PHYSICS 313 - Winter/Spring Semester 2017 - ODU

Astrophysics - Problem Set 10 – DUE Tuesday, April 4

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

Mark each of the following statements with "Y" or "T" if they are correct, and with "F" or "N" if they are incorrect:

1a) Relative to their respective sizes, galaxies are much further apart from each other than stars in our solar neighborhood are.
1b) Elliptical galaxies are mostly found in complete isolation, far away from any other galaxies.
1c) The very largest elliptical galaxies are probably the result of mergers.
1d) The main difference between Seyfert galaxies and Quasars is that the latter are even more luminous.
1e) The word "Quasar" (or QSO) is used because the object it describes is a particularly bright but otherwise ordinary star.
1f) The luminosity of typical AGNs is due to light directly emitted from the event horizon ($R = R_s$) of a black hole.
1g) Particularly bright (over all wave lengths) and highly variable AGNs probably have jets associated with them.
1h) In the past, there were many more AGNs than there are now.
1i) Galaxies were created in the Big Bang right from the start and haven't changed since at all.
1j) Supergiants were particularly common in the early years of the universe.
1k) Very young galaxies didn't contain many white dwarfs.

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Problem 2

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

2a) Which of the following galaxy types is NOT considered "Active" (or AGN)?

1 – Seyfert galaxies.
2 – Andromeda.
3 – Quasars.
4 – Radio Galaxies.

2b) Which of the following statements about elliptical galaxies is false?

1 – They include the Hubble types E0 through E7.
2 – They typically contain a lot more gas and dust than the Milky Way
3 – Some of the smallest galaxies are ellipticals (e.g., dwarf spheroidals)
4 – Some of the largest galaxies are ellipticals (e.g., cD).

Problem 3 – Show your work (not only final results)

What would be the luminosity of a black hole (only an apparent contradiction) that converts one solar mass completely into light every 30,000 years? Compare to the solar luminosity of 3.8×10^{26}W! (This would correspond to the central black hole in the Milky Way if we assume that it converts 10% of the mass it consumes in a year into light).

Problem 4 – Show your work (not only final results)

For the black hole in Problem 3, find out what its minimum mass must be so that the luminosity doesn't exceed the Eddington Limit. What would be, in turn, the minimum radius of that black hole? (Of course, "real" supermassive black holes are even bigger…)