# Why a SPACE Telescope?

STARFINDER

PROGRAM 3

### Instructional Objectives

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

1. explain the phenomena which distort images of the stars and planets when viewed from land, and
2. describe the benefits of placing a telescope above earth's atmosphere.

### Synopsis

This program explains the atmospheric phenomena that distort the views of even the most powerful earthbound telescopes. Students see how the blanket of gas, dust, and vapor that surrounds the earth blocks most of the electromagnetic radiation, and distorts those waves that do penetrate the atmosphere. Demonstrations and graphics of refraction, scintillation, and scattering help to explain why stars appear to twinkle, and why the sky is blue. The segment ends by stating that in order to avoid these distortions of light, people have placed land-based telescopes as high up as possible. Students are reminded that the HST was deployed in April 1990 so that a sophisticated telescope would be above the atmosphere.

The career of the Chief of the User Support Branch at the Space Telescope Science Institute is highlighted in "The People Behind the HST." The branch chief speaks about some of his interests and former jobs that have led to his position in which he helps support the astronomers selected to use the HST.

### Vocabulary

*Atmosphere* - The layers of gases, dust and vapor that surround a planet.

*Density* - The mass of any substance per unit of volume.

*Electromagnetic Spectrum* - The entire range of electromagnetic energy — gamma rays, x-rays, ultraviolet light, visible light, infrared, and radio waves.

*Refraction* - The bending of a wave of light as it passes from one medium to another. This produces a distortion of how objects appear.

*Scattering* - Occurs when light strikes a particle and those wavelengths of light smaller than the particle are reflected by it.

*Scintillation* - The reason the stars appear to twinkle. Light waves are refracted by different atmospheric densities at different angles as they pass through a series of moving pockets of air.

*Wavelengths* - The distance between the crests of electromagnetic waves.

### Previewing

Place a pencil or spoon in a glass of water. Have students discuss what they see. It will appear larger and bent because light travels faster through air than through water. This phenomenon causes light to bend when passing from one medium to another.

Ask students if they have noticed the stars twinkling. Do they think that the stars really twinkle? Why?

Discuss with students visible proof that the atmosphere is not empty. Remind them of seeing dust in sunlight or show pictures of the distinct beams of sunlight seen on cloudy days.

### Postviewing

Discuss the latest information received from the Hubble Space Telescope. Discuss HST's position above earth's atmosphere and the obvious advantages.

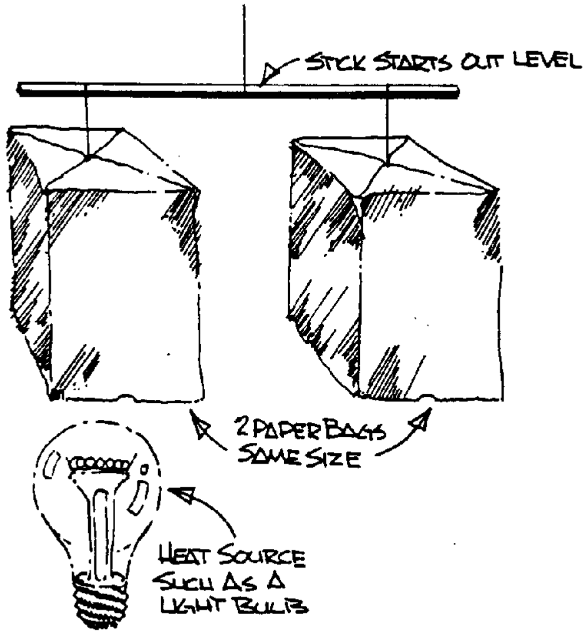
Discuss again the twinkling stars. Some students may want to write a parody of "Twinkle, Twinkle Little Star."

Research some large earthbound telescopes. How have scientists tried to avoid atmospheric distortion?

Discuss with the class the fact that the atmosphere acts as a protective shield from harmful radiation.

## Active Involvement

Hang two inverted paper bags from a stick that hangs from a string tied around the middle (see diagram). The stick should be level. Place a heat source, such as an electric light, under one bag until that bag begins to rise. Use this to lead into a discussion on convection currents in the atmosphere. How do these moving air currents affect earthbound observations of the stars?




Ask students a riddle. Who has seen the sun after it has sunk below the horizon? Actually, we all do this every day because of the refraction of the sun's light through the atmosphere. To illustrate this point, place a coin or similar object in an empty cup. Have several students stand where their views of the coin are just barely obstructed by the side of the cup. Have another student slowly pour water into the bowl. Can they see the coin? Discuss how this phenomenon explains why we see the sun after it has set, and how it affects our view of the stars.

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For middle school readers:

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## Videocassette

The Living Planet Series. "The Community of the Skies." BBC/ Time-Life Video Films, 1984.

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# See for Yourself: Experiments/Projects

STARFINDER

PROGRAM 3

## Making a Nigrometer to Measure the Thickness of the Atmosphere

### ▶MATERIALS:

- one cardboard tube, about 20" long
- lids for each end, one with 1/4" hole, one with 1/16" hole
- black construction paper
- small piece of glass, about 1" X 3" - 4", blackened on one side from the soot of a match flame

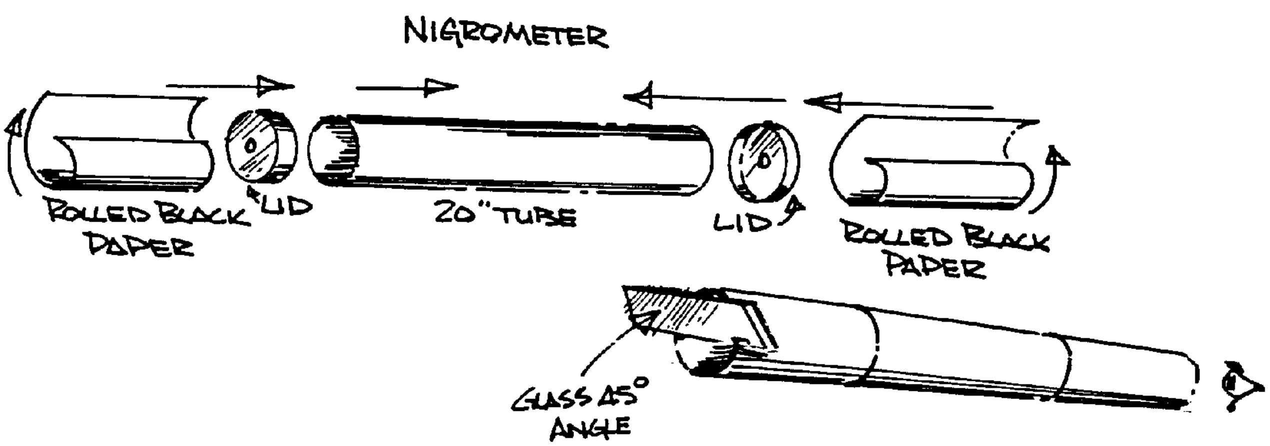
### ▶DIRECTIONS:

To assemble the nigrometer, first punch a 1/4" hole in one lid and a 1/16" hole in the other. Place rolled black paper around both ends, extending a few inches beyond the lids. Holding the end with the smaller hole towards your eye, you are now ready to make your first observation.

1. Look around through the nigrometer. Do you see any colors in the light entering the instrument? Record what you see.
2. Now aim the nigrometer about 60° away from the sun towards as dark a background as possible (the darkened window of a building works well). The light should appear very blue. You are viewing air that lies directly between you and the dark background at which you are pointing. Measure your distance from the dark background and record what you see.

   As you move farther away from the background, the light becomes bluer because the column of air between you and the background object is longer, therefore scattering more light. Move farther away. Measure and record the distance and record what you have observed.
3. Now make a slot in the black paper so that the piece of blackened glass can be inserted at a 45° angle, covering half of the field of view. When you look through the instrument, you should see scattered blue light in the bottom half and the reflection of the blue sky in the upper half. Draw what you see in each half and label.
4. Point the nigrometer at the darkened background again. Adjust your distance from the background until the brightness of the bottom half equals the brightness of the top half. This lets you compare the intensity of light scattered by the entire atmosphere with that of a specific column of air. Now you are ready to determine the distance of the atmosphere directly overhead.
5. Measure your distance to the black background at which you've been pointing. Record.
6. Glass only reflects about 1/20th of the light of the sky. Therefore, the reflected light you are actually receiving from the glass is about 1/20th the light of the sky, and you must adjust your calculations. Multiply the distance measured in #5 by 20. Record. This is the atmospheric thickness at your location.

   The actual distance of measurable atmosphere is approximately 5 1/2 miles at sea level, so if your school is one mile above sea level, and your calculations result in 4 1/2 miles of atmospheric density over your head, your calculations are right on target! But remember, the amount of dust and vapor in the air will affect your results, so coming within a mile is pretty good.



## Creating Blue Skies

▶ MATERIALS:

- 2 clear glasses filled with water
- sliver of soap (do not use detergent)
- flashlight
- aluminum foil
- nail
- milk
- salt or sugar

▶ DIRECTIONS:

Wrap a strip of foil around the end of a flashlight. To make a concentrated beam of light, poke a hole in the end of the foil with a nail.

Dissolve a tiny sliver of soap into one glass of water, and wait for the water to become completely clear.

1. In a darkened room, shine the beam of light horizontally through the glass of plain water. Record what you see.
2. Now shine the beam of light near the surface of the glass with the dissolved soap. Record what you see. The light should be blue much like the blue light of the sky.
3. Dissolve salt into the glass of plain water and repeat the experiment. Record your observation. Compare these results with those of the plain glass of water and the water with soap.
4. Repeat this experiment with other substances. Before shining the light, record your predictions of what the results will be. Record results. Compare and contrast the results of different solutions.

# Science Career Profile

**BRUCE GILLESPIE**
Chief, User Support Branch
Space Telescope Science Institute
Education: B.S. Physics
B.S. Astronomy
Graduate work in Optical Sciences

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## Chief Responsibilities

As the manager of the User Support Branch, Bruce Gillespie is responsible for smoothing the way for those astronomers wishing to use the Hubble Space Telescope. Because the computer and engineering processes can make HST a very complicated telescope to use, the User Support Branch is there to help the astronomers, or users, in their work. One of Bruce's goals is to make the process of observing with the HST similar to the process of observing from the ground, partly because of astronomers' familiarity with ground-based telescopes.

Bruce and the User Support Branch provide the technical information about the HST to professional astronomers. First, he must let astronomers know about the opportunities to use the telescope. Then, because there are so many more astronomers who want to use the HST than there is time available, his branch helps with the process that chooses the actual users.

Bruce then provides technical support to the selected astronomers. He helps them prepare their detailed science programs in the specific computer language that will communicate with the telescope.

Many of the astronomers come from great distances to use the telescope. Once they get to the Space Telescope Science Institute in Baltimore, Maryland, they will need many things and a lot of information to help them get settled. Bruce and his department are the central point of contact for the users. They not only help users work on their project, they help them meet the people they will need to work with, find supplies, get needed tools, even help them get a parking space.

The astronomers generally know what it is they want to do. Bruce's job is to help them find out how to do it.

## A Typical Day

Bruce must oversee the flow of information and problem solving in order to help astronomers to see scientific ideas turn into scientific data. Over half of his day is spent on details, each taking less than an hour to study and solve.

Throughout the day, Bruce interacts and deals with people. He must meet with members of his own staff, other workers at the Science Institute, and astronomers who either want to use the HST or who have already been granted observing time. He may meet with astronomers who have used the HST to make sure the Science Institute's support has been satisfactory.

Part of his day is spent writing letters and reports, reading documents, or catching up on his electronic mail. He must try to know enough about what is happening at the Science Institute in general so that even if he can't find the solution to a problem, he will know who to go to for information or help.

The remainder of the day is spent making long range plans and placing the details of his day into the larger scope of his job.

## Career Viewpoint

Although it is not often done, Bruce has proven that one can be a productive member of the astronomy community without getting a Ph.D. He has spent almost twenty years working in the administration and operations of large ground-based and space observatories.

No matter what the circumstances, Bruce feels that you can find a "yes, it can be done" answer if you work at it. Don't waste time thinking about the reasons why something can't be done; rather look for the action that beats the problem.

Part of the pleasure of Bruce's job is in providing personalized help to astronomers and staff, while getting to know them over an extended period of time. He also enjoys his "behind the scenes" contribution to important research programs. While the credit for major discoveries belongs to the scientists conducting the research, people like Bruce who support the scientists also can feel pride, knowing the part they played.

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