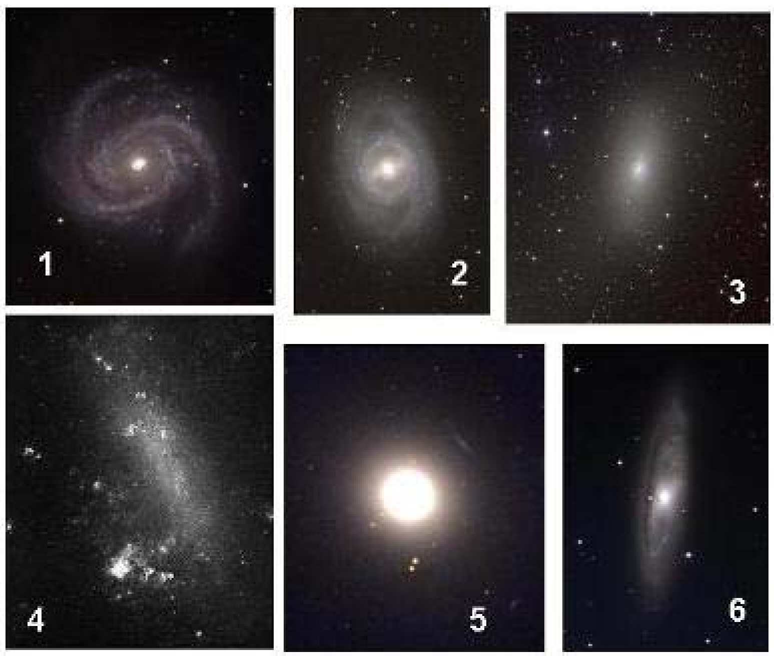
Homework Set 7

These are sample questions. Different students saw different versions of the question. Answers are in red.



1. [1 point each] 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.

1. Galaxy 1	**4.** Galaxy 4
2. Galaxy 2	**5.** Galaxy 5
3. Galaxy 3	**6.** Galaxy 6

- **A.** E6
- **B.** Sc
- **C.** E0
- **D.** Sa
- **E.** Irr
- **F.** SBb

Answer: A:3, B:1, C:5, D:6, E:4, F:2

2. [2 pts] 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.

- ☐ **A.** 3,000
- ☐ **B.** 10,000
- ☐ **C.** 30,000
- ☐ **D.** 1,000

Answer: A

3. [1 pt] Refer to figure 15.14 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, λ 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.

Answer: $v = c\,(\Delta\lambda/\lambda)$, where $\Delta\lambda/\lambda = 0.05$ (or 5%, as noted on the figure).

- ○ **A.** 15,000 km/sec
- ○ **B.** 1,500,000 km/sec
- ○ **C.** 300,000 km/sec
- ○ **D.** 6,000,000 km/sec

Answer: A

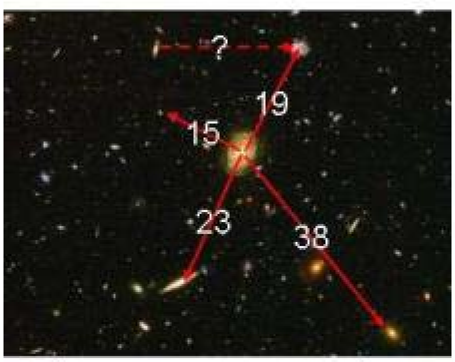
4. [2 pts] Now let's use Hubble's Law to find the distance to that galaxy for which you found the velocity of recession in the previous question. If the value of Hubble's constant were H_o = 26 km/sec per million light years, how far away is the galaxy from us?

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

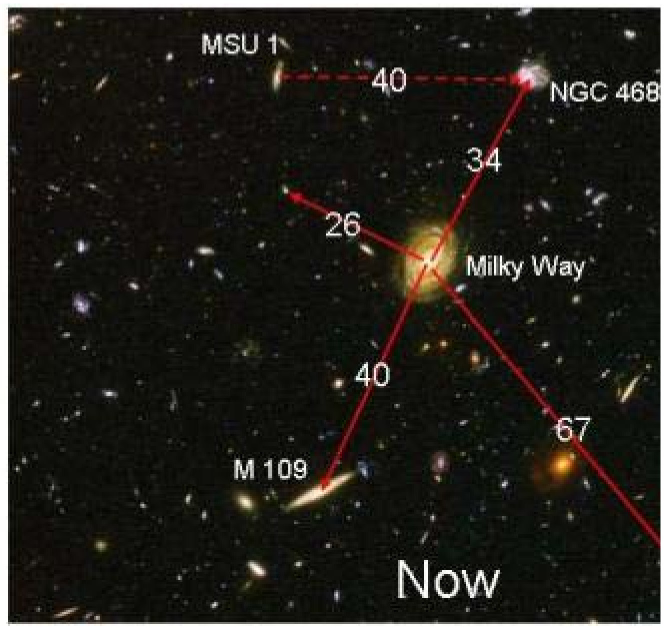
- **A.** 7800000 million light years
- **B.** 576.9 million light years
- **C.** 11538.5 million light years
- **D.** 390000 million light years

Answer: B

d = (15,000 km/sec) / (26 km/sec/million-light-years) = 576.9 million light years.



2 billion years ago



5. [2 pts] The picture 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?

Give your answer in units of millions of light years, rounded to the nearest million. For example, the present distance from MSU 1 to

NGC 4683 would be entered as "40".

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.

The Easy Way to Figure Out The Answer: Every length in the box increases by the same proportion. Since there are two lengths that are currently 40 million light years (including the one from MSU1 to NGC 4683), and 2 billion years ago one of those distances was 23 million light years, then the distance in question must also have been 23 million light years. This all works because the expansion of the universe *must* look the same to any observer on any galaxy.

Answer: 23