Ay 10 - Problem Set #10
Due: November 22, 11am

Please write your full name, section number, and GSI's name at the top of your homework. Also, be sure to put your homework in the correct box in the basement of Campbell Hall. There is a 20% penalty per day for the late submission of assignments, however you do get one "freebie" (see course syllabus for more info).

Remember to always show your work; no credit will be given for just a final answer. However, if you get most of the question right but get the final answer wrong, you will get most of the points. Use a calculator where necessary and dont forget units if the answer requires them.

If you use any resource besides the textbook, lecture, or section (*e.g.* a web site), be sure to include proper attribution for the reference. Feel free to work with other students in the class, but remember that all work turned in must be your own (*i.e.* don't just copy the work of another student).

1. **(8 points) A Really Deep Question**

   Figure 1 is called the Hubble Deep Field. It is an image of galaxies at the farthest distance that any telescope has ever looked.

   (a) Each dot in the image is a galaxy (except for the two big stars which are actually in the foreground of the picture). You can identify the stars because they have streaks of light coming off of them, due to diffraction effects by the telescope. Estimate how many galaxies are pictured. Explain the method you used to arrive at this estimate.

   (b) This picture shows about $1/30,000,000$ of the sky. How many galaxies like the ones in the picture fill the entire sky?

   (c) It took the Hubble 2 weeks to produce the above image. How many years would it take for the Hubble to image the entire sky in the same way?

   (d) It would be great if we could image the whole sky like this, but there are practical problems, like money. It takes an average of about $350 million per year to operate the Hubble Space Telescope. Based on your answer to part (c), how much would the taxpayers of America have to pay for a full picture of the sky like the Hubble Deep Field. (Note- we haven't attempted to image the whole sky. Your answers to (c) and (d) should explain why!)

2. **(6 points) My Spectrum's Moving.....ack!**

   Figure 2 is the spectrum of a nearby galaxy that Jeff took at the Lick observatory. The main emission line of hydrogen is shown in the spectrum– it's the huge peak.

   (a) What is the observed wavelength of the hydrogen emission line?

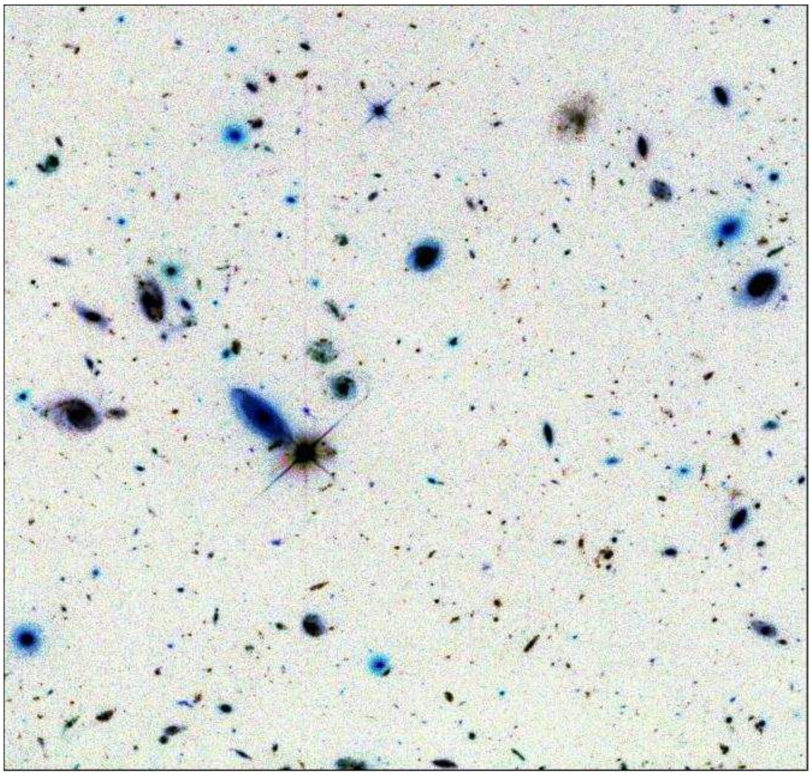

Figure 1: The Hubble Deep Field

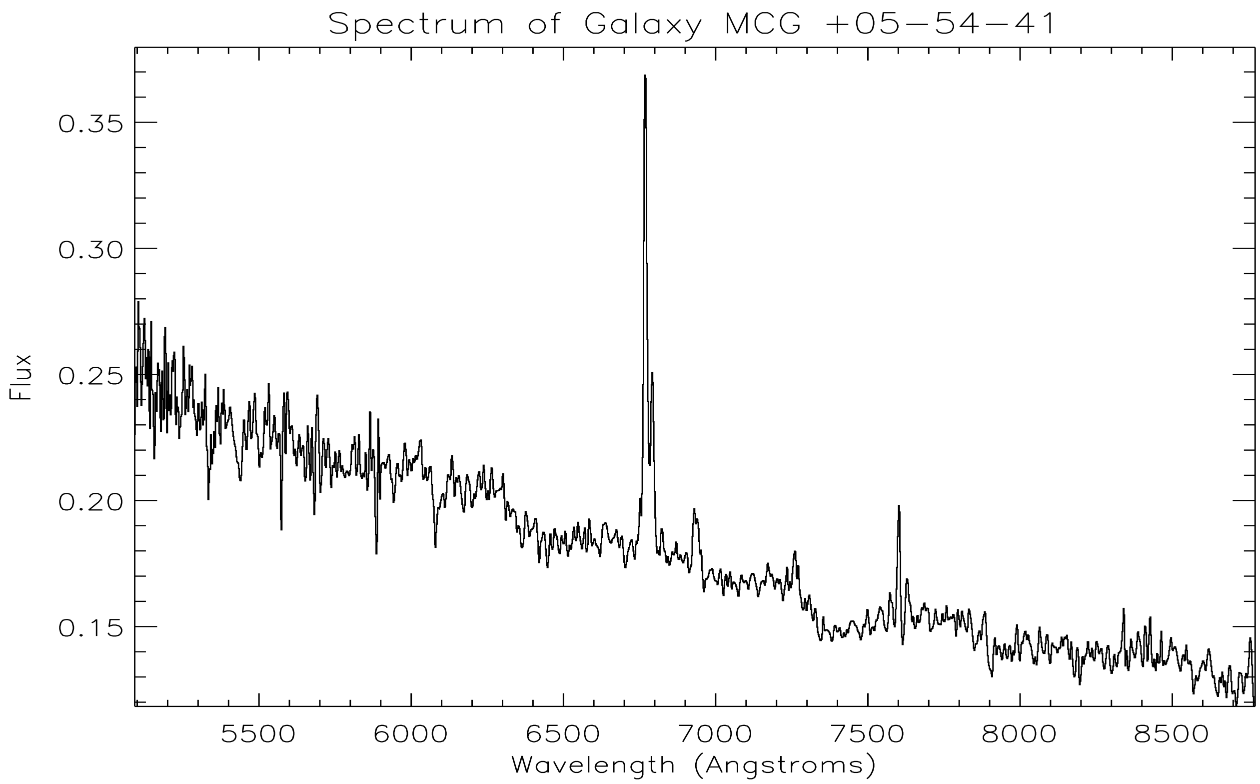

Figure 2: CCD spectrum obtained by J. Silverman and D. Wong on Sep. 29, 2006, with the Lick 3-m telescope (+Kast spectrograph) at Lick Observatory.

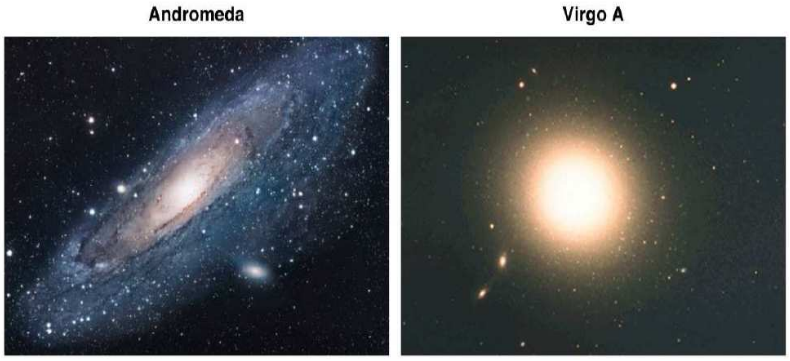

Figure 3: Two example galaxy types

(b) The actual wavelength of this emission line in the laboratory is 6563 Angstroms. (Recall that an Angstrom is 10^{-10} meters.) Based on how much the line has been Doppler shifted, how fast is the galaxy moving? Is it moving towards us or away from us?

(c) Based on your answer to part (b) and the current value of H_0, what is the distance to this galaxy?

3. **(7 points) Spiraling into an Ellipse**

Figures 3 shows two different galaxies that are good examples of their respective class of galaxies.

(a) For each galaxy, state whether it is an elliptical, spiral, peculiar or irregular galaxy.

(b) Which galaxy has more gas and dust?

(c) Which galaxy has an older stellar population?

(d) Which galaxy still has star formation occurring? What feature(s) in the picture indicates star formation?

(e) In which galaxy could we see a Type Ia supernova?

4. **(6 points) A High Profile Question**

In Figure 4, you will see some rotational velocity curves as a function of radius and some mass curves as a function of radius.

(a) Match each rotational velocity curve (the lettered curves) to the mass profile (the numbered curves) that would produce the observed rotation and explain briefly why you matched them the way you did.

(b) One of the pairs of velocity/mass curves corresponds to a galaxy like the Milky Way. Which pair is this?

(c) Which pair is like our Solar System?

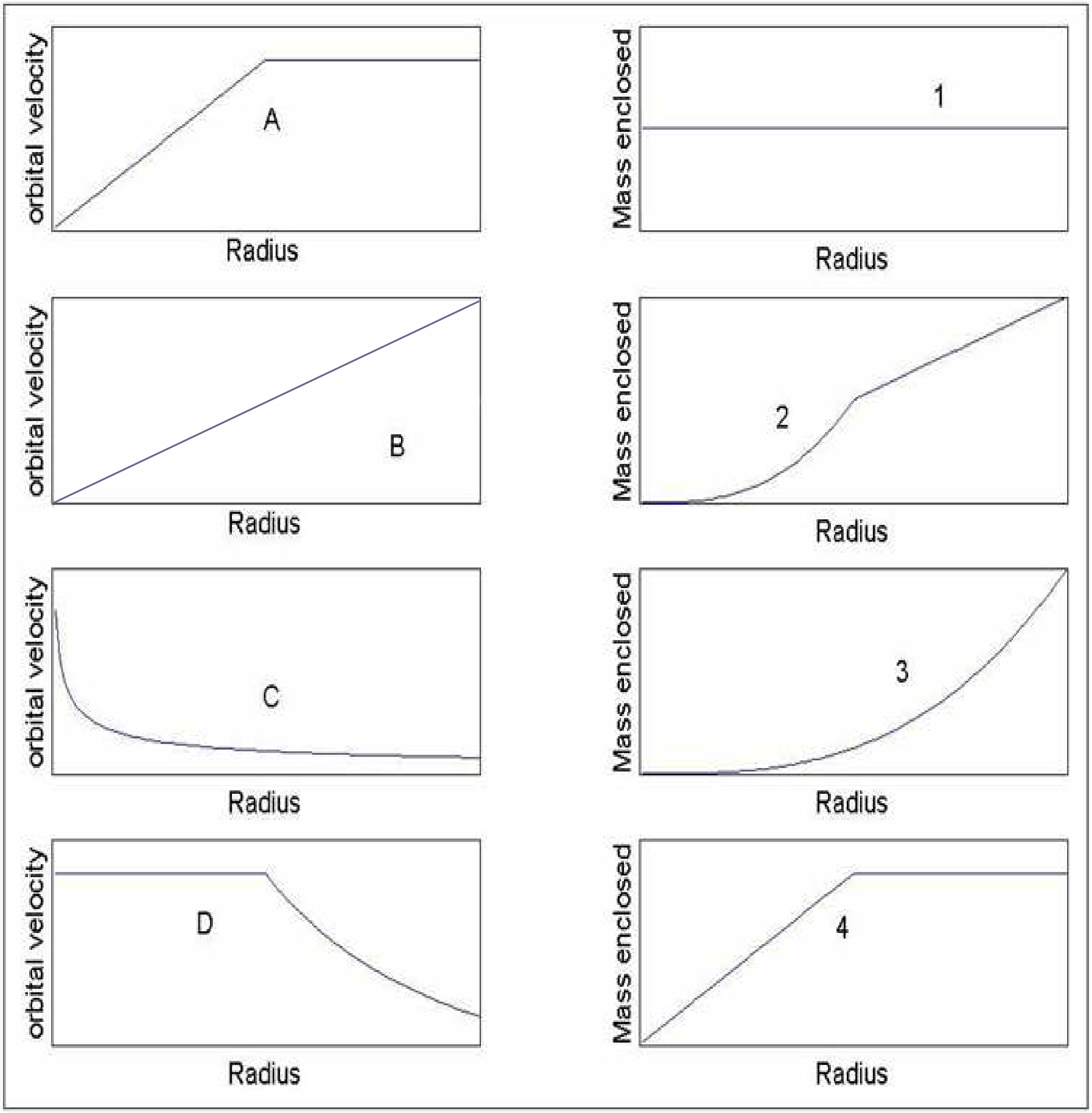

Figure 4: Rotational velocity curves and mass profiles