Lecture-Tutorials for Introductory Astronomy

PRELIMINARY EDITION

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Looking at Distant Objects

Imagine that you have received six pictures of six different children who live near six of the closest stars to the Sun. Each picture shows a child on his or her 12th birthday. The pictures were each broadcast directly to you (using a satellite) on the day of the child's birthday. Note the abbreviation "ly" is used below to represent a light-year.

John lives on a planet orbiting Ross 154, which is 9.5 ly from our Sun.
Peter lives on a planet orbiting Barnard's Star, which is 6.0 ly from our Sun.
Celeste lives on a planet orbiting Sirius, which is 8.6 ly from our Sun.
Savannah lives on a planet orbiting Alpha Centauri, which is 4.3 ly from our Sun.
Inga lives on a planet orbiting Epsilon Eridani, which is 10.8 ly from our Sun.
Ron lives on a planet orbiting Procyon, which is 11.4 ly from our Sun.

1) Describe in detail what a light-year is. Is it an interval of time, a measure of length, an indication of speed, or some other quantity?

2) Which child lives closest to the Sun? How far away does he or she live?

3) What was the greatest amount of time that it took for any one of the pictures to travel from the child to you?

4) If each child was 12 years old when he or she sent his or her picture to you, how old was each of the children when you received their picture?

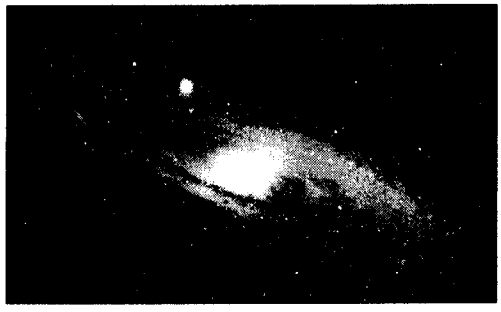
John_____ Peter_____ Celeste___

Savannah _____ Inga _____ Ron _____

5) Is there a relationship between the current age of each child and his or her distance away from Earth? If so, describe this relationship.

6) Imagine that the six pictures were broadcast by satellite to you and that they arrived at exactly the same time. For this to be true, does that mean the all of the children sent their pictures at the same time? If not, which child sent his or her picture first and which child sent his or her picture last?

7) The telescope image at the right was taken of the Andromeda Galaxy, which is located 2.5 million ly away from us. Is this an image showing how the Andromeda Galaxy looks right now, how it looked in the past, or how it will look in the future? Explain your reasoning.



8) Imagine that you were observing a distant star that was located in a galaxy 100 million ly away from you. By analysis of the starlight received, you are able to tell that the image we see is of a 10 million year old star. You are also able to predict that the star will have a lifetime of 50 million years, at which point it will end in a catastrophic supernova.

   a) How old does the star appear to us here on Earth?

   b) How long will it be before we receive the light from the supernova event?

   c) Has the supernova already occurred? If so, when did it occur?

9) Imagine that you take two images of two main sequence stars that have the same mass. From your observations, both stars appear to be at the same point in their evolution. Consider the following possible interpretations that could be made from your observations.

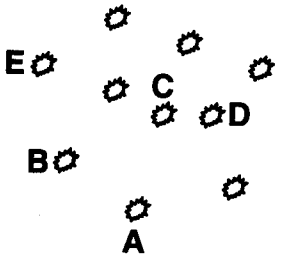
   a) Both stars are the same age and the same distance from you.
   b) Both stars are the same age but at different distances from you.
   c) The stars are actually different ages but at the same distance from you.
   d) The star that is closer to you is actually the older of the two stars.
   e) The star that is farther from you is actually the older of the two stars.

   How many of the five choices (a-e) are possible? Which ones? Why?

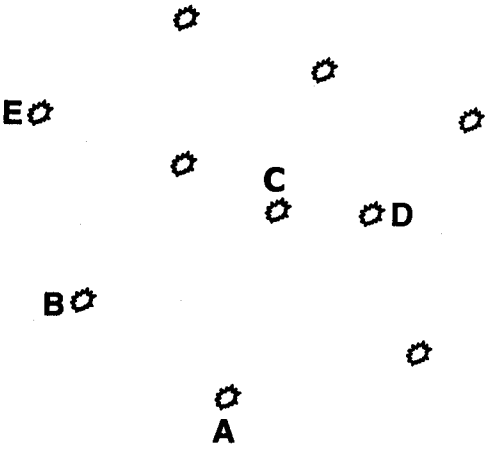
Expansion of the Universe

The two drawings below represent the same group of galaxies at two different points in time during the history of the Universe.

Early Universe



Universe Some Time Later



1) Examine the distance between the galaxies labeled A - E in the *Early Universe*. Are all the galaxies the same distance from each other?

2) Describe how the Universe changed in going from the *Early Universe* to the *Universe Some Time Later.*

3) Do the galaxies appear to get bigger?

4) Will stars within a galaxy move away from one another due to the expansion of the Universe?

5) Compare the amount that the distance between the D and C galaxies changed in comparison to the amount that the distance between the D and E galaxies changed. Which galaxy appears to have moved farther, C or E?

6) If you were in the D galaxy, how would the A, B, C and E galaxies appear to move relative to your location?

7) If you were in the D galaxy would the A, B, C, and E galaxies all appear to move by the same amount in the time interval from the *Early Universe* to the *Universe Some Time Later*?

8) Rank the A, B, C, and E galaxies (from greatest to smallest), in terms of their relative speeds away from you in the D galaxy.

9) Now imagine that you are in the E galaxy. Rank the A, B, C and D galaxies, in terms of their relative speeds away from you, from greatest to smallest.

10) Is there a relationship between the apparent speed of an object and its distance from you in the Universe? If so, describe this relationship.

11) Would your answer to question 10 be true in general for all locations in the Universe?

12) Consider the following discussion between two students regarding the possible location of the center of the Universe.

Student 1: *Since all the galaxies we observe are moving away from us we must be at the center of the Universe.*

Student 2: *If our Milky Way Galaxy were like galaxy A and if the Andromeda galaxy were like galaxy B, then we would both see all other galaxies moving away from us. So I'm not sure if our Milky Way Galaxy is the center or if it's Andromeda.*

State whether you agree or disagree with *each* of the student statements. Explain your reasoning for *each*.