ASTR1050
Fall 2025

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Due Date: 7 November, 11:59 PM

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1. **The Sun orbits the galaxy 8 kpc from the center at a speed of 220 km s^{-1}. Calculate the time it takes for the Sun to complete one revolution, also known as the "galactic year." There are 1000 parsecs in 1 kiloparsec and 3.09×10^{13} kilometers in 1 parsec.**

2. **We learned Kepler's Third Law describes planetary motion, and gives semi-major axis as a function of mass and period. Using the Sun's orbital period and orbital distance, calculate the mass of the Milky Way galaxy, in Solar masses.**

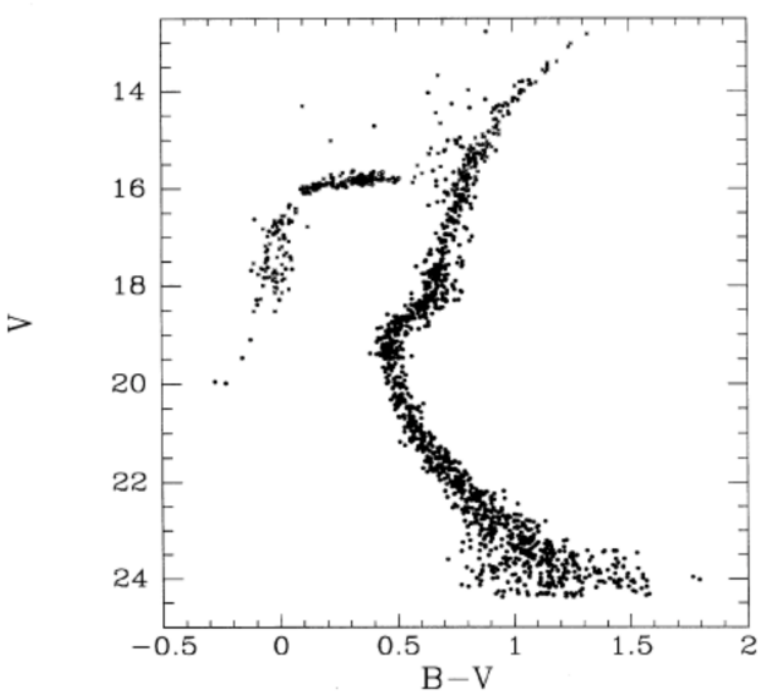
$$a^3 = \frac{GM}{4\pi^2} P^2$$

3. **Suppose the average mass of a star in the Milky Way is 0.33 $M_\odot$. How many stars are in the Milky Way.**

4. **If a star 20 light hours from the center of the Milky Way has an orbital speed of 6200 km s^{-1}, how much mass, in solar masses, is located inside interior to its orbit? The speed of light is 3×10^8 m s^{-1} and 1 light hour is the distance light travels in 1 hour (3600 seconds).**

5. **Find the density of this central object, in kg/m^3, assuming the mass you calculated before is uniformly distributed throughout the entire sphere with radius 20 light hours. For a sphere, volume is $V = \frac{4}{3}\pi R^3$ and density is $\rho = \frac{m}{V}$.**

6. **Below is an HR diagram for globular cluster Messier 13. Using the main-sequence turnoff and the table below, estimate the age of M13.**



Spectral Type	B-V color	Lifetime (years)
O5	-0.45	10^6
B0	-0.30	10^7
A0	0.00	5×10^8
F0	0.30	2×10^9
G0	0.60	10^{10}
K0	0.80	2×10^{10}
M0	1.40	7.5×10^{10}

Table 1. Spectral types and lifetimes

7. **Calculate the radius of a blackhole with the same mass as the Sun.**
8. **Suppose the core of a B0 star collapses into a black hole ($M \sim 5\ M_\odot$). Find the Schwarzschild radius of the resulting black hole.**
9. **Calculate the radius necessary to collapse the Earth to make a black hole. The mass of the Earth is 5.98×10^{24} kg.**
10. **Calculate the period of a satellite orbiting this newly created blackhole-Earth orbiting at a distance of 6000 km. Kepler's Laws are still valid for black holes. The period of an orbiting body is given by:**

$$P^2 = \frac{4\pi^2}{GM} a^3 \ ,$$

and the mass of the Earth is 5.98×10^{24} kg.