

Modeling Gravity

COMPUTER SIMULATION

AN OBJECT'S MOTION in space is determined by the gravitational forces between that object and the other objects in space.

Using models, we can investigate how the masses of objects and the distances between them affect the motions of those objects. From these models, we can learn how massive the different objects in our Solar System must be for our Solar System to act the way it does.

This knowledge can help us understand the motions of and within galaxies in our universe.

GUIDING QUESTION

How can models help us understand the role of gravity in the motion of space objects?



This photo of a group of galaxies was taken by a camera aboard NASA's Hubble Space Telescope.

MATERIALS

For each student

- 1 computer with Internet access
- 1 Student Sheet 1, "Planet Information"
- 1 Student Sheet 2, "Modeling Galactic Gravity"

PROCEDURE

Part A: The Mass of Our Sun

1. Open the Modeling Gravity simulation on your computer.
2. Choose one (or more) of the planets in our Solar System.
3. Find your chosen planet on Student Sheet 1, "Planet Information." Identify the distance your planet is from the Sun in astronomical units and how long it takes for your assigned planet to complete one orbit around the Sun—in years.
4. On the computer screen, select your planet.
5. In the upper left corner of the simulation is the simulated distance between your planet and the Sun. Drag your planet until this simulated distance matches the actual planet–Sun distance on Student Sheet 1.
6. Use the slider to change the mass of the Sun, and notice that in this simulation, the mass of the Sun changes without changing the distance you set in Step 5. Press "Run Simulation" and observe how long it takes for your planet to complete one orbit.
7. Press "Stop Simulation" and repeat Step 6 until the time it takes for your planet to complete one orbit is the same as what is on Student Sheet 1.
Hint: If you need your planet to orbit faster, increase the gravitational force between the Sun and your planet.
8. Write down the mass of the Sun from Step 7 .

9. Repeat Steps 2- 8 for a different planet, and answer Analysis item 1.

Part B: Galactic Gravity

10. Read the following information about the gravitational forces that determine the motions of objects within galaxies.

In the late 1900s, an astronomer named Vera Rubin was studying the motions of stars in the Andromeda Galaxy. She created a mathematical model based on gravity to predict how fast objects should be orbiting the center of the galaxy. She then observed how fast the objects were actually orbiting. Her data showed that her model's



predictions were way off! Since gravity is due to distance and mass, either her mass or distance measurements were wrong. She figured out that there must be mass in the galaxy that cannot be seen. Astronomers call this source of mass dark matter. When Dr. Rubin added dark matter into her model, her new predictions matched her observations. Her model now explained the motion of stars around the center of the Andromeda Galaxy.

Because of Dr. Rubin's discovery, other astronomers have discovered that all galaxies have dark matter, even our own! The gravitational forces from normal matter and dark matter in the Milky Way cause our Solar System to orbit around the center of our Galaxy.

ANALYSIS

1. How many times more massive is the Sun than Jupiter? Use data from this activity and Student Sheet 1 to complete your calculation.
2. Follow the instructions on Student Sheet 2, "Modeling Galactic Gravity to model a portion of a galaxy. Keep in mind that galaxies usually have billions of stars, but this model only looks at three stars within a galaxy.

3. Think about all you needed to know to complete Student Sheet 2.

a. Describe the role of gravity in determining the

- orbits of the stars.
- orbits of the planets around Star A.
- orbit of the one moon you included in your model.

b. Do the planets orbiting Star A orbit in the same direction?

Explain.

Hint: Make sure your answer mentions solar system formation.

4. Would it be possible to create a scale model of a galaxy and a solar system on one piece of paper?

Hint: A typical solar system is about 100 AU from its center to its edge, and the average distance between stars in a galaxy is about 250,000 AU.