Earthbound Telescopes

STARFINDER

PROGRAM 16

Instructional Objectives

After viewing the program and participating in the follow-up activities, the student will be able to:

1. describe the purpose of optical and radio telescopes,
2. explain why astronomers prefer very large telescopes, and
3. explain why the use of an interferometer is important in radio astronomy.

Synopsis

Program 16 opens with the "HST Data Stream." In this segment, Eric Chaisson shares some of the latest information received from the Hubble Space Telescope.

The second segment focuses on the energy-gathering capabilities of optical and radio telescopes. Animated graphics and video sequences will demonstrate the light-gathering and resolving powers of optical telescopes. Students will be able to examine the relationship between these two major telescopic functions and the size requirements of optical telescopes.

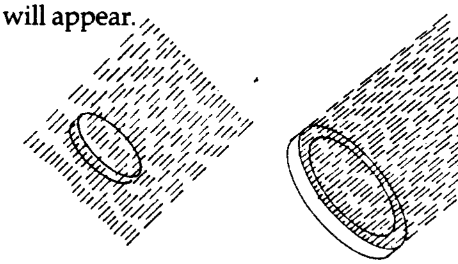
The importance of radio telescope size is also explained. Two forms of radio telescopes are described—the single parabolic antenna and the interferometer. The students will see a diagram showing how a radio antenna receives radiation and relays energy signals to a control room for computer analysis. A graphic representation of an interferometer which forms a telescope nearly equal to the diameter of the earth is also depicted. The conclusion of this science segment presents some of the contributions to astronomy made by optical and radio telescopes.

The career segment will introduce the students to Peter Kandefer, one of five amateur astronomers who has been given the unprecedented opportunity to make observations with the HST. Peter will describe his interest in examining magnetic fields and variation in the brightness of stars.

Vocabulary

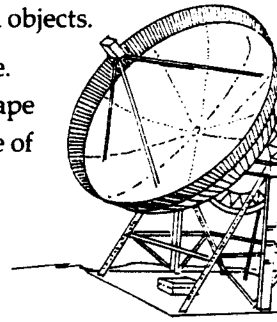
Interferometer - The combination of two or more radio telescopes linked together to simultaneously receive and combine radiation from space. The resolution of an interferometer can be considered equal to that of a single radio telescope that would extend over the distance that separated the telescopes.

Light-Gathering Power - The extent to which an optical telescope is able to collect visible, infrared, and ultraviolet radiation. The greater the concentration of light, the brighter the object will appear.



Optical Telescope - A telescope which collects visible radiation to form images of celestial objects.

Parabolic Antenna - A radio telescope. Parabolic describes the "bowl" shape of the collecting surface of this type of telescope.



Radiation - Energy which is emitted or reflected by celestial objects.

Radio Telescope - A telescope which collects radio waves from celestial objects.

Resolving Power - The extent to which a telescope is able to separate fine details from the radiation of a celestial object.

Previewing

Describe and demonstrate the concept of light-gathering power. Shine a flashlight from a distance of fifteen inches onto two hand lenses of different sizes. Ask students to pick out the lens which is receiving more light. Discuss the significance of light-gathering ability to the optical telescope.

Describe the resolving power of an optical telescope. If available, compare pictures of binary stars, one which shows them as a combined star and one which shows them clearly separated.

Demonstrate a parabolic curve. A parabolic curved reflector is located in a flashlight. A large six volt flashlight works best for demonstration purposes. Show students the reflector and ask them to explain its function in the flashlight. Draw a comparison between the parabolic reflector in the flashlight and the parabolic curve of a radio antenna.

Review the differences in wavelength between visible light radiation and radio waves. Compare these wavelengths with the size requirements of optical and radio telescopes.

Describe an interferometer and explain how it is used in radio astronomy to receive radio waves.

Postviewing

Ask students to describe the purpose of optical and radio telescopes.

Have students explain the importance of the size of an optical telescope with respect to light-gathering and resolving powers.

Ask students to explain why the use of an interferometer is important in radio astronomy.

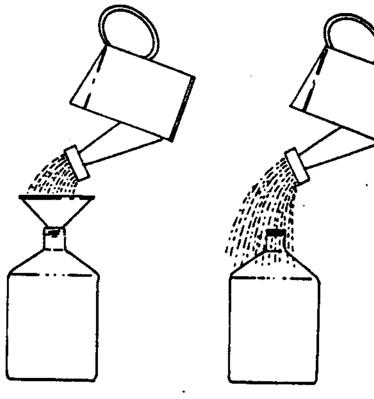
Ask students to describe similarities and differences between optical and radio telescopes.

Discuss some of the observations made by optical and radio telescopes that were described in the program. Have students compare these to HST images that were described in programs one through fifteen.

Active Involvement

Have students research multiple mirror telescopes and compare them to a radio telescope interferometer.

Students can conduct an experiment using the following analogy of light-gathering power. In this analogy, water droplets will represent photons of light. A soda bottle or jar with a small aperture will represent a telescope lens.



Have the students sprinkle water into the bottle or jar with a shower head or watering can for 10 seconds. The students should measure the amount of water gathered and record their findings. Then have the students add a funnel to the bottle or jar. The funnel's aperture must be wider than that of the container. The students should sprinkle water over the funnel for 10 seconds, making certain that the water is evenly distributed over the funnel. Have the students measure the amount of water collected and record their findings. Students will discover that the difference in the amount of water collected by the bott jar aperture and funnel is equal to the square of the aperture. If the diameter of the bottle/jar aperture is on inch and the diameter of the funnel is 4 inches, the fun will have collected 16 times more water. Ask the stude to determine how much more water would be collecte a funnel with a diameter of 8 inches. Ask them how thi analogy relates to light-gathering power. They should reason that the larger the aperture, the more light can gathered.

Telescopes is a computer text and diagram tutorial progr on the optics and properties of astronomical telescope The principles of refraction and reflection as they relat lenses and mirrors are described. Other topics include focus, magnification, light-gathering power, resolving power, and the relative merits and disadvantages of refracting and reflecting telescopes. The mathematics f figuring magnification, light-gathering power, and resolving power are demonstrated. To obtain the catalogue, *Software for Aerospace Education*, which lists th and other computer programs, contact: NASA Office o Educational Technology; Educational Affairs Division; XET; National Aeronautics and Space Administration; Washington, D.C. 20546.

Your class can build an 8" Newtonian reflecting telesco for your school with materials available from a hardwa store and optics that can be mail-ordered. Total cost of telescope and accessories would be approximately $42 A complete description, instructions, list of resources, glossary of terms, and a bibliography are available by contacting Geoff Chester, National Air and Space Muse Room 3356E, Smithsonian Institution, Washington, D.C 20560.

Bibliography

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Chaple, Glenn F., Jr. *Exploring With a Telescope.* New York: Franklin Watts, 1988.

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See for Yourself: Experiments/Projects

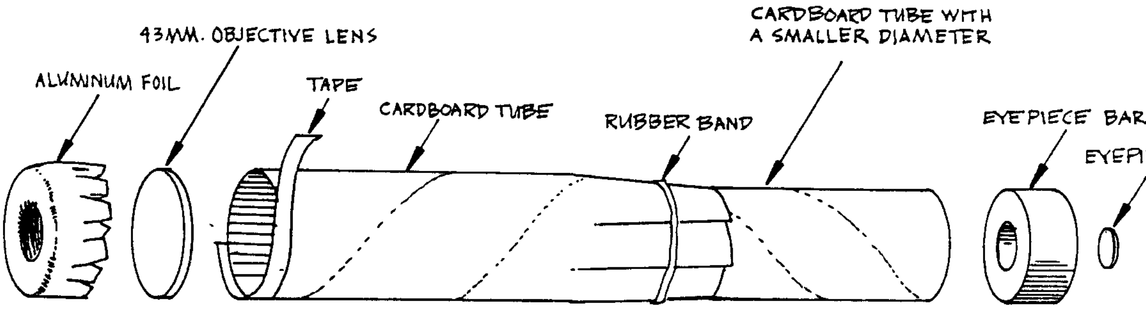
STARFINDER

PROGRAM 16

Building an Optical Telescope*

▶ MATERIALS:

- 43mm objective lens of 400 mm focal length**
- eyepiece lens of 25mm focal length**
- foam rubber ring eyepiece barrel**
- 2 cardboard tubes from paper towels or gift wrapping paper
  The tubes should have slightly different diameters.
- a rubber band
- masking tape
- aluminum foil
- paper and pencil
- compass
- scissors



Adapted with permission from Project STAR, Harvard-Smithsonian Center for Astrophysics.

***Materials are available from Learning Technologies, Dept. T., 59 Walden St., Cambridge, Mass. 02140; 617/547-7724. Sets of plastic lenses and the eyepiece barrel cost $5 each or 10 for $20. Ten cardboard tube kits with lenses cost $30.*

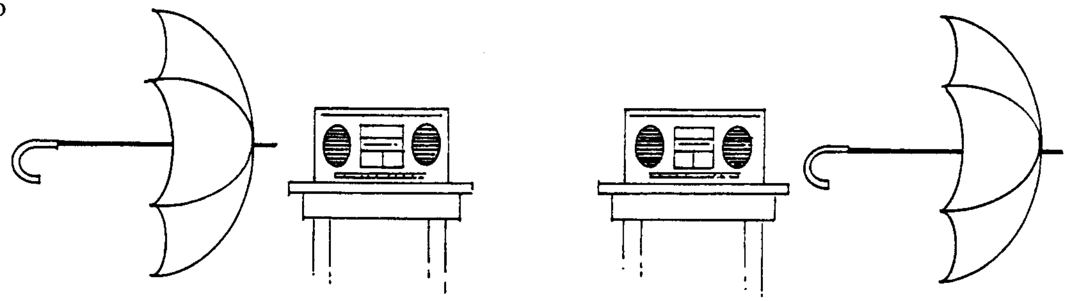
▶ DIRECTIONS:

1. Center the eyepiece lens into the foam rubber ring. The convex side of the lens should face the ring's small hole.
2. Insert the foam ring into the smaller tube so that the edge of the ring is flush with the tube's end.
3. Insert and carefully tape the 43mm objective lens into the larger tube. The convex side of the lens should face out.
4. Cut a few slits into the top of the larger tube.
5. Fit the slitted end of the larger tube over the open end of the smaller tube and place a rubber band over the slitted area to hold the two tubes together. The smaller tube should be able to slide in and out to focus the telescope.
6. Use a compass to trace two circles, one 10mm and one 20mm in diameter onto a piece of paper. Cut out each circle with scissors. Place the circles in the center of two-four inch square pieces of aluminum foil. Carefully trace around each circle, poking out holes in the aluminum foil with a pencil point. The pieces of aluminum foil can now be molded over the front of the telescope whenever there is a need to cut down on the glare of bright objects, such as when viewing the moon or a planet. The foil is also useful in reducing chromatic aberration, a common problem among simple telescopes in which the lens acts like a prism to split light into a rainbow of colors. This gives objects that ar observed a "false color."
7. This simple telescope is similar in many ways to one built and used by Galileo. Try taping it to a photo tri to keep it steady for viewing. The images seen from telescope are upside-down. Why?
8. Aim the telescope at various objects in the night sky Record your observations in a logbook. Look for crat and mountain ranges on the moon.
9. Carefully observe stars and planets. They may look identical through this simple telescope, but there is a way to tell them apart. Make various sightings and record your observations. Next, place the aluminum over the front of the telescope to reduce glare and chromatic aberration. Look for and record any characteristics you notice about the objects sighted. I you discover that an object is very disc-like and does not twinkle with bright rays, you have probably discovered a planet. What characteristics can you rec about the stars that you observe?

Making a Simple "Parabolic" Reflector

▶ MATERIALS:

- umbrella
- aluminum foil (heavy-duty is preferable)
- masking tape
- portable radio



▶ DIRECTIONS

Place the radio on a table. Open and line the inside of the umbrella with aluminum foil. Try to shape the foil so that it is as parabolic (bowl-shaped) as possible. Use masking tape to hold the foil in place. You will use this reflector to receive and to strengthen incoming radio signals.

1. Turn the radio on and tune in to the lowest frequency. Survey and record all of the frequencies of the radio stations heard. Indicate which radio signals are particularly weak.
2. Hold the umbrella's parabolic reflector so that it faces the radio and can focus the incoming signal back to the radio's antenna. Tune in to the weakest stations received and note if there is any improvement to their signals.
3. Survey the stations again and record if any additional stations were picked up when using the parabolic reflector.
4. While receiving a radio signal, turn the umbrella around so that the parabolic reflector is no longer facing the radio. Record any changes in signal strength relative to the different placement of the umbrella.
5. Explain how this simple parabolic reflector is able to receive and strengthen radio signals.

Science Career Profile

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PETER KANDEFER

Amateur Astronomer with observing time on the HST
Education: Associate Degree, Electronics Technology
B.S. and M.S. in Electrical Engineering

What is it like to have a dream come true? Just ask Peter Kandefer. He is one of five amateur astronomers in the United States who have been selected to make observations on the Hubble Space Telescope. To Peter, going from a backyard telescope to the HST is like going from a bicycle to a Porsche automobile. Imagine his excitement when he opened up a thin letter from the Space Telescope Science Institute one day and read, "You have been awarded time..."

Peter Kandefer grew up in Torrington, Connecticut, a town surrounded by coyotes, beavers, deer, and evening skies that are just right for star gazing. As a child in 1957, he saw two bright comets, Mrkos and Arend-Roland, in the night sky. That experience sparked his curiosity about the universe and got him hooked on astronomy. Peter saved all of his money to buy a telescope and learned all that he could by reading as many magazines and books as he could find.

In high school, he developed additional scientific interests. As a freshman, he was fascinated with geology; as a sophomore, it was biology. In his junior year he took an interest in chemistry and as a senior, it was physics. While in high school, Peter took as many math and science courses as he could. After graduation he attended Ward Technical Institute in Harford for two years where he earned his associate degree. Afterwards, he did a short stint in the army in Southeast Asia and then returned home to complete his bachelors and masters degrees in electrical engineering at Northeastern University in Boston, Massachusetts.

While pursuing his degrees in electrical engineering, Peter worked full-time and attended classes in the evening. In his spare time, he attended meetings of the Amateur Telescope Makers of Boston, an astronomy club located at the Harvard-Smithsonian Center for Astrophysics. There Peter was exposed to professional astronomers who shared their knowledge and insights with the amateurs.

As Peter's knowledge and interest in astronomy continued to grow, so did the size of the telescope that he chose to use. He started out with a one-inch and graduated to a six-inch in 1966. Currently he uses an eight-inch telescope, a standard for amateurs because of its convenient size and portability. The availability of affordable computer programs in astronomy has enhanced and enriched Peter's interests. With one particular program, he can monitor a portion of the sky all day and get a planetarium view of the skies.

Peter found the idea for his proposal topic that won time on the HST in *Sky and Telescope* magazine. Two paragraphs in an article on Type A peculiar stars described the basic characteristics of the magnetic field of stars. Being an electrical engineer, he understood electromagnetic theory, which is also studied by physicists and astronomers. He decided that he could combine his interests in electrical engineering and astronomy to create a workable project.

Peter developed his idea by reading other magazine articles and books about variable stars. The "variables" are stars which change brightness over a period of days to years. Scientists study varible stars because they provide important clues about how stars evolve over their long cycles.

In his observation, Peter will use the spectroscope to see the "chemical fingerprints" of one star. This will tell him what physical processes there are—temperature, size, and chemical composition of the star itself. Of the 200 billion stars in our galaxy, only 30,000 variable stars have been found. Of those 30,000 stars, only 600 have magnetic fields. Most stars lead a very routine life, they are born out of dust and debris and they die in huge nova or supernova explosions. The variable stars are the key to understanding how all the other stars evolve and go through their various stages and processes.

Peter wants to study the variable stars for two purposes—to determine stellar atmospherics and the size of the star's magnetic field, and to aid in the study of nuclear magnetic fusion, since stars glow through fusion. The project is exciting to Peter because it gives him the opportunity to do pure research. He will be able to relay scientific information to the public and to publish his results in a professional astronomical journal.

To Peter Kandefer, outer space is as close as one's own backyard. Away from city streetlights, several thousand stars can be seen with the unaided eye. Peter believes that anyone can become an amateur astronomer. Even a basic pair of binoculars and a sky chart from an astronomy book will provide many interesting sights. There are also some excellent astronomy magazines which are sold at most bookstores. Through these magazines and a local amateur astronomy club, a novice in astronomy could get acquainted with astronomy and telescopes.

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A production of

MARYLAND STATE DEPARTMENT OF EDUCATION
MARYLAND INSTRUCTIONAL TECHNOLOGY • INTEC

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Major funding provided by

MARTIN MARIETTA

and
U.S. Department of Education

Office of Educational Research and Improvement

Fund for the Improvement and Reform of Schools and Teaching

Dwight D. Eisenhower National Mathematics and Science Program