Stars and Galaxies

Seeing into the Past

We can't travel into the past, but we can get a glimpse of it. Every time we look at the Moon, for example, we see it as it was a little more than a second ago. That's because sunlight reflected from the Moon's surface takes a little more than a second to reach Earth. We see the Sun as it looked about eight minutes ago, and the other stars as they were a few years to a few centuries ago.

And then there's M31, the Andromeda galaxy — the most distant object that's readily visible to human eyes. This great amalgamation of stars stands almost directly overhead late this evening. When viewed from a dark sky-watching location, far from city lights, it looks like a faint, fuzzy blob. But that blob is the combined glow of hundreds of billions of stars — seen as it looked more than two million years ago.

Andromeda is like a larger version of our own Milky Way galaxy. It's a flat disk that spans more than a quarter-million light-years. Its brightest stars form spiral arms that make the galaxy look like a pinwheel. Yet the galaxy is so far away that its structure is visible only through telescopes.

The light from M31 has to travel about two and a half million light-years to reach us — about 15 quintillion miles — the number 15 followed by 18 zeroes. Yet even across such an enormous gulf, the galaxy is so bright that we can see it — faintly — with our own eyes, crossing high overhead late tonight.

This is the transcript of a StarDate radio episode that aired October 14, 2006. Script by Damond Benningfield, ©2006.

Student Page

A galaxy is a gravitationally bound system of stars, gas, and dust. Galaxies range in diameter from a few thousand to a few hundred thousand light-years. Each galaxy contains billions (10^9) or trillions (10^{12}) of stars. In this activity, you will apply concepts of scale to grasp the distances between stars and galaxies. You will use this understanding to elaborate on the question, Do galaxies collide?

Explore

On a clear, dark night, you can see hundreds of bright stars. The next table shows some of the brightest stars with their diameters and distances from the Sun. Use a calculator to determine the scaled distance to each star (how many times you could fit the star between itself and the Sun). Hint: you first need to convert light-years and solar diameters into meters. One light-year equals 9.46×10^{15} meters, and the Sun's diameter is 1.4×10^9 meters.

Star (Constellation)	Diameter (Sun=1)	Distance (light-years)	Scaled Distance (distance÷diameter)
Spica (Virgo)	8	261	
Betelgeuse (Orion)	600	489	
Deneb (Cygnus)	200	1,402	
Altair (Aquila)	2	17	
Vega (Lyra)	2.7	26	
Sirius (Canis Major)	1.6	8.6	

There are three galaxies beyond the Milky Way that you can see without optical aid: the Andromeda galaxy, the Small Magellanic Cloud, and the Large Magellanic Cloud. Figure the scaled distance to these galaxies (how many times you could fit the galaxy between itself and the Milky Way).

Galaxy	Diameter (light-years)	Distance (light-years)	Scaled Distance (distance÷diameter) (no conversion needed)
Milky Way	100,000	0	
Andromeda Galaxy	125,000	2,500,000	
Large Magellanic Cloud	31,000	165,000	
Small Magellanic Cloud	16,000	200,000	

Explain

How does the scaled distance of galaxies compare to stars?

Elaborate

Do you think galaxies collide? Why or why not?

Teacher Lesson Key

Objectives

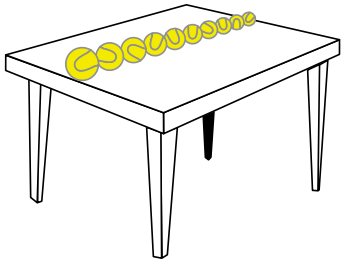
- Calculate scale distances of stars and galaxies.
- Compare neighboring galaxies to neighboring stars.
- Understand the relative distances between objects in space.

National Science Education Standards

- Content Standard in 9-12 Science as Inquiry (Understanding about scientific inquiry)
- Content Standard in 9-12 Earth and Space Science (Origin and evolution of the universe)

Engage

Find a round object in the classroom that is about 2 to 5 inches in circumference (such as a water bottle, tennis ball, or soda can). We will use a tennis ball as an example. Using a table that everyone can see, ask the students, "How many tennis balls would it take to go from one end of this table to the other? In other words, how many tennis balls across is the table?" Accept all answers. Then find the answer in front of the class by moving the ball across the table one space at a time, counting each move out loud.



Explore (Answers)

Stars To convert Distance (ly) x 9.46 x 10^{15} (m/ly) Diameter (Suns) x 1.4 x 10^{9} (m/Sun)	Scaled Distance Distance÷Diameter (both must be in the same units, do conversions first)
Spica (Virgo)	2.22 x 10^{8}
Betelgeuse (Orion)	5.51 x 10^{6}
Deneb (Cygnus)	4.74 x 10^{7}
Altair (Aquila)	5.74 x 10^{7}
Vega (Lyra)	6.51 x 10^{7}
Sirius (Canis Major)	3.59 x 10^{7}

Galaxies Distance÷Diameter (no conversion needed)	Scaled Distance from Milky Way Distance÷Diameter (no conversion needed)
Milky Way	------
Andromeda Galaxy	20
Large Magellanic Cloud	5.32
Small Magellanic Cloud	12.5

Explain

How does the scaled distance of galaxies compare to stars?

Galaxies, compared to their size, are much closer together than stars. Neighboring stars are usually millions of star-diameters apart, while galaxies are usually less than 100 galaxy-diameters apart.

Elaborate

Do you think galaxies collide? Why or why not?

Galaxies do collide. They are relatively close to each other and they have the combined mass of billions of stars. So even over large distances, the attraction between galaxies can accelerate them toward each other. Thick of bowling balls (galaxies) versus sand grains (stars) on a trampoline (space). The galaxies stretch and distort the trampoline much more, and over a wider area, than do single stars. Even though galaxies collide, the stars within *galaxies seldom collide because they are so far away from each other. Clouds of gas and dust in the galaxies* do *collide, though, giving birth to new stars.*

Evaluate

Rubric: Explore = 60 pts (6 pts for each calculation), Explain = 25 pts, Elaborate = 15 pts