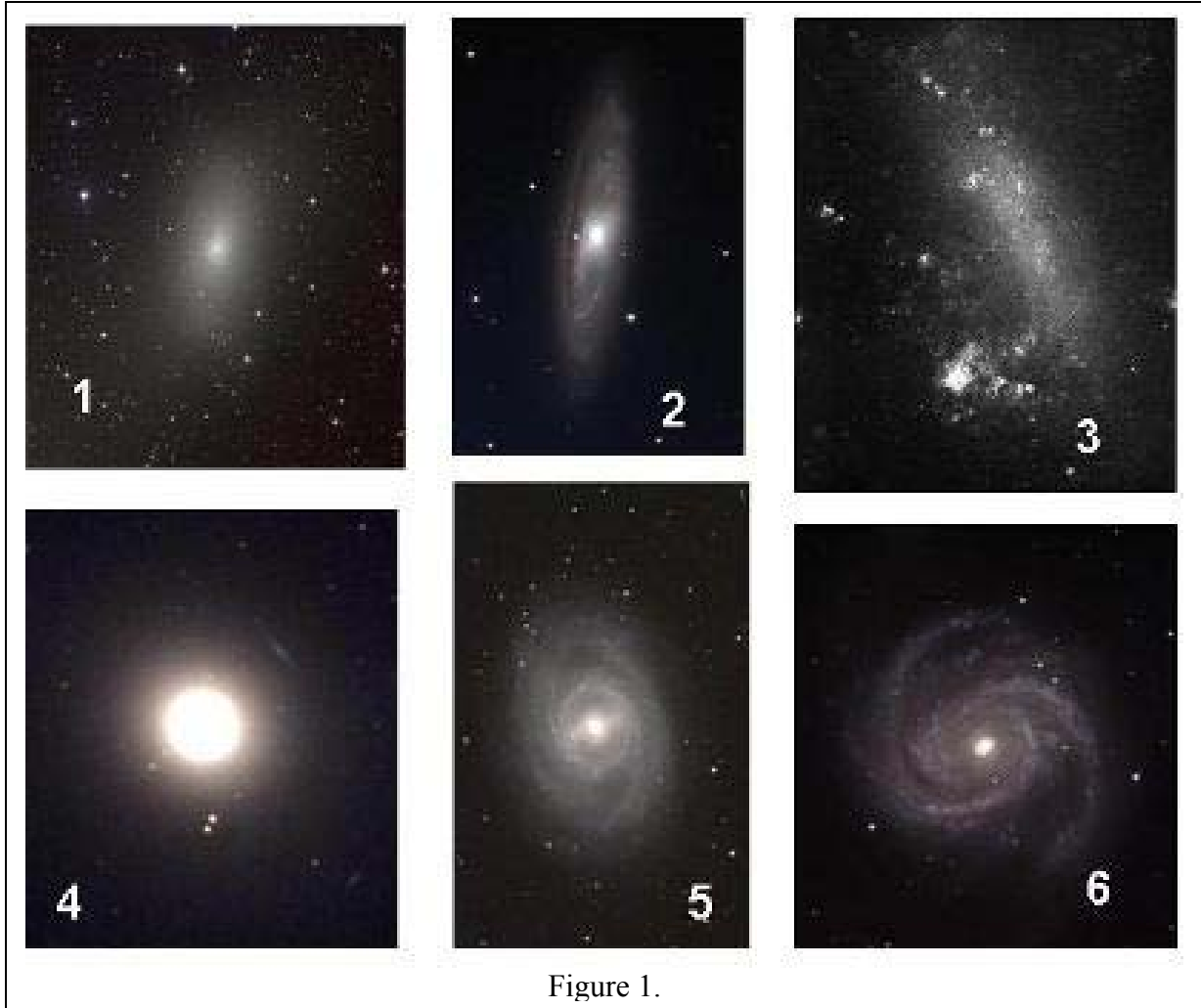


ISP 205  
Review Questions, Week 13

This is not required homework. It will not be graded. Answers will be supplied next week.

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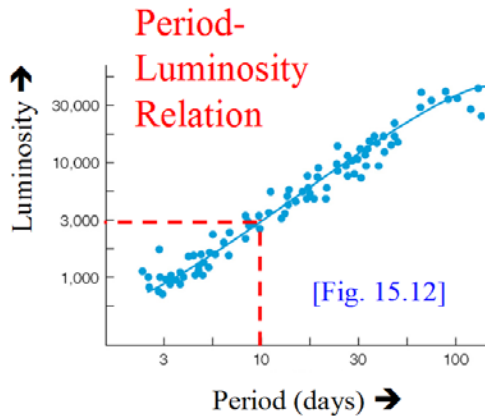
1. Match the galaxy shown in the figure to its Hubble Type. Refer to Section 15.1 of the text, and particularly to Fig. 15.7, for guidance. But... careful... all of the spiral galaxies in Fig. 15.7 are seen face-on, while this may not be the case for all of the galaxies you are being asked to classify.

SBb \_5\_      Sa \_2\_      Sc \_6\_      Irr \_3\_      E0 \_4\_      E6 \_1\_

2. A pulsating variable star has a period of 10 days. About how many times more luminous is it than the Sun? Refer to Fig. 15.12 in the textbook. *It is about 3000 times more luminous than the Sun. Once you know the star's luminosity  $L$ , you can calculate its distance  $r$  from the measured apparent brightness (or flux)  $F$ , using the equations*

$$F = \frac{L}{4\pi r^2}$$

$$r = \sqrt{\frac{L}{4\pi F}}$$



3. Refer to Figure 15.15 in your textbook, which shows the spectra of two galaxies. The upper spectrum is what we would see if the galaxy were at rest relative to our own galaxy. The lower spectrum is for a galaxy that is moving away from us due to the expansion of the Universe, so that the Doppler effect has shifted its absorption lines to the red. The shift can be related to the velocity of recession of the galaxy through the formula  $\Delta\lambda/\lambda = v/c$ . In this formula,  $\lambda$  is the "rest" wavelength of an absorption line,  $\Delta\lambda$  is the amount by which the Doppler effect has changed its wavelength,  $v$  is the velocity of the galaxy, and  $c$  is the speed of light (300,000 km/sec). What is the velocity of recession  $v$  of the galaxy shown in the lower spectrum?

*Hint...* read the figure and caption. The authors have already measured  $\Delta\lambda/\lambda$  for you.

*The figure tells you that  $\Delta\lambda/\lambda = 0.05 = v/c$ , so  $v = 0.05 \times c = 15,000$  km/sec.*

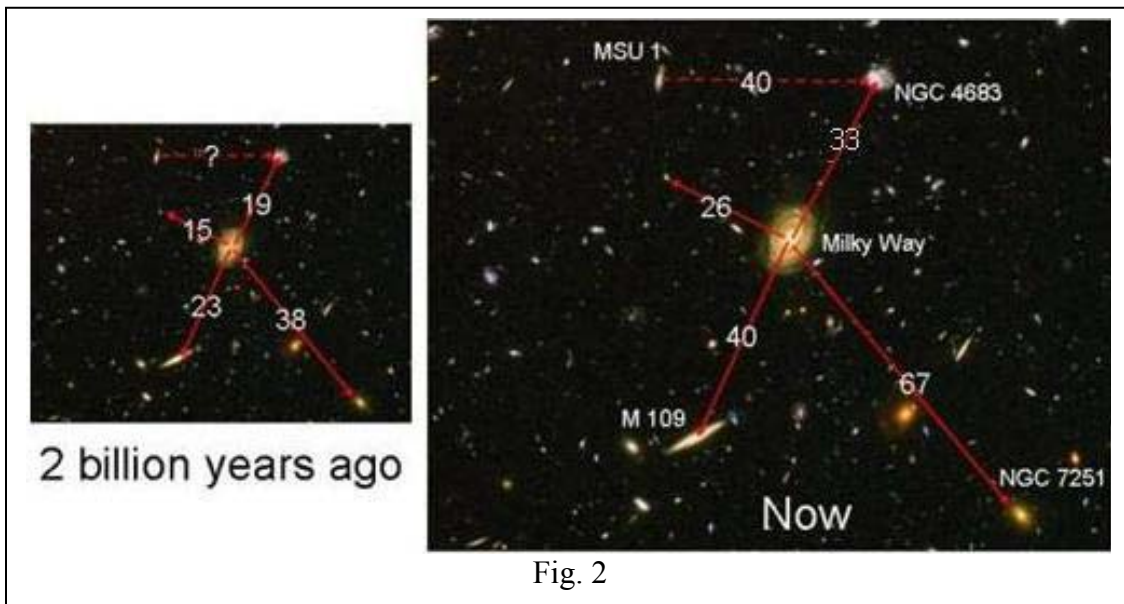
4. Now let's use Hubble's Law to find the distance to that galaxy for which you found the velocity of recession in the previous question. If the value of Hubble's constant were  $H_0 = 22$  km/sec per million light years, how far away is the galaxy from us?

*Hint...* Solve for the distance  $d$  in the equation  $v = H_0 d$ , where  $v$  is the velocity you found in the previous question.

*Answer:*  $d = 15,000/22 = 681$  million light years.

5. The picture below shows two cross sections of the same chunk of the universe, at time intervals separated by 2 billion years. We are on the Milky Way Galaxy, and have measured the distances to a number of other galaxies at both times. Our results (in millions of light years) are shown on the figure. Another astronomer who lives in the distant galaxy MSU 1 (where everybody is Green) is carrying out a similar experiment, but unfortunately missed taking the measurement 2 billion years ago because of cloudy weather. But we can help him/her/it out. Two billion years ago, what was the distance from MSU 1 to NGC 4683?

*Hint...* there is no need to measure anything with a ruler. The expansion of the universe is uniform and must look the same to anybody measuring it from any galaxy. Just think about what that means.



*In the expanding universe, everything expands by the same proportions. So find the expansion factor  $R(t)$  by taking the ratio of the distances now and 2 billion years ago, between any pair of galaxies. For example, the distance between the Milky Way and NGC 7251 increased by the ratio  $67/38 = 1.7$ . So the distance between MSU 1 and NGC 4683 must have increased by the same ratio, and the distance 2 billion years ago was  $40/1.7 = 23$  million light years.*