PHYSICS 313 - Winter/Spring Semester 2017 - ODU

Astrophysics - Problem Set 3 – DUE Thursday, February 2

GENERAL INSTRUCTIONS:

Please submit your solution using the following format. You can submit it as an email to skuhn@odu.edu anytime before midnight on the day on which the Problem Set is due; in this case, you **must** use an electronic file format (like MS Word, LaTeX, .pdf, Mathematica etc.) or simple text (follow the rules of some programming language like Fortran or C to write mathematical expressions like x**2 for the square of *x* etc.). Alternatively, you can write your solution by hand on paper and turn it in **in class** on the same day (no late submissions); please write clearly and cleanly!

For each problem (part), type the problem number (e.g., "1a." or "2c"), followed by a space, and then your solution. For "yes/no" questions, enter "Y" or "N", for multiple choice questions, enter the correct choices ("1" or "3" or…) without any additional characters, and for numerical questions, quote the result in the form "3.1415" or "3.1415e12". For conceptual questions, just write the text (no special formatting needed). Some problems require mathematical derivations or equations in addition to text or numbers (clearly stated in the problem text). **Only** for those cases may you use a **clean** scanned image of a handwritten derivation, included in your electronic submission (if you choose that route).

IN ALL CASES, make sure that your full name appears on all your submissions to guarantee you get credit for your work! Also, do NOT simply copy someone else's solution (honor code!) – you can ask for help if you get stuck, but you must submit your OWN work. (I will randomly ask questions during class to check whether you understand the solution you submitted.

Problem 1

Please answer the following questions with "Y" or "N":

1a) Do we need Special Relativity to understand the Doppler shift of light emitted from fast-moving objects?
1b) If a star would pass our solar system with very high speed, there would be a Doppler shift even when it moves exactly perpendicular to our line of sight. True?
1c) The absorption spectrum of a star is completely determined by its chemical composition alone. True?
1d) Because hydrogen is the most common element in stars, the Hydrogen Balmer absorption lines are the most prominent (dark) ones for all stars. True?
1e) Blue stars tend to be brighter than red stars. True?
1f) A red star can never be more luminous than any blue one. True?

Problem 2

The following is a set of multiple choice questions. Answer each with a single digit:

2a) Which one of the following properties does **not** tend to **increase** with temperature of a main sequence star?
1 – Its distance from Earth
2 – Its size
3 – Its mass

4 – Its total luminosity
5 – Its emission of blue light

2b) Which of the following types of stars is on the "main sequence" in the Hertzsprung-Russel diagram?
1 – M7 spectral type stars
2 – Blue Supergiants
3 – White dwarfs
4 – Neutron Stars
5 – Red Giants

2c) Which of the following statements about the Special Theory of Relativity is true?
1 – Two events that are simultaneous in one inertial system must be simultaneous in any other one.
2 – Light emitted from the head of the locomotive of an onrushing train going 90% of the speed of light will appear to move towards me at 1.9 c.
3 – I observe the clock in a system moving at 60% of c relative to me. When my own clock tells me 10 seconds have elapsed, that other clock shows only 8 elapsed seconds.
4 – The length of a rigid object is the same as measured from an inertial system in which the object is at rest vs. from an inertial system moving at high speed relative to the first one.

Problem 3

The escape velocity of Earth is 11.2 km/s (i.e., an object that reaches that velocity can leave Earth's gravitational field for good). Assuming the mass of a hydrogen atom as 1.66 x10^{-27} kg, calculate the fraction of all hydrogen atoms with enough kinetic energy to reach this escape velocity, using the (simplified) probability factor $\frac{1}{e^{E_{kin}/kT}}$. Take the temperature at the surface of Earth as 300 K. (You may ignore any "degeneracy" and "Normalization" factors here, although in practice they play a big role).

Problem 4

XC [Text only]: Assume you observe a pair of stars (a binary star system), 1 parsec from Earth, that are rotating around each other in a plane that you are viewing edge-on. With your high-resolution telescope, you find that they appear to fluctuate in apparent distance between zero and 1" (arc-second = 1/3600 of a degree). You observe their red/blueshift as a function of time and you find that when one of them is redshifted by a certain amount, the other one is blueshifted by exactly the same amount. After ½ year, the pattern is exactly opposite – the formerly redshifted one is now blueshifted and vice versa. The whole game repeats itself exactly after 1 year. What can you conclude about the masses of both stars? [You don't need any math, just some clever arguments. Make sure you explain your reasoning.]