Cosmology

STARFINDER
PROGRAM 30

Instructional Objectives

After viewing the program and participating in accompanying activities, the student will be able to:

1. define cosmological model,
2. state that all cosmological models are based on assumptions and list the three most common factors, and
3. explain the fundamental differences among three cosmological models (Big Bang; Steady State; Oscillating Universe).

Synopsis

Dr. Eric Chaisson brings us his final update for *StarFinder*. *StarFinder's* reporter interviews Kathy Sullivan, one of the astronauts on the HST shuttle mission in April of 1990.

The last "Science Links" segment is a gestalt of the universe. Show 30 begins to explore the nature of cosmology for the student. Cosmology is the study of the organization and structure of the universe.

The segment begins with a reminder to the students that looking at the light from stars that are billions of light years away is the same as looking back into time. This is a repetition of a concept presented throughout the series.

Cosmology assumes that our knowledge of our solar system and galaxy applies to the entire universe. Modern-day cosmology also depends on two additional factors incorporated into the models. The first is that the more distant a galaxy, the faster it speeds away from earth. This factor was discussed in detail in Show 4 and the analogy of the raisin yeast cake was used to clarify the concepts for students. The second is that the universe is currently expanding. The speed with which galaxies are rushing away from earth and each other supports this factor.

This segment briefly outlines three cosmological models. Each model makes testable predictions about observable quantities such as the age of the universe or the abundance of helium relative to hydrogen.

The Big Bang Theory holds that all matter was once crowded to an extreme density and that the universe suddenly began its expansion with an explosion. The Steady State Theory holds that the universe has always existed, and has stayed essentially the same over time. The Oscillating Universe Theory holds that the universe expands and contracts in a repeated pattern. The gravitational attraction of matter stops the expansion and causes the contraction.

This segment closes with a philosophical quote from Edwin Hubble. It reminds us of the limit of our information and the constant search for knowledge.

This show may be a stretch for some of the students. For those students ready for abstract thought, it is an opportunity to use a new found talent. The postviewing activities are meant to aid teachers with this transition.

Vocabulary

Assumption - A postulate or proposition assumed; an assertion taken as true.

Contradict - To assert the opposite of what was said earlier; to go against what was said previously.

Cosmology - The study of the organization and structure of the universe. A cosmologist tries to piece together those properties of the universe at its largest observable extent into a self-consistent hypothesis that describes the structure and evolution of the universe in terms of the properties of astronomical objects on a smaller scale, such as galaxies and stars.

Recede - To move back or retreat.

Previewing

Review the concept of the expanding universe with the students.

Ask students to name or describe different types of models with which they are familiar.

Have students research the background of the people who were on the HST shuttle mission in April, 1990. NASA will provide this kind of information.

Postviewing

Ask students to think back over all the images Dr. Eric Chaisson has shown them. Which ones do they remember best? Why?

Discuss the kind of job Kathy Sullivan has chosen.

Discuss the term "assumption" when developing a scientific model. Why are assumptions so critical? Discuss why it is necessary for models to make predictions. Ask students to discuss the process of science. How does what we have observed with the HST fit into the process of science?

Active Involvement

George Lemaitre (1894–1966) was probably the first to propose a specific model for the Big Bang itself. Have the students research his life and report on the model he proposed.

The details of the standard model for the Big Bang were first worked out in a paper by Robert Wagoner, William Fowler, and Fred Hoyle in 1967. Three fundamental ideas are believed to hold the key to understanding the changes that occurred the first few minutes after the universe began. Have the students research and explain the following findings.

1. The universe cools as it expands.
2. When the universe was only seconds old, the universe was so hot that collisions of photons could produce material particles.
3. The higher the energy of a typical photon, the more massive are the particles that can be produced by the collision of two such photons.

The mean density of matter in space is a crucial concept in supporting or not supporting cosmological models. Have the students investigate the role of the mean density of matter and the implication of various estimates.

Bibliography

For high school readers:

Caes, Charles J. *Cosmology: The Search for the Order of the Universe.* Blue Ridge Summit: Tab Books, 1986.

Field, George & Eric Chaisson. *Invisible Universe.* New York: Macmillan Publishing Company, 1985.

Gribbin, John. *In Search of the Big Bang.* New York: Bantam Books, 1986.

Gribbin John. *The Omega Point.* New York: Bantam Books, 1988.

Hawking, Stephen W. *A Brief History of Time.* New York: Bantam Books, 1988.

Jespersen, James & Jane Fitz-Randolph. *From Quarks to Quasars.* New York: Macmillan Publishing Company, 1987.

Weinberg, Steven. *The First Three Minutes.* New York: Basic Books, Inc. Publishers, 1977.

For middle school readers:

Gallant, Roy A. *Once Around the Galaxy.* New York: Franklin Watts, 1983.

Herbst, Judith. *Sky Above and Worlds Beyond.* New York: Athenaeum, 1983.

Jacobs, Francine. *Cosmic Countdown.* New York: M. Evans and Co., Inc., 1983.

Lampton, Christopher. *New Theories on the Birth of the Universe.* New York: Franklin Watts, 1989.

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See for Yourself: Experiments/Projects

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Demonstrating a Model

▶ MATERIALS:

- balloons
- waterproof/permanent magic markers
- partners

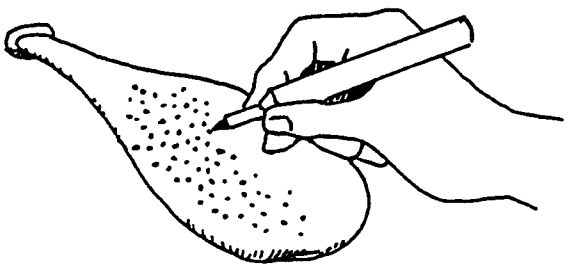
▶ DIRECTIONS:

You will use the balloon to demonstrate each of the cosmological models described in the Science Links segment.

1. Big Bang Theory
2. Oscillating Universe Theory
3. Steady State Theory

Next to each title above, briefly describe each theory. This will help you when you are ready to demonstrate.

1. Using the magic marker, make hundreds of small dots on the balloon (see diagram). The dots represent the particles of the super atom at the start of time.



2. Think about your description of each of the theories. Select one theory to demonstrate. How would you represent it with the balloon? Write down your idea. Then try it out and ask your partner which of the theories you are representing. If your partner understands your demonstration, make a note of it. Continue on until you have a demonstration for each of the theories.
3. Write out a description for your demonstration of each theory.

Infinity

▶ DIRECTIONS:

Does the universe go on forever? Does the universe have an edge? If it has an edge, what is beyond the edge? Try to visualize your answers to the questions above.

Collect the opinions of experts on this point. Try to collect opinions of scientists and of philosophers. Do their visualizations differ?

Discuss the concept of infinity with your classmates. Try to make the concept real by giving everyday examples of infinity.

Are We Alone In The Universe?

▶ DIRECTIONS:

Frank Drake is an American astronomer who is a pioneer in the search for extraterrestrial intelligence. Drake developed an equation to estimate the number of potentially communicative civilizations in the Milky Way Galaxy.

DRAKE'S EQUATION

$$N = R_s f_p n_p f_p f_i f_c L_c$$

Research the meaning of each of the factors in the equation. What is the range of estimates for each factor? What is the lowest estimate of N? The highest estimate of N?

Write a report to summarize scientists' endeavors to search for extraterrestrial life. Begin with the efforts of Frank Drake and Carl Sagan. What evidence have scientists found so far to support Drake's equation?

Science Career Profile

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KATHRYN SULLIVAN

NASA Astronaut
Education: B.S. Earth Sciences
Ph.D. Geology

As far back as she can remember, Kathryn Sullivan has been curious about our planet—curious about its natural systems, its geologic systems, its biologic systems, and curious about the people who live on it. Her life-long quest for adventure and exploration has led her to study and live around the world, taken her to the depths of the ocean floor, and sent her orbiting 380 miles above the earth.

Although Kathy has always been interested in science, she did not originally plan on a career as a scientist, much less as an astronaut. In fact, after discovering a natural talent for learning languages, she became very proficient in French during high school and chose to major in languages in college. It was only after taking some required science classes in college that her interests in science were rekindled, prompting her to change her major to earth sciences. Never content to stay in one place, Kathy left her California campus and spent a year at a university in Norway, where she was able to combine her sense of adventure, her facility for learning new languages, and her studies in geology and oceanographic research.

It may seem strange to end up with a career in outer space after an education in marine geology, but Kathy points out there are many similarities between the two. Seventy percent of the earth is covered by water, and parts of these waters are still as little known as is outer space. In her graduate studies at Dalhousie University in Canada, Kathy had a chance to explore and map an area of the sea floor that had never before been mapped, described, or analyzed. It did not seem out of place, then, for her next step to be in the opposite direction, the uncharted world of outer space.

Kathy has flown on two space shuttle missions, logging over 200 hours in space. In 1984, she became the first U.S. woman to perform an Extravehicular Activity (space walk) when she left the space craft for 3 1/2 hours. In April of 1990, Kathy was a member of the Space Shuttle Discovery's crew when it deployed the Hubble Space Telescope. Once again, she suited up and was ready to step into space if the HST needed help as it left the shuttle cargo bay and began its independent orbit around earth.

Kathy's responsibilities as a NASA astronaut include much more than flying on shuttle missions. Her space flights are exciting, but she loves all aspects of her job, from the early planning phases to the time a shuttle lands. Over the space shuttle's history, she has worked on software development, been the lead chase photographer for launch and landing, provided orbiter and cargo tests, done check out and launch support at Kennedy Space Center, and worked as a Capsule Communicator (CAPCOM) on three shuttle flights.

Kathy sees her work in the space shuttle program as one of being a team member. She says that working on a mission is like putting together a giant jigsaw puzzle. Not only is it important that everything from the orbiter to the spacesuits work, it is vitally important that the whole team work together, at the right time and in the proper sequence. Each crew is together for several years before the shuttle actually flies. This length of time allows people to become familiar with the spacecraft and the equipment, and also with the other team members.

Career Viewpoint

Kathy sees the neat thing about science as having questions for which we don't yet have the answers. What you need as a scientist is a combination of skills—math skills, chemistry skills, geologic or physics skills—whatever it takes to help you figure out an answer. Unlike your tests in school, where you are asked to know the specific answer to certain questions, a true scientific problem lets you take your turn finding an answer based on logic, proper mathematics, and proper science. True to her adventurous nature, Kathy compares this experience to standing on the edge of a cliff with everybody else behind you. How exciting to be where no one has gone before.

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