Modeling the Big Bang Theory

Strand Astronomy

Topic Investigating the Big Bang theory

Primary SOL ES.13 The student will investigate and understand scientific concepts related to the origin and evolution of the universe. Key concepts include
a) cosmology, including the Big Bang theory; and
b) the origin and evolution of stars, star systems, and galaxies.

Related SOL ES.2 The student will demonstrate an understanding of the nature of science and scientific reasoning and logic. Key concepts include
a) science explains and predicts the interactions and dynamics of complex Earth systems;
c) observation and logic are essential for reaching a conclusion.

Background Information

The Big Bang Theory is the prevailing cosmological model that explains the early development of the universe. According to the Big Bang Theory, the universe was once in an extremely hot and dense state which expanded rapidly. This rapid expansion caused the universe to cool and resulted in its present continuously expanding state. According to the most recent measurements and observations, the Big Bang occurred approximately 13.75 billion years ago, which is considered the age of the universe.

Materials

- 12-inch, round latex balloons
- Permanent felt-tip marking pens
- 24-inch pieces of string
- Metric rulers

Vocabulary

Big Bang theory, blueshift, Doppler effect, redshift, electromagnetic spectrum

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Upon completion of this activity, students will understand the concepts and mechanisms of the Big Bang model and will achieve an understanding of the continued expansion of the universe.

1. As a class use the "Observe the change in a star's spectrum as its motion changes" link found in the resources section of the lesson to study red shift and blue shift to gain a better understanding of the meaning of the two terms.
2. If time permits, show all or portions of "Back to the Beginning" from A NOVA videos. This will offer another view of the Big Bang Theory and its origin as told by Neil DeGrasse Tyson.
3. Give students five minutes to write down or sketch an explanation of the Big Bang Theory. Then, have them share their explanations in a class discussion. Facilitate and/or moderate the discussion until the class develops a group explanation.

4. Tell students to take five minutes to come up with and write down their thoughts and ideas on how this explanation could be tested. Then, again have students share their thoughts and ideas in a class discussion.
5. Give each pair of students a balloon, a marking pen, a piece of string, and a metric ruler. Tell students they will model the Big Bang and the resulting expansion of the universe. In each student pair, one student will be the balloon Holder and the other will be the balloon Marker.
6. Have each balloon Holder inflate the pair's balloon until it is about 10 cm (4 in.) in diameter and then hold the inflated balloon tightly but not tie the end.
7. Instruct each balloon Marker to use a felt-tip marker to put six dots on the balloon in widely scattered locations. Have him/her label one dot "Home" and the others "A" through "E." Tell students that the Home dot represents the Milky Way galaxy, and the others represent other galaxies formed in the early universe.
8. Without letting any air out of the balloon, have each Marker use the string and ruler to measure the distance from Home to each dot and record the distances under the Time 1 heading in a table like the one at right.

	Distance from Home				
	Time 1	Time 2	Time 3	Time 4	Time 5
Dot A					
Dot B					
Dot C					
Dot D					
Dot E					

9. Now, have each balloon Holder inflate the balloon some more so that its diameter is about 5 cm (2 in.) longer than it was. Again, have each Marker measure the distance to each dot and record the distances under Time 2.
10. Have each Holder inflate the balloon using 5-cm (2-in.) increments three more times. After each inflation, have each Marker measure and record the distances under the appropriate heading.

Assessment

- **Questions**
  - How did the distance from the Home dot to each of the other galaxies change each time you inflated the balloon?
  - Which galaxies appeared to move the greatest distance—those near Home or those farther away from Home?
  - How could you use this model to simulate the "Big Crunch"—i.e., a time when all of the galaxies might collapse in on themselves?

Extensions and Connections (for all students)

- Have the students research and report on recent discoveries related to Big Bang theory, especially scientific research about the most distant objects and current calculations for the age of the universe.

Strategies for Differentiation

- Demonstrate a red shift by partially inflating a long, slender balloon and using a black marker to draw a waveform along its length. Continue inflating the balloon to show students how an expanding universe causes a red shift in light coming from distant galaxies. Ask students to explain what they observed.

- Have small groups of students research the work of Arno A. Penzias and Robert W. Wilson for which they won a Nobel Prize in 1978. Ask each group to create a comic book that illustrates the story of their work and explains how it relates to the Big Bang Theory.
- Direct students to write a short newspaper article about the Big Bang Theory that addresses an audience of people who are unfamiliar with the theory. Challenge them to imitate the style of articles appearing in the local paper.