $1 M_\odot = 2 \times 10^{33} \text{ g}$; and $1 \text{ AU} = 1.5 \times 10^{13} \text{ cm}$.

(i) How fast would a body orbit a $10^6 M_\odot$ black hole at a distance of 1 AU?

(ii) At what orbital radius from this black hole will the orbital velocity reach the speed of light, $c = 3 \times 10^{10} \text{ cm/s}$? This radius is known as the Schwarzschild radius.

3. The Sun has a luminosity of $3.9 \times 10^{33} \text{ ergs/s}$, a radius of $7 \times 10^{10} \text{ cm}$, and a surface temperature of 5800 K. Use the blackbody formula $L = 4\pi\sigma R^2T^4$ to answer the following questions.

(i) A star has a luminosity 0.16 times that of the sun and a temperature of 4000 K. What is its radius?

(ii) Another star has a luminosity 500,000 times that of the sun and a radius 18 times that of the sun. What is its temperature?