BiteScis | STUDENT

Cosmic Explosions

Applying Newton's Laws on a Massive Scale

Introduction

For a civilization isolated on a single planet and equipped with little more than telescopes and mathematics, we've been able to learn a remarkable amount about the structure and history of our universe. In recent decades, scientists have precisely measured what materials make up the universe, mapped the distribution of its stars and galaxies across billions of light years of space, and recovered actual images of the universe as it appeared at the time of its birth. And yet, many big questions remain in **cosmology**—the study of the origins and evolution of our universe—that have enormous consequences for how and where life can exist. In this activity, you will learn about some current research about forces that act on galaxies and apply forces concepts to galactic contexts.

What To Do

STOP & read Science Bite:
Galactic Forces in Action!

After reading the Science Bite, answer the analysis questions below.

Analysis Questions

1. Explain what causes clusters of galaxies to form.

2. What law explains the attractive forces among galaxies? How is this law relevant to everyday life on Earth?

3. How do scientists know that the forces pushing galaxies together are smaller than the forces pulling galaxies apart? Explain in terms of galactic motion.

4. Scientists have proposed that too much dark energy would have prevented the existence of life in the universe. What do they base that claim on?

5. Describe a gamma ray burst and explain whether they are life-promoting or life-inhibiting. Include a quote from the Bite to support your answer.

Figure 1 from the Bite is shown below.

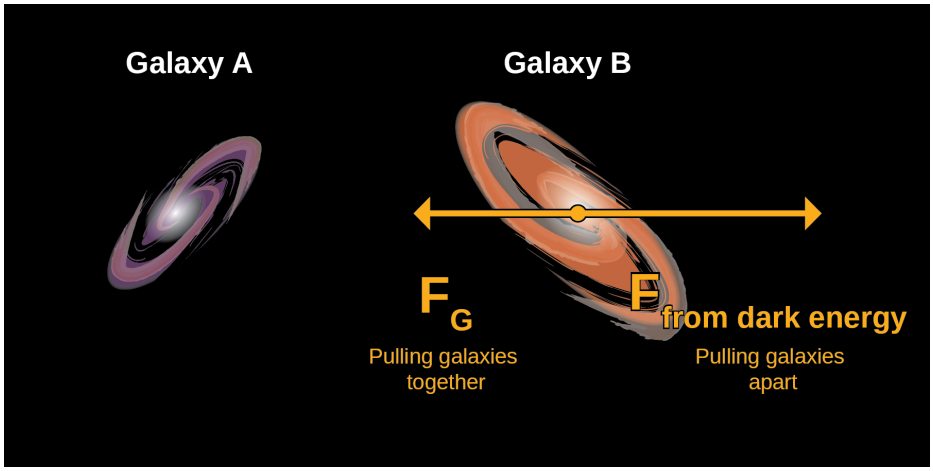

Figure 1. Galactic Forces. Model of forces acting on adjacent galaxies.

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6. Use **Figure 1** to answer the following questions.

a. Using a metric ruler, measure the length of the gravitational force (F_G) force arrow to the nearest 0.1 cm.

b. Using a metric ruler, measure the length of the force from dark energy ($F_{\text{from dark energy}}$) force arrow to the nearest 0.1 cm.

c. Given that the arrow length is proportional to the magnitude of the forces, which force is stronger, F_G or $F_{\text{from dark energy}}$?

d. What direction is the net force acting on Galaxy B? Justify your answer using evidence from the diagram.

e. What direction is Galaxy B accelerating? How do you know?

f. Suppose Galaxy B has a mass that is 3 times smaller than Galaxy A. How does the force Galaxy B exerts on Galaxy A compare to the force Galaxy A exerts on Galaxy B in terms of both magnitude and direction? Support your answer by referring to one of Newton's Laws of Motion.

g. Measure the distance between the center of Galaxy A and the center of Galaxy B in the **Figure 1** diagram above to the nearest 0.1 cm.

Figure 2 below shows the positions of Galaxies A and B at a later time than in **Figure 1.**

Figure 2. Position of Galaxies A and B at a Later Time.

7. Use **Figure 2** to answer the following questions.

a. Measure the distance between the centers of Galaxies A and B in **Figure 2** above to the nearest 0.1cm.

b. How does the distance in **Figure 2** compare to the distance in **Figure 1**?

c. How does the gravitational force of attraction F_G between the two galaxies in **Figure 1** compare to that in **Figure 2**? (Choose the best answer below, then justify your choice).

i. F_G in Figure 1 is twice as great as in Figure 2

ii. F_G in Figure 1 is four times as great as in Figure 2

iii. F_G in Figure 1 is equal to that in Figure 2

iv. More information about the masses of the galaxies is needed to make a comparison.

Explain your answer choice.

Figure 3 below shows Galaxy A and another of its neighboring galaxies, Galaxy C.

Figure 3. Position of Galaxies A and C.

8. Use **Figure 3** to answer the following questions.

a. Measure the distance between the center of Galaxy A and the center of Galaxy C in the **Figure 3** diagram above to the nearest 0.1 cm. How does this compare to the distance between Galaxy A and B in **Figure 2**?

b. Galaxy C has a mass three times that of Galaxy B. How does the gravitational force of attraction F_G between Galaxies A and C compare to that between Galaxies A and B in **Figure 2**?

i. F_G between A and C is three times as great as that between A and B
ii. F_G between A and C is nine times as great as that between A and B
iii. F_G between A and C is the same as that between A and B
iv. More information about the masses of the galaxies is needed to make a comparison.

Explain your answer choice.

9. **Connect to the Big Question**. Astronomers engaged in research about dark energy and the origin of the universe are trying to learn more about where we come from and the conditions that led to human life on Earth. Why do you think this research matters?