

BRINGING IT CLOSER



**A Science Module Designed for Third – Sixth
Students Grade Students about Telescopes and How
They Work**

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Topic of the Module

Believe it or not, we can see most of the planets in our solar system using the unaided eye. When we observe the planets, most of us can not tell any of the planets' features, like its color, composition, or relative size but just see the planets as points of light. This module gives students an opportunity to bring objects closer by using a refracting telescope, much like the one Galileo used. Students will discover how reflecting and refracting telescopes work; the parts of a refracting telescope, and enhance their skill of observation.

Goal of the Module

The goal of this module is for students to gain an understanding how a telescope works and why scientists use them to explore the universe by *BRINGING IT CLOSER*.

Targeted Grade Level

This module is designed for students from grades three to six. Listed below are some specific strategies for each grade level, which reflect the California Science Standards.

3rd Grade-Using the California Science Content Standards, focus on the concepts that telescopes magnify the appearance of distant objects in the sky, including the Moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than the number that can be seen by the unaided eye.

4th Grade- Using the California Science Content Standards, focus on the concepts, regarding the difference from inference (interpretation) and understand scientists' explanations come partly from what they observe and partly from how they interpret their observations. Measure and estimate the focal length.

5th Grade- Using the California Science Content Standards, focus on the concepts, of recording data by using appropriate graphic representations (including charts, graphs, and labeled diagrams) and make inferences based on those data. Write a report of an investigation that includes conducting tests, collecting data or examining evidence, and drawing conclusions.

6th Grade- Using the California Science Content Standards, focus on the concepts of developing a hypothesis and communicate the steps and results from an investigation in written reports and oral presentations.

Objectives (General)

At the end of the lesson, all students will attain the knowledge and skills indicated in the following objectives.

1. Students will explain the difference between refraction and reflection.
2. Students will determine the difference between using an aided and unaided eye to observe.
3. Students will explain that observations are made with all senses.
4. Students will be able to identify the parts of a refracting telescope. Students will assemble the tube, objective lens (aperture = diameter), and eyepiece (allows you to change magnification) so that they can make observations.
5. Students will demonstrate how to capture an image using a magnifying glass onto a sheet of paper. Students will be able to explain why the image appears upside when capturing an image using a magnifying glass.

Objectives (Specific)

At the end of the activities, students will also attain the knowledge and skills indicated in the following objectives.

3rd Grade

1. Students will be able to explain why telescopes magnify the appearance of some distant objects in the sky, such as the Moon and the planets.
2. Students will be able to explain why the number of stars that can be seen through telescopes is dramatically greater than the number of stars that can be seen by the unaided eye.

4th Grade

1. Students will describe that the difference from inference (interpretation) and understand scientists' explanations come partly from what they observe and partly from how they interpret their observations.
2. Students will be able to measure and estimate the focal length of a telescope.

5th Grade

1. Students will be able to construct charts and graphs and labeled diagrams.
2. Students will be able to make inferences based on the data collected.
3. Students will demonstrate how to record data by using appropriate graphic representations. Students will demonstrate how to write a report of an investigation that includes conducting tests, collecting data or examining evidence, and drawing conclusions.

6th Grade

1. Students will demonstrate how to develop a hypothesis and communicate the steps and results from an investigation in written reports and oral presentations.

Time Needed

Two class periods of one hour each.

Day 1: How to observe objects; Reflection and Refraction; How Telescopes work; Parts of a refracting telescope.

Day 2: Determining focal length and how to focus a telescope onto an object.

California Science Standards

California Science Standards for Grade 3:

Earth Sciences

4. Objects in the sky move in regular and predictable patterns. As a basis for understanding this concept:

- c. Students know telescopes magnify the appearance of some distant objects in the sky, including the Moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than the number that can be seen by the unaided eye.

California Science Standards for Grade 4:

Investigation and Experimentation

6. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- a. Differentiate observation from inference (interpretation) and know scientists' explanations come partly from what they observe and partly from how they interpret their observations.
- b. Measure and estimate the weight, length, or volume of objects.

California Science Standards for Grade 5:

Investigation and Experimentation

6. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagrams) and make inferences based on those data.
- i. Write a report of an investigation that includes conducting tests, collecting data or examining evidence, and drawing conclusions.

California Science Standards for Grade 6: **Investigation and Experimentation**

7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.

Students will:

- c. Communicate the steps and results from an investigation in written reports and oral presentations.

Pre-Requisite Skills and Knowledge

To ensure that all students will be successful, the students should be competent in the following skills.

1. How to use a dictionary.
2. How to use an atlas and encyclopedia.
3. How to use a ruler in English Measurements (i.e. inches)
4. The five senses (see, hear, smell, taste, and touch).
5. Appropriate capitalization of proper and improper nouns.

Materials Needed

Materials are indicated before each activity.

Glossary

The following vocabulary words should be addressed before completion of the module. Have the students look up the following words in the dictionary and, with a partner, explain the meaning of each word. Discuss the base words for some of the vocabulary words. For example, the base word for observation is observe.

1. **Optical telescopes**-magnify distant objects by using lenses or mirrors to refract (bend) light rays so they focus (come together).
2. **Observation**-To see, watch, perceive, or notice.
3. **Naked Eye**-Using your own eye without the help of an aid.
4. **Aided Eye**-Using mediums such as glasses or telescopes to assist in the observation of objects.
5. **Reflection**-A property of light which uses mirrors as it's medium to focus an object.
6. **Refraction**-A property of light that uses lenses as it's medium to focus light.
7. **Magnifies**-To make an object appear larger.
8. **Focus**-A point at which rays of light meet after being reflected or refracted.

Science Content

Have you ever wanted to see something, but it was just too far away? Imagine you are at top of huge Ferris wheel and when you look down to the ground, the people look small. What would happen if you wanted to take their picture? When you look through the camera, the people would actually appear bigger. What might be a possible explanation? In this context, the camera works just a like telescope. The information in this section offers teachers the science content necessary to effectively teach the module - *Bringing It Closer*.

History of Telescopes

The invention of the telescope is often attributed to Hans Lippershey, an optician who, in 1608, aligned two lenses of different curvatures and focal lengths. It is not known how Galileo heard of the process, but there is evidence that Galileo quickly bought or ground a lens and made a simple telescope that he demonstrated in 1610 to the Senate in Venice. He is credited with discovering four of Jupiter's moons, mountains on Earth's moon, phases of Venus, sunspots and Saturn's rings. This telescope that Galileo designed some 400 years ago is very similar to one that elementary school students will be using in this module.

How Telescopes Work

Regardless of the type and complexity, all telescopes work in virtually the same way. Telescopes capture light and provide a detailed image to the viewer. In fact, the human eye and a camera are also telescopes. Radio telescopes work in a similar fashion – they capture radio waves to provide an image to the viewer.

How do telescopes work? Actually telescopes work rather simply. The first lens (or mirror), called the **objective lens (primary mirror)**, collects light from a distant object and brings the light to a point or **focus**. The image is now focused onto a small focal surface that we can not see well without assistance. The second lens, called the **eyepiece**, takes the focused light gathered from the objective lens and magnifies the image. Thus the eyepiece is just a magnifying glass that looks at an image produced by the objective lens. The distance from the objective lens to the point where the image is focused is called the **focal length**.

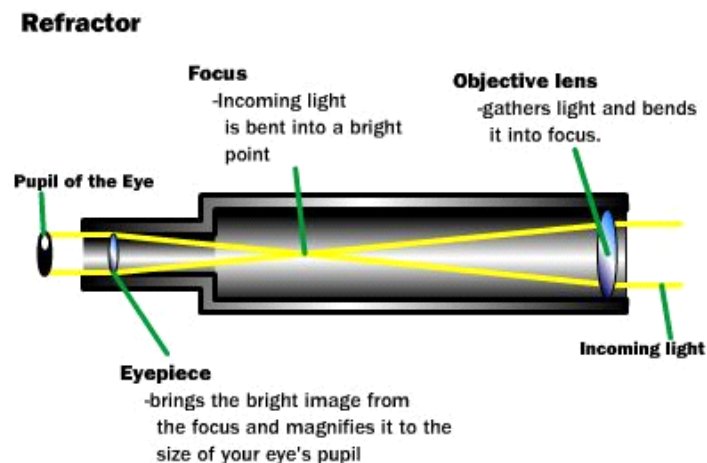
Refracting Telescopes

Refracting telescopes use lenses to capture light and create an image. First, the objective lens captures light from a distant object and brings the light to a focus inside the telescope (see figure below). Then, the eyepiece takes that point of light and creates a magnified

image for the viewer.

Refracting telescopes have three key limitations. First, refracting telescopes do not bring all of the light to the same focus. In this case, different colors of light refract (or bend) by different amounts. So when the light is refracted through the objective lens, different colors reach focus at different distances from the lens. This defect is called chromatic aberration. Second, refracting telescopes have size restrictions. Specifically, a refracting telescope uses lenses that light must pass through. Therefore, the lens must be supported by a frame located around the circumference in order to support the lenses properly. If the weight of the lens is not properly supported, some flexing of the lens occurs. The lens flexure will inhibit the quality of the image to be viewed. And third, the cost to make a lens for a refracting telescope is extremely expensive due to the high cost of manpower needed to polish a lens and the high cost of glass that is almost perfectly pure and uniform.

If refracting telescopes have fair number of disadvantages, why would anyone want to use a refracting telescope? The answer is simple. The key advantage to using a refracting telescope is that this type of telescope works well for an amateur astronomer in small sizes, say 4-inches in diameter and smaller. Small refracting telescopes can be constructed from household items. (Refer to the end of the module for directions for constructing a refracting telescope.)



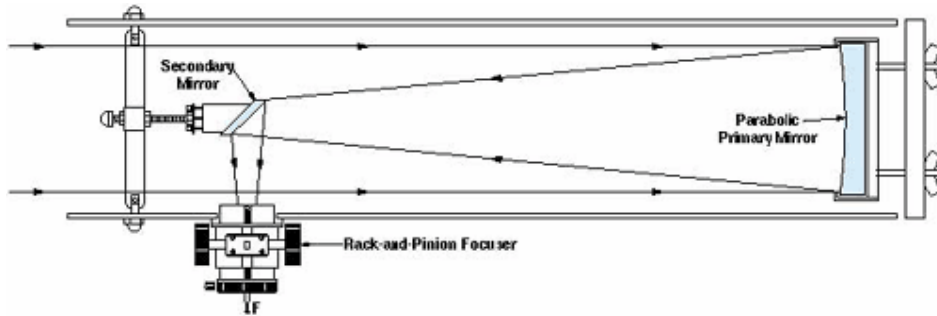
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Reflecting Telescopes

Another type of telescope commonly used by astronomers is the reflecting telescope. Reflecting telescopes use a mirror instead of a lens to collect light from a distant object and provide a detailed image to the viewer. A diagram of a reflecting telescope is presented below. The light from a distant object is collected and concentrated by a curved mirror, called a **primary mirror**. Then the light is directed towards a second mirror, called the **secondary mirror**. Finally, the light is directed to **eyepiece** that allows a person to view a magnified image of the object as before using an eyepiece (not shown in the figure).

Reflecting telescopes have fewer problems than refracting telescopes. In a reflecting

telescope, the mirrors reflect the light more accurately than the lenses do in a refracting telescope. The mirrors in a reflecting telescope are able to be supported on the backside since the light does not pass through the mirror. The mirror of a reflecting telescope has only one side that needs to be accurately machined and polished and which ultimately makes it less expensive to make. So reflecting telescope are often desirable because they are more accurate, easier to support, and less expensive to make or purchase. Virtually all telescopes made for astronomical research for more than a century have been reflectors.



Example of a Reflecting Telescope

What You Can See Through an Amateur Telescope

The astronomical phenomena you can see in the night sky are dependent upon the size of the telescope. The aperture is the term used to denote a telescope's size. The aperture is the diameter of the lens or mirror that determines the amount of light focused by the telescope's optical system. For example, using a 6-inch telescope, one can see almost every type of object in the night sky but only see the brightest objects of a particular type. The moon and planets can be observed through an amateur telescope as well as the brightest nebula (M42 in Orion), clusters (M13, M3) and galaxies (M31 Andromeda). When one observes the night sky from the mountains or desert, the disturbances caused by the city lights are not a factor, providing an optimum environment to view planetary and stellar phenomena. The skies are much clearer and depending on your elevation, the objects in the sky such as the planets and the Moon can be seen in a much clearer view.

The most electronically advanced telescope used by some amateur astronomers, has a built-in Global Positioning System (GPS), so it can align itself up with the stars. It can automatically focus on (or find) any of the 40,000 objects in its database. In addition, these telescopes can be used for film astrophotography and charge-coupled device (CCD) imaging. Many, if not most, of the most beautiful astronomical images produced today are done by amateurs – many from their own back yards.

What is Light?

Since telescopes capture light to provide a detailed image to the viewer, it is helpful to discuss the concept of light. Light is electromagnetic energy composed of **photons** which are the smallest unit of electromagnetic energy. Light comes in different wave lengths and energies. In fact, the shorter the light waves - the higher the energy of the photons and the longer the light wave - the lower the energy of them. Since light comes in different wavelengths different telescopes have been designed to capture a particular part of the spectrum. Follow the description of the light spectrum is a description of each type of telescope.

In the list below, the types of light are presented from longest wavelengths (radio) to short wavelengths (gamma), and representative telescopes that observe at those wavelengths are given. What follows is then a description of those types of telescopes and how they work.

1. **Radio waves** - The 100-m Green bank Telescope in Green Bank, West Virginia is used to study millimeter-wavelength radiation.
2. **Microwaves** - Used to learn about the structure of nearby galaxies, including our own Milky Way
3. **Infrared waves** - NASA's Kuiper Airborne Observatory, an instrumental airplane, carried a 0.9-m telescope aloft. Such infrared observations are especially useful to study gas and dust clouds are space, which cannot be observed as well from the ground.
4. **Visible light waves** - Some examples of telescopes used to capture visible light are your eyes, camera, refracting and reflecting telescopes.
5. **Ultraviolet light waves** - The Hubble Space telescope is the largest telescope ever in space for observing the ultraviolet part of the spectrum (although its primary purpose is to observe at visible wavelengths).
6. **X-ray waves** - The study of the process that brings photons or particles of matter to high energies. Another concentration will be on the formation and evolution of black holes.
7. **Gamma ray waves** - The Compton Gamma-Ray Observatory was built to observe objects in our Milky Way Galaxy and beyond.

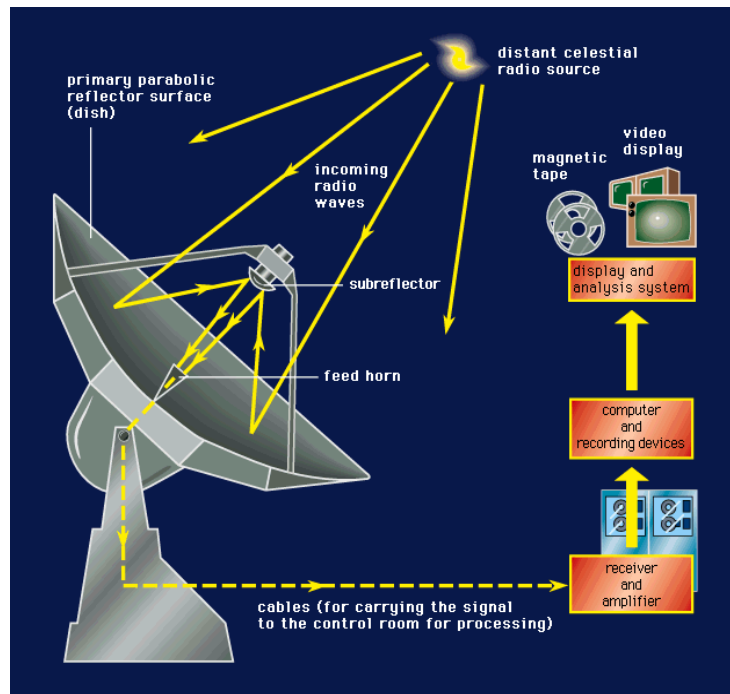
Radio Telescopes

Most radio telescopes function much like a reflecting telescope. The radio telescopes have a large, horseshoe-shaped mount supporting a huge, curved dish that serves as a collecting area. The dish captures cosmic radio waves and reflects them to a focal point. At this focal point, a receiver detects the signals and channels the signals to a computer. The computer provides the viewer with the detailed image of the object being observed.

Radio telescopes also have some limitations. The key problem in the world of radio telescopes is interference from radio stations, military and aeronautical radar, CB radios and cell phones. Interference is a phenomenon that occurs when two type of waves (sound waves, light waves, ocean waves, and seismic waves from earthquakes) meet at the same time and place. In astronomy, **interferometry** is a technique that measures incoming radiation at two different locations and then combines the two signals and an **interferometer** is the instrument used to

determine its measurement.

Georgia State University's Center for High Angular Resolution Astronomy has built a stellar interferometer on Mt. Wilson in Southern California. The array consists of five 1 meter telescopes in a Y-shaped pattern which is positioned in such a way that the maximum separation between telescopes is 350 meters. The arrangement of the five telescopes creates the same resolution as a single telescope 350 meters in diameter and provides images of 0.2 milliarcsec in the visible part of the spectrum. That's how big a dime would appear from the other side of the Earth! This particular interferometer has already provided scientists the opportunity to measure the brightness changes from the center to the limb of several giant stars.



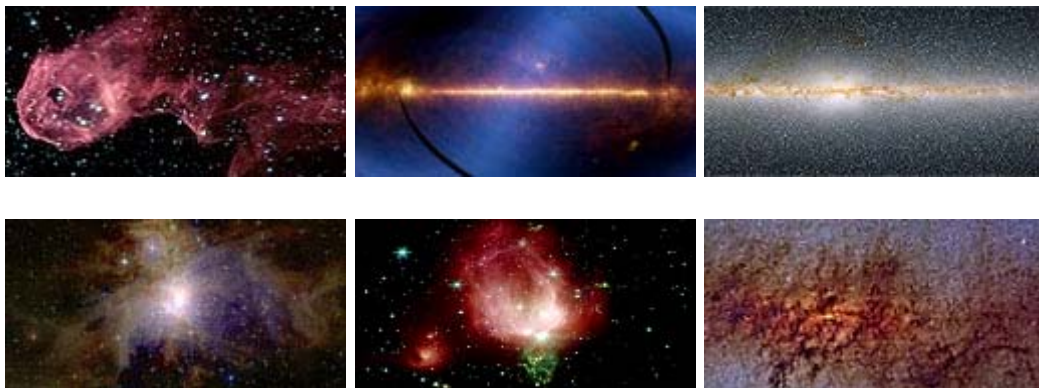
Example of a Radio Telescope

Microwaves Telescopes

Microwave telescopes operate in a similar fashion as radio telescopes. Microwaves have a shorter wavelength than radio telescopes so the telescopes must be built to a smaller scale in order to maintain their accuracy. Microwave telescopes are used to examine the microwave background and have provided astronomers with a tool to examine the Big Bang. Microwave telescopes can actually see the fading glow from the Big Bang. Microwave telescopes can also study the molecular chemistry taking place in interstellar clouds and are used to examine star-formation regions.

Infrared Telescopes

Infrared telescopes are used to examine molecules and star-formation clusters. Infrared telescopes can also be used to examine gases and dust clouds which are difficult to observe from the ground. Even though infrared telescopes can be used from a mountain top location, the optimum infrared telescopes are located in space. Spitzer, an infrared space telescope, was launched to capture images of star-formation clusters and some of these images are presented below. Because room-temperature objects (and you!) glow at infrared wavelengths, these telescopes must be cooled typically to -400F or below to reduce the glow so the faint images of astronomical objects can be captured. Infrared telescopes can see through the dust that litters galaxies and map out and measure the properties of star-forming regions everywhere within them.



Visible Light Telescopes

The largest telescope on Earth is the European Southern Observatory's Very Large Telescope (VLT), located in Chile. This Telescope consists of four 8-meter telescopes that can work independently (one telescope) or in a combined mode (two, three or four telescopes). In a combined mode, the VLT provides the total light collecting power of a 16-meter single telescope, which makes it the largest optical telescope in the world. The four 8-meter telescopes, when supplemented with 3 auxiliary 1-meter telescopes, may also be used in interferometric mode providing high angular resolution imaging. The useful wavelength range extends from the near UV (ultra-violet) up to 25 microns in the infrared.

One of the most popular visual light telescopes is the Hubble Space Telescope (HST). The HST is capable of detecting ultraviolet light but it is best known for the images it obtains from visible light. Even though the building and maintenance costs of the Hubble Space Telescopes have been considerably high, it has produced a substantial number of images from space which had never been captured before. These new discoveries have proved to be extremely useful for astronomers and scientists.

The James Webb Space Telescope (formerly known as the Next Generation Space Telescope) which is the newest visible light telescope will make its debut in 2010.

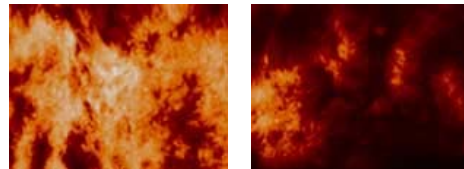


Hubble space Telescope

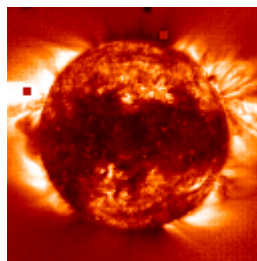


Ultraviolet Telescopes

The space telescope TRACE (Transition Region And Coronal Explorer) was launched in 1998 to take ultraviolet pictures of our sun. Astronomers and scientist are planning to use the images captured by TRACE to address some of the mysteries and phenomena of the Sun which are yet to be answered. Specifically, the ultraviolet pictures from this telescope may advance the discoveries of the how solar weather works. A sample of the solar ultraviolet images captured by the TRACE telescope is below.



Another ultraviolet space telescope, SOHO, continues to offer astronomers additional images of our sun. An image captured from SOHO is presented below.



GALEX is another ultraviolet space telescope that is measuring the radiation from very hot, young stars in distant galaxies.

X-Ray Telescopes

An X-ray telescope is used to capture particular images of compact objects, such as neutron stars, black holes, and hot gasses. X-ray telescopes are also able to record images of very hot gases in excess of 1.8 million °F (1 million °C). Since the earth's atmosphere blocks all x-rays from celestial objects, X-ray telescopes must capture their images from space. Below are some images taken from the X-Ray telescope, Chandra.

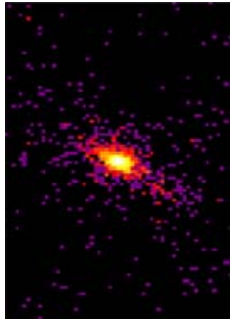
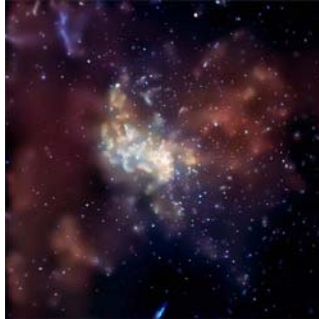


Image of a Galaxy

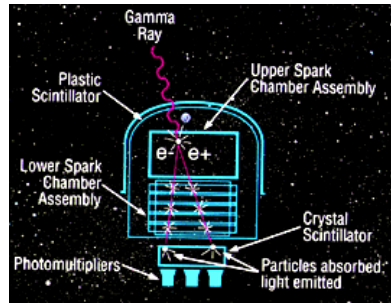


A Giant Star

An X-ray telescope is a telescope that is put into space to detect the X-ray part of the electromagnetic spectrum. X-ray images in space may be produced by very hot gases in excess of 1.8 million °F (1 million °C). The primary reason that X-ray telescopes are put into space is because the energy above earth's surface is much higher than the energy on earth. Also the earth's atmosphere is opaque in the short wave lengths in outer space the X-ray telescope must be placed in space.

Gamma Ray Telescopes

Because of the high energy of gamma rays, most light can not be reflected. In fact, gamma rays pass through most materials. High energy physics has produced some tools that astronomers use to analyze the characteristics of photons. In order to receive a clear signal from gamma rays, interference from other types of rays must be suppressed. Typically, gamma rays deliver a weak signal and require long hours of observations. There are two types of gamma ray telescopes. The first type is called a spectrometer, which separates the light signals into different wavelengths to produce a spectrum. A spectrometer focuses on a specific region of the night sky and collects as many images as possible. The second type of gamma detectors is used to recreate an image. There are some inherent problems in this gamma detector because it must rely on the interactions of the photons to calculate the direction of entry. The detector could also use a device called a coded-mask to reconstruct the image.



Example of a gamma ray detector

Signal Detectors

A telescope captures light and provides a detailed image to the viewer. There are several ways to obtain the images from a telescope.

Film

The camera is a telescope that uses film to capture the image. The objective lens of a telescope collects light from an object. The image is then focused to a point. In a camera film is placed at the location where the image becomes focused. When a photograph is taken in a film camera, the process of snapping the picture is the means used to record (or capture) the image.

Hubble Space Telescope

Taking color pictures with the Hubble Space Telescope is much more complex than taking color pictures with a film camera. The Hubble does not use film at all. Instead, its cameras record light from the universe with special electronic detectors, similar to those found in digital cameras. The detectors produce images of the cosmos not in color, but in shades of black and white. When one sees a color image from the HST, these images are actually combinations of two or more black-and-white exposures to which color has been added during image processing. The colors in Hubble images are assigned by the imaging specialists and may not necessarily be the identical colors that an observer would see if he/she were able to view the imaged objects from a spacecraft. Using color as a tool to enhance an object's detail or to visualize what ordinarily could never be seen by the human eye is a process often used in space photography. Photographs are taken and then recorded on computer disks and then transferred to the earth via radio waves. Each day, the Hubble Space Telescope archives 3 to 5 gigabytes of data and delivers between 10 to 15 gigabytes of images to astronomers and scientists worldwide. This is typical of how all visible and infrared telescopes capture images.

Spectrograph

Astronomers use a spectrograph to take a unique picture of a distant object, called a spectrum. The spectrograph collects all light waves and then it spreads the light into a spectrum. To view the visible light spectrum, use a prism to refract the light into separate wavelengths. Every element from the periodic table has a unique pattern of the spectrum. Astronomers can discover the elements of a particular star or another cosmic object by examining the spectrums of light obtained from telescopes.



Activities and Procedures

Motivation Activity:

Spark your students' interest by asking the following fun fact questions as an introduction to instruction.

Fact

Laika was the first living creature to orbit space. A good-natured, husky-mix stray from the streets of Moscow, thought to be around three years old, she was launched from Earth on November 3, 1957. Her real name was Kudryavka ("Little Curly"), "laika" being the Russian word for "barker." It is not known how long Laika survived, but as of January, 2003, based upon current Russian research, she is thought to have survived for four days.



Laika-first living being in space

Questions to Pose to Students:

- **Why do you think a dog was sent into space before a human?** To ensure that organisms could survive in the environment beyond Earth.
- **Why do you think a dog was sent instead of another animal?** Since the first human space flight did not occur until April 12, 1961 with the one-orbit flight of cosmonaut Yuri Gagarin, stray dogs were used as the living organisms sent into space.

Fact

Stars twinkle because of the distortion caused by the gases and dust particles that make up Earth's atmosphere.

Question to Pose to Students:

- **Do you think stars twinkle when seen from space?** When viewed from space, stars don't twinkle because there are no gases or dust particles to distort their light.



Who invented the telescope?

The invention and introduction of the telescope are attributed to two individuals. Ask your students to research these two individuals, and if appropriate, have them write a paper and present an oral report on the scientists.

Fact

Though he probably wasn't the first to invent it, Dutch eyeglass maker **Hans Lippershey** (1570?–1619) is credited for putting two lenses on either end of a tube in 1608 and creating a “spyglass.” (Even then, it wasn't Lippershey but his children who discovered that the double lenses made a nearby weathervane look bigger.)

The first person to turn a spyglass toward the sky was an Italian mathematician and professor named **Galileo Galilei** (1564-1642). Galileo, who heard about the Dutch spyglass and began making his own, realized right away how useful the device could be to armies and sailors. As he made better and better refracting telescopes (as they were later named) Galileo decided to point one at the Moon.



Galileo Galilei



Hans Lippershey



Part I: Observation and Parts of a Telescope

Because distances in space are so great, scientists use instruments to study what is beyond Earth's atmosphere. In this investigation, you will learn what observation is and make an inference which lens to look through to bring an object of distance closer and larger in size.

ACTIVITY #1

Objective: Understanding what observation is and how to infer information from the data observed.

Materials Needed

- Telescopes. (See Resources where to purchase telescopes). * (If you do not or cannot afford telescopes, refer to Activity Procedure at the end of this module on how to build them using simple household products).
- Overhead transparency of a picture relating to the Solar System where students can observe three different observations about the picture (See last page of this module titled transparency).
- Overhead Projector. (You can also construct a slide using Power Point if computers are available).
- Pen and Paper
- Dictionaries

Procedures

Ask students to use their dictionary to look up the word observe.

Pose questions such as:

1. What did you observe about the moon last night?
2. What do you observe about the second hand on the clock?
3. Or, any question that requires the students to use any of their five senses and comment on an observation.

Then, using your transparency or power point slide, ask the students to make three observations about the picture and write them down. Allow them about three minutes to observe the picture. Students can work in pairs if this strategy works better for the student. Ask the students to share their observations with the class.

Parts of a refracting telescope



1. Sliding cardboard tubes
2. Cap (red)
3. Cardboard washer (white)
4. Foam eyepiece holder (grey)
5. $\frac{1}{2}$ in. spacer (cardboard)
6. Small convex (bulging) lens (eyepiece)
7. Larger slightly convex lens (objective)

Begin the next task by asking the students to form into groups of two (this activity is suitable for group work especially for a larger group such as more than twenty). Tell the students when to do this task before what to do. An example of the dialogue might sound like:

When I say Solar System, I want you to form into groups of two and begin by un-assembling your telescopes. I want you to place the two lenses in one pile, and the other pieces set them aside in a neat pile. You will now have two separate piles for the parts of the telescope.

Ask the students to then take each lens, (careful not to scratch it), and look through each lens at an object in the classroom such as the clock, and record what they observe with the small (eyepiece) lens, and the larger (objective) lens. When they look through the smaller lens, the object that is far away appears larger and closer. When they look through the larger lens at the same object, the object should appear further away and smaller. After the students have had a chance to view the object through each lens, ask them to infer which lens they should look through to observe the stars or the moon. The students should answer the smaller lens.



Part II. Reflection and Refraction

Optical telescopes magnify distant objects by using lenses or mirrors to refract (bend) light rays so they focus (come together). Telescopes “capture” light and bring it to a focus.

The two most common types of optical telescopes are:

1. Reflecting telescopes are optical telescopes that refract light rays by reflecting them off curved mirrors.
2. Refracting telescopes are optical telescopes that use lenses to refract the light rays.

ACTIVITY #2

Objectives: After performing this activity, students should be able to see the difference between reflecting and refracting. Noting that with refracting the light is entering through the telescope and coming to a focus point on the dark wall. With reflecting, the student should note that the light is reflecting off the mirror onto the wall coming to a focus.

Materials Needed

- Magnifying glasses of varying powers. (10x, or 4x magnification power)
- Flashlight
- Small mirrors
- Dark Wall (You can use a black poster board if a dark wall is not available)
- Bucket

Introduction to the Activity

Before you begin this activity, ask your students (while holding up a bucket), what a bucket is used for. Varying replies will be to put sand in, to collect water, to put rocks in etc. Explain to the students that like a bucket which is used for collection or gathering, a telescope also captures or gathers light.

Procedures:

To demonstrate the difference between refracting and reflecting, we will use flashlights, magnifying glasses, mirrors, and a dark wall.

To demonstrate refraction (how light bends), take a magnifying glass, the flashlight and shine the flashlight through the magnifying glass onto the dark wall, noting how on the dark wall the light shining through the magnifying glass comes to a focus. This is a demonstration of

refraction. You can also use a pencil and a cup of water to demonstrate how light appears to bend at the air-water surface.

To demonstrate reflection, take the mirror, flashlight, and move to the dark wall. While standing with your back to the wall, take the mirror and shine the flashlight onto the mirror as to enable the light to reflect (bounce) off the mirror onto the dark wall. This is a demonstration of reflection.



Part III. How Does a Refracting Telescope Work?

Refracting telescopes use lenses to form an image for our eyes to view.

ACTIVITY #3

Objectives: After performing this activity, 1. Students will be able to explain focal length and the process of focusing. 2. Students will be able to capture an object's image on the paper and explain why the image is inverted.

Materials Needed

- A small box with small writing on it.
- Telescopes
- Light source (A window is an ideal light source. If no windows are available a flashlight or small lamp can act as a light source)

Procedures

To determine focal length, take a small box and place some sort of amusing message on it (I used **MOM** because upside down it spells **WOW**). Place the box underneath the light source making sure the rest of the room is as dark as possible. If you have a window in your room, place the box by the window, turning off all of the lights. If your room has no windows, place the box underneath the light source. Now turn on the light source if using. Standing at least fifteen feet from the box, point the telescope towards the writing on the box. When you begin, make sure the telescope is not extended. Ask the students; "What do you notice?" The students should notice that one could not see any of the writing on the box. Ask the students to begin to pull the telescope out; they will notice the lettering coming into a focus. The length you need to pull out the telescope to properly focus the lettering is your focal length. The students should notice that the lettering is upside down. Ask students why the image is upside down. To help explain why

the object is upside down, the understanding of light entering through an object is slower than when it travels through the air. The light is bending through the object; therefore, it is just like when we look in a mirror. You are going to see the object as an opposite.



Part IV. Using a Magnifying Glass and Paper to Understand Focal Length

ACTIVITY #4

Objectives: After performing this activity, 1. Students will be able to further explain focal length and the process of focusing. 2. Students will be able to capture an object's image on the paper and further explain why the image is inverted.

Materials Needed

- A Magnifying glass (two different sizes, 2x and 10x)
- Image such as a photograph with people (if window is not available)
- Ruler
- Light source such as a flashlight or small lamp if window is not available
- Pieces of 8 ½ x 11 light colored paper

Procedures

To understand further the concept of focusing and focal length, this exercise compliments activity #2 nicely.

Scenario 1 – With a window. If you have a window at your disposal, look for an object such as a tree, a person, or a plant. Hold the paper about chest height. Take the small magnifying glass (2x), and pointing it towards the object, bring the object into focus onto the paper. Measure the difference from the magnifying glass to the focused object on the paper, this is your focal length. Now using the 10x magnifying glass, follow the same procedure as you did with the small (2x) magnifying glass. Again, measure the distance from the focused object to the magnifying glass. You should see a difference in the distances, the smaller magnifying glass should record a smaller focal length than the larger telescope. Have your students record the varying data they observed and if age appropriate, have them write a written report using the appropriate standards for each grade level.

Scenario 2 – Without a window. If a window is not at your disposal, a flashlight or lamp will also suffice. Using the chosen light source, place an image such as a photograph besides the light source, and using the same procedure as above, focus the image onto the paper.

* *Activity Footnote*



Building Your Own Telescope (Optional)

Materials Needed

- small piece of modeling clay
- 1 thin (eyepiece) lens
- small-diameter cardboard tube
- 1 thick (objective) lens
- large-diameter cardboard tube

Directions

1. Press small pieces of clay to the outside of the thin lens. Then put the lens in one end of the small tube. Use enough clay to hold the lens in place, keeping the lens as straight as possible. Be careful not to smear the middle of the lens with clay.
2. Repeat Step 1 using the thick lens and large tube.
3. Slide the open end of the small tube into the larger tube to make a telescope.
4. Hold your telescope, and look at an object through one lens. Then turn the telescope around, and look through the other lens. Slide the small tube in and out of the large tube until what you see is in focus, or not blurry. How do the objects appear through each lens?

Refracting Telescope Kit

Refracting Telescope Kit

Experiment with each element of a simple 16-power refracting telescope and see how the lenses work when put together without using an optical bench. Galileo's first telescopes lacked precision and clarity. Nevertheless, he made astonishing discoveries with his crude instruments. This simple lab enables students to build a telescope that is similar to Galileo's. Use the telescope and see how it is similar to a pinhole camera view inverted astronomical images estimate the magnification power find the focal length of a lens see how the moon looked to Galileo.

The Kit includes (10 of each unless noted): inner and outer tubes plastic lenses (43mm diameter, objective, 400mm focal length) plastic lenses (17.5mm diameter, 25mm focal length) foam holders, cardboard spacers and washers for the eyepiece lenses red plastic caps 1 set of instructions & activities.

- 1 **PS-04B: Refracting Telescopes (set of 10 bulk) \$45.00**
- 2 **PS-04B/Single: 1 Complete Telescope Kit \$8.00**



Visit www.starlab.com for ordering information.

RESOURCES

Books

Farndon, John, *1000 Facts on Space* (It.), 2002

Davis, Kenneth C., *Don't Know Much About Space*, First Edition.

Harcourt Science Manual, Teacher's Edition, California Edition.

Pasachoff, Jay M., *Astronomy: From The Earth To The Universe*, Sixth Edition, 2002.

Websites

[www.spacecom/science astronomy/astronomy/interferometry-101.html](http://www.spacecom/science_astronomy/astronomy/interferometry-101.html)

www.hao.ucar.edu/public/education/sp/images/hale.html

www.starlab.com

Transparency

