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.

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 = 9.46x10^{15} meters, Sun's Diameter = 1.39x10^{9} meters, Sun's mass = 2.0x10^{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:**

<table>
<thead>
<tr>
<th>STAR and CONSTELLATION</th>
<th>DIAMETER</th>
<th>DISTANCE From Sun (light-years)</th>
<th>MASS (estimated) Sun = 1</th>
<th>RATIO Distance : Diameter</th>
<th>SCALE DISTANCE From Sun Sun Diameter = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spica, Virgo</td>
<td>8</td>
<td>261</td>
<td>18</td>
<td>2.2E+08</td>
<td>1.77E+09</td>
</tr>
<tr>
<td>Rigel, Orion</td>
<td>70</td>
<td>815</td>
<td>10</td>
<td>7.91E+07</td>
<td>5.54E+09</td>
</tr>
<tr>
<td>Betelgeuse, Orion</td>
<td>600</td>
<td>489</td>
<td>15</td>
<td>5.54E+06</td>
<td>3.32E+09</td>
</tr>
<tr>
<td>Deneb, Cygnus</td>
<td>200</td>
<td>1402</td>
<td>25</td>
<td>4.76E+07</td>
<td>9.53E+09</td>
</tr>
<tr>
<td>Altair, Aquila</td>
<td>2</td>
<td>17</td>
<td>1.8</td>
<td>5.78E+07</td>
<td>1.16E+08</td>
</tr>
<tr>
<td>Vega, Lyra</td>
<td>2.7</td>
<td>26</td>
<td>2.7</td>
<td>6.54E+07</td>
<td>1.77E+08</td>
</tr>
<tr>
<td>Antares, Scorpius</td>
<td>800</td>
<td>391</td>
<td>15</td>
<td>3.32E+06</td>
<td>2.66E+09</td>
</tr>
<tr>
<td>Sirius, Canis Major</td>
<td>1.6</td>
<td>8.5</td>
<td>2.3</td>
<td>3.61E+07</td>
<td>1.78E+07</td>
</tr>
</tbody>
</table>

**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.

**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.
### Live... from McDonald Observatory! Videoconference

**“Galaxies: Make a Scale Model”**  
Teacher Edition for grades 8-12

<table>
<thead>
<tr>
<th>GALAXY</th>
<th>LUMINOUS DIAMETER (light-years)</th>
<th>DISTANCE From the Milky Way (light-years)</th>
<th>MASS Sun = 1</th>
<th>RATIO Distance : Diameter</th>
<th>SCALE DISTANCE From Milky Way Diameter = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milky Way</td>
<td>100,000</td>
<td>2 x 10^{11}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andromeda</td>
<td>125,000</td>
<td>2,500,000</td>
<td>3 x 10^{11}</td>
<td>20.0</td>
<td>25</td>
</tr>
<tr>
<td>Large Magellanic Cloud</td>
<td>31,000</td>
<td>165,000</td>
<td>2 x 10^{10}</td>
<td>5.3</td>
<td>1.65</td>
</tr>
<tr>
<td>Small Magellanic Cloud</td>
<td>16,000</td>
<td>200,000</td>
<td>6 x 10^{9}</td>
<td>12.5</td>
<td>2</td>
</tr>
</tbody>
</table>

### References and Extensions:

StarDate Astro Guides on the components of the Milky Way and the Local Group of Galaxies:  

NASA Activity – A Galaxy Up Close – students measure the scale of a galaxy from an image:  