UNIVERSITY OF KANSAS
Department of Physics and Astronomy
Physical Astronomy (ASTR 391) — Prof. Crossfield — Spring 2020

Problem Set 1
Due: Friday, February 15, 2019, in class
This problem set is worth **51 points**.

1. **Astronomical Coordinates [12 pts].**

   (a) What are the RA and Dec of Polaris? [2 pts]

   (b) If you were observing Polaris from Santa's Workshop at the North Pole, what would be the star's approximate elevation angle θ (i.e., the angle one would measure from the horizon directly up to the star)? [3 pts]

   (c) If you were observing Polaris from KU (as you can on a clear night), what would be its approximate elevation angle? [3 pts]

   (d) The star Gamma Velorum (or γ Vel) is an especially large, hot, and massive star called a Wolf-Rayet star. Where would be a good idea to observe this star? Why (or why not) would it be a good idea to observe this star from KU? [4 pts]

2. **Astronomical Magnitudes [9 pts].**

   (a) You observe a star ("Star 2") and find that compared to γ Vel, $m_{\rm Star2} - m_{\gamma\ \rm Vel} = 5$ mag. By what factor does γ Vel appear brighter or fainter than Star 2? [3 pts]

   (b) Your colleague tells you that Star 2 is roughly 30$\times$ closer than γ Vel. How are the two stars' absolute magnitudes related, and what is the **approximate** ratio of their luminosities? [6 pts]

3. **Astronomical Concepts [13 pts].**

   (a) In a galaxy far, far away, the gas giant Endor orbits a Sun-like star at a distance of a_E. Endor (mass m_E) is orbited by a Forest Moon (m_m) with the same separation as found in the Earth-Moon system ($a_{\leftmoon}$). What is the ratio of the gravitational forces between Endor and its star (mass m_*) and between Endor and its moon? Which Force is stronger? [6 pts]

   (b) You have invented a matter-antimatter reactor with 100% efficiency. Congratulations: you're a shoo-in for the Nobel Prize. (a) If you put 0.5 kg of matter (and an equal amount of antimatter) in your reactor, approximately how much energy ($E_{\rm reactor}$) is released? (b) If the reactor takes 0.5 s to use that fuel, what was its approximate power output in Solar Luminosities ($L_\odot$)? (c) How does $E_{\rm reactor}$ compare to the total amount of energy used on Earth in a year? [7 pts]

4. **The Simplest Star [12 pts.]** You are studying a star with mass M_* and radius R_* has uniform density and is composed entirely of hydrogen atoms (mass m_H). (This is a very crude approximation for a star, as we will learn later!)

   (a) What is the number density n inside the star? [3 pts]

   (b) Assume the hydrogen in the star is an ideal gas, and furthermore that pressure increases linearly from the surface toward the central core, such that $P(r) = P_c(1 - r/R_*)$. What is the **thermal profile** of the star, i.e. what is $T(r)$? Write your answer in terms of M_*, R_*, P_c, and r (not n or $P(r)$). [5 pts]

   (c) Plot n, P, and T for $0 \leq r \leq 2R_*$. [4 pts]

5. **City on a Hill [5 pts.]** Calculate an order-of-magnitude estimate of the mass of Mount Oread, in kg and in $M_\oplus$ (Earth masses).