

ASTR 1200-001 Gen. Astronomy: Stars & Gals Spring 2018. Project 4.
Fri Apr 13.

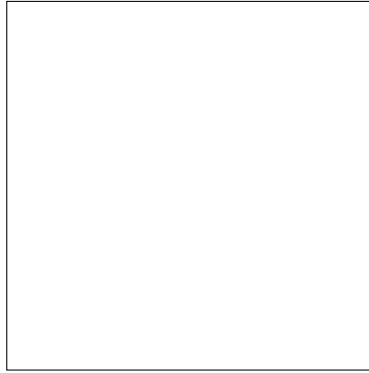
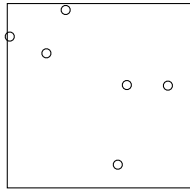
Scribe's name:

Names of other members of the group:

The Expanding Universe

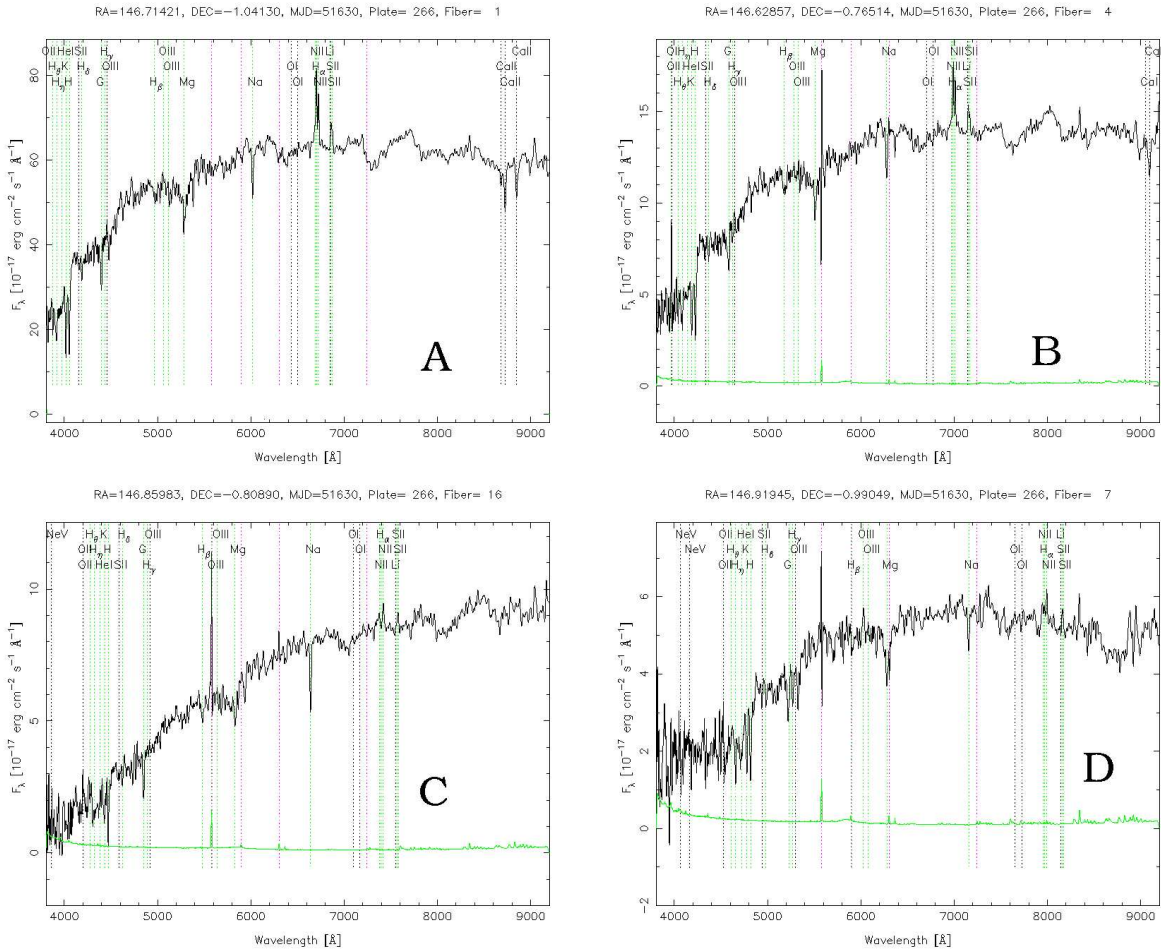
1. What do astronomers mean by the statement that “the Universe is expanding”?
2. Explain in words (not mathematics) why Hubble's law, $v = H_0 d$ (recession velocity = Hubble's constant \times distance), indicates that there was a Big Bang.
3. Is the Milky Way expanding with the Universe? Is the Local Group of galaxies expanding with the Universe? Explain.

4. On the left is a schematic sketch of some galaxies in the Universe when the Universe was, say, 10 billion years old. On the right, sketch what it might look like when the Universe gets to be twice as old, 20 billion years old. Explain why you drew what you drew. [Assume that the galaxies are far enough away from each other that Hubble's law applies.]



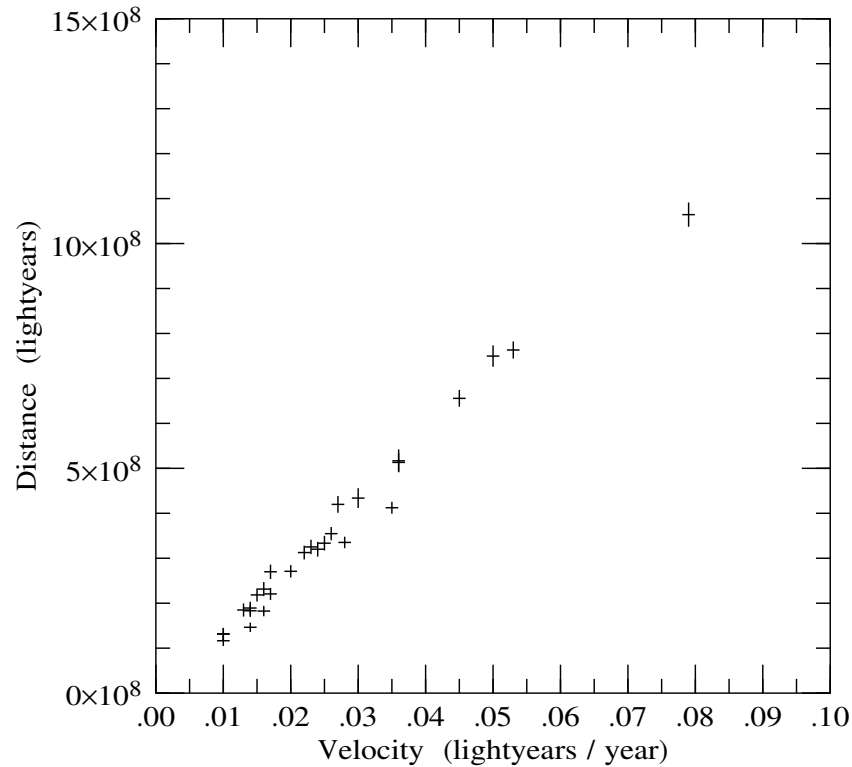
5. From our point of view living in the Milky Way, galaxies are expanding away from us in all directions. Does this mean that the Milky Way is the center of the Universe? Suppose that you lived on another galaxy half way across the Universe from the Milky Way. Would you see galaxies expanding away from you in all directions? Explain.

6. Here are some spectra of galaxies observed by the Sloan Digital Sky Survey (from <http://cas.sdss.org/dr3/en/tools/getimg/>). **Mark** the position of the H α line on each spectrum. Then **order** the galaxies A–D by redshift, from smallest to largest. [Hint: Put the galaxies in order of the wavelength of their H α line, whose unredshifted wavelength is $6563 \text{ \AA} = 656.3 \text{ nm}$.]



7. Order the above galaxies A–D by apparent brightness, from brightest to faintest. Does the ordering agree or disagree with the order in the previous question? Why might that be so? [Hint: The vertical axis measures brightness. Look at the numbers labeled on the vertical axis. Bigger numbers are brighter.]

8. Here is a Hubble diagram of thermonuclear supernovae (data from Nobili et al. 2005, <http://arxiv.org/abs/astro-ph/0504139>). Draw a straight line through the data. [Hint: Your straight line should go through the origin (the bottom left corner). Why?] Estimate the age of the Universe from your line. Explain what you did.



9. Why is it thermonuclear supernovae, and not some other species of astronomical object (like galaxies), that astronomers use to plot a Hubble diagram to cosmological distances?