Make your own Galaxy
5-E Lesson Key

Introduction

The Hubble Space Telescope has revealed a universe full of galaxies, and stunning detailed structures within nearby galaxies. A galaxy is a gravitationally bound system of stars, gas, and dust. They range in size from a few thousand light years to a few hundred thousand light-years in diameter for the luminous matter. In this activity, students apply mathematical concepts of scale to make a model of our Galaxy, the Milky Way. They use their model and data to elaborate on the question: do galaxies collide?

Materials

Cotton balls or polyester batting, black poster board, metric ruler, glue, glitter, scissors.
Guide to Beyond the Solar System

Objectives

Build a scale model of our Galaxy
Identify major components of our galaxy
Calculate scale distances in a model of our Galaxy
Visualize our place in our Galaxy using their model
Compare neighboring galaxies to neighboring stars.

NSES

Science as Inquiry: understanding about scientific inquiry
Physical Science: motions and forces
Earth and Space Science: origin and evolution of the universe

Engage

Read and/or listen to a StarDate radio script *Milky Way Clouds* September 5, 2004. Visit http://stardate.org to download an audio file. Some students may want to read and listen.

Explore

Build a model of our Galaxy according to the Beyond the Solar System activity. Make sure students read and understand the section *Some of the materials represent major characteristics of our galaxy.*
Read the sections *The Milky Way*, then *Types of Galaxies,* then *The Local Group* in the Guide to Beyond the Solar System.
Identify each major component of your model: disk, bulge, spiral arms.

Explain

On a clear dark night, you can see hundreds of bright stars. Where are most of the bright stars you can see without optical aide in your model?

All of these stars are very close to the Sun.

In the model, the scale factor is $\frac{100{,}000\ light\,years}{30\ cm} = 3333\frac{light\,years}{cm}$

So in the model, all these stars fit inside a pinky finger width at the Sun's location.

Make sure students convert Distance and Diameter to the same unit: meters. Astronomers use light-years and Sun units because the numbers are very large. It's easier to think of the enormous distances and sizes in more familiar or physical terms.

Star and Constellation	Diameter Sun = 1	Distance from Sun Light-Years	Mass (estimated) Sun = 1	Ratio Distance : Diameter	Scale Distance from Sun Sun Diameter = 1
Spica, Virgo	8	261	18	*2.22E+08*	*1.77×10^{9}*
Rigel, Orion	70	815	10	*7.91E+07*	*5.54×10^{9}*
Betelgeuse, Orion	600	489	15	*5.54E+06*	*3.32×10^{9}*
Deneb, Cygnus	200	1402	25	*4.76E+07*	*9.53×10^{9}*
Altair, Aquila	2	17	1.8	*5.78E+07*	*1.16×10^{8}*
Vega, Lyra	2.7	26	2.7	*6.54E+07*	*1.77×10^{8}*
Antares, Scorpius	800	391	15	*3.32E+06*	*2.66×10^{9}*
Sirius, Canis Major	1.6	8.5	2.3	*3.61E+07*	*5.78×10^{7}*

1 light-year = 9.4605×10^{15} meters Sun's diameter = 1.39×10^{9} meters Sun's mass = 2×10^{30} kilograms

Ratio Distance:Diameter – how many star diameters between the star and the Sun.
Scale Distance from Sun – how many Sun diameters between the star and the Sun.

Elaborate

There are three galaxies beyond the Milky Way that you can see without optical aide: Andromeda Galaxy, Small Magellanic Cloud, Large Magellanic Cloud.

How does the ratio of the separation of galaxies to their size compare to stars?

Galaxy	Luminous Diameter Light-Years	Distance from Milky Way Light-Years	Mass Sun = 1	Ratio Distance : Diameter	Scale Distance from Milky Way Milky Way Diameter = 1
Milky Way	100,000		2×10^{11}		
Andromeda Galaxy	125,000	2,500,000	3×10^{11}	*20.0*	*25*
Large Magellanic Cloud	31,000	165,000	2×10^{10}	*5.3*	*1.65*
Small Magellanic Cloud	16,000	200,000	6×10^{9}	*12.5*	*2*

Sun's mass = 2×10^{30} kilograms

Ratio: Distance:Diameter – how many galaxy diameters between the Milky Way and the (Andromeda Galaxy, Large Magellanic Cloud, Small Magellanic Cloud).
Scale Distance from Milky Way – how many Milky Way diameters between the Milky Way and the (Andromeda Galaxy, Large Magellanic Cloud, Small Magellanic Cloud).

Do you think galaxies collide? Why or why not?

Galaxies, compared to their size, are closer together than stars. They are also much more massive, having the combined mass of billions of stars. So, even over a large distance the force of gravity between galaxies can accelerate them toward each other. Think of bowling balls (galaxies) on a trampoline (space) vs. sand grains (stars) on a trampoline. The galaxies will stretch and distort the trampoline much more over a wider area than individual stars. Plus, the galaxies are not so far separated with respect to their sizes.

Evaluate

Rubric for Explore (Milky Way model), Explain, and Elaborate

	5 points	15 points	25 points
Scale	Incorrect ratio, incorrect equation. Places the Sun outside the bulge. Places brightest stars near the Sun. Other model galaxies are spread apart by a few galaxy diameters.	Incorrect ratio, correct equation Student generally locates the Sun. Student generally locates brightest stars. Tries to apply a scale to place other model galaxies.	Centimeters to light-years ratio correct. Student locates the Sun accurately. Student can accurately locate bright stars in relationship to the Sun Student correctly places model galaxies according to scale.
Parts	Identifies some parts. Parts are distinguishable. Bulge and arms peppered with stars.	Identifies all parts. Parts are distinguishable. Bulge and arms peppered with stars of the correct color	Identifies all parts. Parts are clearly modeled. Bulge has red and yellow stars. Arms appear sparse and dotted with blue and silver glitter.
Creativity	Little effort to creatively incorporate the properties of the Milky Way in their model.	Parts are modeled correctly. Bulge and arms have stars of the correct color peppered throughout.	Parts look realistic Bulge is more densely packed than arms, with stars peppered throughout Arm stars are sprinkled in knots
Explain and Elaborate	Incorrect equations, and errors in calculations. Notes that galaxies are closer together than stars. Concludes that gravity could pull them together. Few or no references to Explain or Elaborate data.	Correct equations, errors in calculations. Notes that galaxies are closer together than stars (relative to their diameters), and tries to explain that gravity could pull them together. References some data in the Explain or Elaborate sections	Correct equations and calculations. Correctly infers that galaxies do collide because relative to their size, they are close together. The gravitational forces between galaxies can pull them together. Explicitly references the data in the Explain or Elaborate sections.

StarDate: September 5, 2004

Milky Way Clouds

http://stardate.org/radio/program.php?f=print&id=2004-09-05

One of the most beautiful and awe-inspiring sights in the heavens arches high overhead tonight: the Milky Way, a hazy band of light that stretches roughly north-south a couple of hours after sunset. But you need to get away from city lights to see it, and you need to look before the Moon rises in late evening.

The Milky Way looks like a single structure, but it's really the combined glow of millions of individual stars in the disk of our Milky Way galaxy. The center of the galaxy is in the constellation Sagittarius, a teapot-shaped pattern of stars that's low in the south.

As you study the Milky Way, you'll notice dark streaks and blobs mixed with the bright band of light. These are clouds of interstellar dust that populate the Milky Way. Although the clouds are near-perfect vacuums, they're huge, so their material piles up. The dust grains in the clouds are about the size of the particles in cigarette smoke. They absorb the light of the stars behind them, so they look dark.

The smallest clouds visible from Earth are only about one light-year across, and they're about 20 times as massive as the Sun. The biggest are a couple of hundred light-years across, and contain enough material to make hundreds of stars as massive as the Sun.

These clouds are like the one that gave birth to the Sun and Earth about four and a half billion years ago. So some of these dark clouds may someday give birth to their own stars and planets.

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