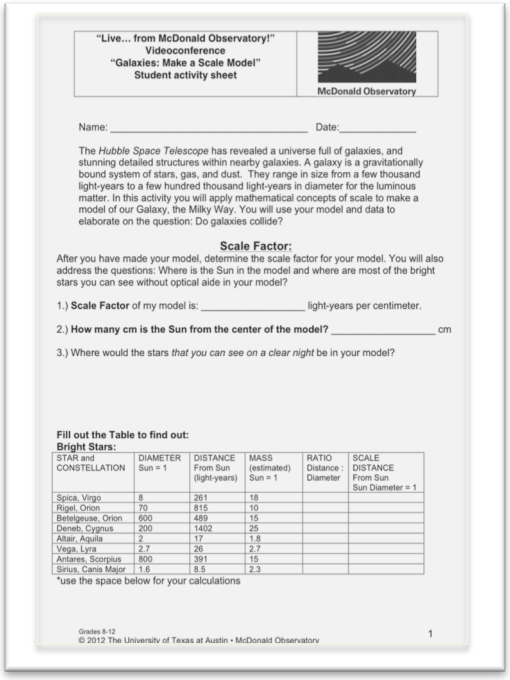
Live… from McDonald Observatory! Videoconference
"Galaxies: Make a Scale Model"
Teacher Edition for grades 8-12

Introduction

The videoconference will give a brief introduction to McDonald Observatory. Students will then apply mathematical concepts to make a model of our galaxy, the Milky Way. They will use their model and data to elaborate on the question: do galaxies collide? The student sheets are designed to help the student answer and discuss important concepts. Students should be directed to not fill in their sheets until prompted.

Investigation: Make a model of the Milky Way.

Prior to the videoconference, students should have filled in the pre-assessment sheet. The drawings and words that they use will help you gauge their pre-conceptions as well as prepare them for encountering new information about stars, galaxies, and the Universe.



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Videoconference
"Galaxies: Make a Scale Model"
Student activity sheet

McDonald Observatory

Name: _____ Date:_____

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 you will apply mathematical concepts of scale to make a model of our Galaxy, the Milky Way. You will use your model and data to elaborate on the question: Do galaxies collide?

Scale Factor:

After you have made your model, determine the scale factor for your model. You will also address the questions: Where is the Sun in the model and where are most of the bright stars you can see without optical aide in your model?

1.) **Scale Factor** of my model is: _____ light-years per centimeter.

2.) **How many cm is the Sun from the center of the model?** _____ cm

3.) Where would the stars *that you can see on a clear night* be in your model?

Fill out the Table to find out:
Bright Stars:

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		
Rigel, Orion	70	815	10		
Betelgeuse, Orion	600	489	15		
Deneb, Cygnus	200	1402	25		
Altair, Aquila	2	17	1.8		
Vega, Lyra	2.7	26	2.7		
Antares, Scorpius	800	391	15		
Sirius, Canis Major	1.6	8.5	2.3		

*use the space below for your calculations

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The facilitator will discuss the idea of models and will lead students through a short discussion about the advantages and limitations of models. The facilitator will then lead students in groups of 2-3 in making a 30-cm disk scale model of the Milky Way galaxy.

In addition to the Student Sheets, please have these materials ready in your classroom prior to the videoconference. Go through the list at least one day in advance so that you can be sure that they are available.

Materials Needed for the Model:
Black poster board or construction paper – PRECUT to 30-cm diameter disk (1 per group)
40 cotton balls or poly batting (per group)
Metric ruler (1 per group)
White Glue (1 per group)
Red, blue, yellow, and white glitter (1 batch per group)
Calculator (1 per student)

The facilitator will also lead the students in a discussion to identify the major components of our galaxy. After they have made their model students will calculate the **Scale Factor** of their model in light-years per cm, and the number of centimeters between the Sun's location and the center of the galaxy in the model. Students will also answer where stars that you can see with your eyes on a clear night would be in their model. *The students should recognize that all of these stars are very close to the Sun.*

In the model, *the scale factor is 100,000 (light-years) / 30 cm = 3333 light-years/cm*.
So in the model, all these stars fit inside a pinky finger width at the Sun's location.

Scale Distances between Bright Stars:

Students will fill in the table shown on Page 1 of the student sheet. Students need to remember to convert *Distance* and *Diameter* to the same unit: meters.
There is room on Page 2 for students to make calculations and show their work in order to fill out Table 1.
For reference: 1 light-year = 9.46×10^{15} meters, Sun's Diameter = 1.39×10^{9} meters, Sun's mass = 2.0×10^{30} kg

Ratio Distance:Diameter – tells the students: *how many star diameters between the star and the Sun*.

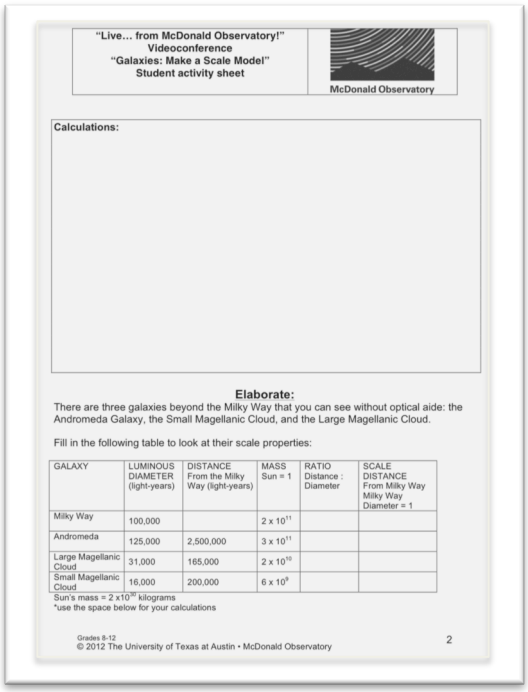
Scale Distance from Sun – tells the students: *how many Sun diameters between the star and the Sun*.

Table 1 with Answers:

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	2.2E+08	1.77E+09
Rigel, Orion	70	815	10	7.91E+07	5.54E+09
Betelgeuse, Orion	600	489	15	5.54E+06	3.32E+09
Deneb, Cygnus	200	1402	25	4.76E+07	9.53E+09
Altair, Aquila	2	17	1.8	5.78E+07	1.16E+08
Vega, Lyra	2.7	26	2.7	6.54E+07	1.77E+08
Antares, Scorpius	800	391	15	3.32E+06	2.66E+09
Sirius, Canis Major	1.6	8.5	2.3	3.61E+07	5.78E+07

Elaborate – Table 2:

Students will calculate the Distance:Diameter ratio, and scale distance from the Milky Way for the three galaxies that can be seen from Earth without optical aide: Andromeda, the Large Magellanic Cloud, and the Small Magellanic Cloud. They will fill in their calculations in Table 2, on page 2 of the student sheet, and there is room below on page 3 of the their sheet for students to make calculations and show their work.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Calculations:

Elaborate:

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

Fill in the following table to look at their scale properties:

GALAXY	LUMINOUS DIAMETER (light-years)	DISTANCE From the 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	125,000	2,500,000	3×10^{11}		
Large Magellanic Cloud	31,000	165,000	2×10^{10}		
Small Magellanic Cloud	16,000	200,000	6×10^{9}		

Sun's mass = 2×10^{30} kilograms
*use the space below for your calculations

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Ratio Distance:Diameter – tells the students: *how many galaxy diameters between the Milky Way and the (Andromeda, Large Magellanic Cloud, Small Magellanic Cloud)*.

Scale Distance from Sun – tells the students: *how many Sun diameters between the star and the Sun*.

Table 2 with Answers – shown below on following page.

Students then elaborate on the question: Do you think galaxies collide? Why or why not?

Answers - Students should recognize that:
Galaxies, compared to their size, are closer together than stars. Therefore, even when galaxies collide, the stars within them probably don't collide. The galaxies are also much more massive, having the combined mass of billions of stars. So even over a large distance the force of gravity between the 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 space/trampoline much more over a wider area than individual stars.

As an extension: Talk to students about what does collide in a galaxy when a collision occurs, and that is the gas and dust. Therefore, this results in a lot of new star formation due to galaxy collisions.

GALAXY	LUMINOUS DIAMETER (light-years)	DISTANCE From the 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	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

References and Extensions:

StarDate Astro Guides on the components of the Milky Way and the Local Group of Galaxies:
http://stardate.org/astro-guide/btss/galaxies/milky_way

http://stardate.org/astro-guide/btss/galaxies/local_group

NASA Activity – A Galaxy Up Close – students measure the scale of a galaxy from an image:
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/SMII_Problem15.html