MISSION PLAN

Telescopes as Tools for Astronomers

1. GENERAL

The Mission Team members will begin to understand that telescopes are tools of the astronomer and function as systems, having common elements that gather and focus light from distant sources in the sky, creating images. Telescopes also have elements that allow astronomers to see the focused images and/or to attach cameras or detectors to record the images.

2. LEARNING OBJECTIVES

SUBJECT AREA: Astronomy/Space Science

TASK: The Mission Team members will understand why astronomers need telescopes to examine the universe, what functions telescopes perform, and how they are built.

CONDITIONS: The Mission Team members will be provided diagrams and pictures of different telescopes, example astronomical images, and a kit to build a simple telescope. Observing session to use Mission Team member telescope and see other types of telescopes.

STANDARD:

The Mission Team member will be able to explain

- What are the different parts of a telescope?
- Why are there different kinds of telescopes?
- What is needed to sense or record data from a telescope?
- How do telescopes assist astronomers in making observations of far away objects that appear very faint or small?
- How the telescope was invented and first used for astronomy?

The Mission Team member will be able to build and use a simple telescope to make an astronomical observation.

3. PRESENTATION GUIDE

a. Introduction (5 min)

Good morning/afternoon, I am _____and today we will examine Telescopes as Tools for Astronomers. Today you will learn why astronomers need telescopes, what telescopes do, who invented the telescope and who first used it to study the universe. You will also learn why there are different types of telescopes and what their parts are. We will also build a small telescope for you to use. We plan (weather permitting) to have a star party for you to use your telescope and see other telescopes.

b. Development (30 min)

Why astronomers use telescopes?

Overview

Astronomers use telescopes to study astronomical objects that are at large distances from the earth, which makes them

- Too dim to be seen or detected
- Too small or fuzzy to see details

The telescope was invented by

- Dutch lens maker Hans Lippershay (1608)
- First used by Galileo of Italy to make astronomical observations and made discoveries

Discussion

Hans Lippershey, a spectacle-maker from Holland, is the man that most historians believe invented the telescope. If he was not the actual inventor, he was at least the first person to market it. It is possible that Lippershey stole the invention from two little kids who were playing in his shop with his lenses. The kids saw that when they held two lenses together, the weather vane on a nearby church became larger and distinct. Lippershey then tried that himself, slapped a tube in between the two lenses, and, viola!, a telescope.

Galileo was the first scientist to use telescopes for the study of astronomy. The story is told that Galileo was made aware of a new device apparently from Amsterdam invented by an optician, which allowed objects at a distance to be viewed more easily. Galileo took the idea of the telescope and began to make technological improvements on it. He soon had a device that he could market to politicians and to the merchants of Venice. They were able to see faraway ships at sea approaching the land. Some of these ships might be enemies; telescopes providing advance warning of attack. Other ships were carrying goods for trade. With the help of the telescope, merchants could manipulate the price of commodities and make larger profits off each shipload of goods. The merchants were grateful enough to Galileo that they set him up with a good income and a university chair. Galileo also used his telescope to make many new discoveries about the solar system. He discovered craters on the moon,

phases of Venus, the moons of Jupiter, and sunspots. He used his discoveries to support Copernicus's heliocentric model of the universe.

Begin by displaying any picture of the night sky. Tell the Mission Team members that in this picture there is a small cluster of stars that they have been asked to investigate. You may point to any starry or fuzzy area on the picture or even a blank spot, claiming that as the location of the cluster in question.

Ask: Why is investigating this star cluster going to be difficult? Don't let the group off easy on this question. It may appear small and dim to us. Do we know it is small? It might be very big. Is it really dim, or just far away?

Ask: What is the primary tool that astronomers have available to them to overcome the problems of distance and dimness?

What are telescopes?

Overview

The purpose of a telescope system is to
- Make bright images (most important)
- Resolve details in images
- Make objects look larger (least important)

The functions of the telescope system are
- Find and point at astronomical objects
- Collect lots of light
- Focus the light into an image
- Record or show the image

Telescopes are systems containing
- A primary or objective mirror or lens (to collect and focus light)
- Structures to hold the mirrors and/or lenses in place
- A mount for pointing the telescope and in some cases tracking objects in the sky
- Eyepieces or camera to show or record the image

The three different types of telescopes are:
a. **Refractor** (uses a lens to gather and focus light)
b. **Reflector** (uses a curved mirror to gather and focus light)
c. **Compound** also called catadioptric (uses both a lens and a mirror to gather and focus light)

Discussion

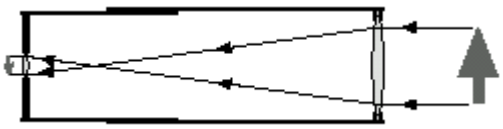
Prior to this lesson, have each Mission Team member bring in a picture of a telescope. Mission Team members should record any information that is readily available about their scope.

A telescope has three general properties:

- How well it can collect the light
- How well it can resolve fine details
- How much it can magnify the image

A telescope's ability to collect light and resolve details is directly related to the diameter of the lens or mirror -- the aperture -- that is used to gather light. Generally, the larger the aperture, the more light the telescope collects and brings to focus, and the brighter and more detailed the final image.

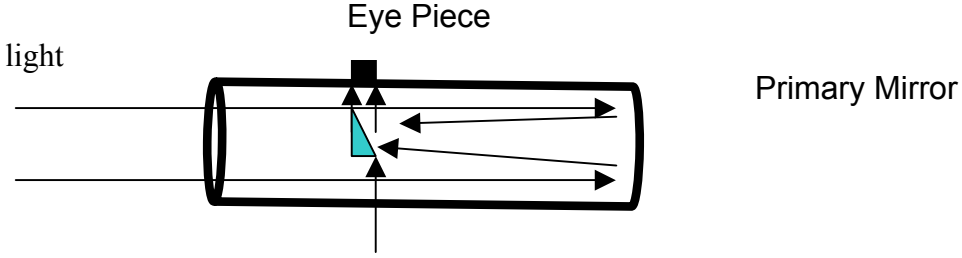
Refractors are the type of telescope that most of us are familiar with. They have the following parts:



A long tube, made of metal, plastic, or wood
A glass combination lens at the front end (objective lens)
A second glass combination lens (eyepiece)

The tube holds the lenses in place at the correct distance from one another. The tube also helps to keeps out dust, moisture and light that would interfere with forming a good image. The objective lens gathers the light, and bends or refracts it to a focus near the back of the tube. The eyepiece brings the image to your eye, and magnifies the image. Eyepieces have much shorter focal lengths than objective lenses.

Isaac Newton developed the **reflector** about 1680. Instead of using a lens to gather light, Newton used a curved, metal mirror (primary mirror) to collect the light and reflect it to a focus. Newton placed the primary mirror in the back of the tube. Because the mirror reflected light back into the tube, he had to use a small, flat mirror (secondary mirror) in the focal path of the primary mirror to deflect the image out through the side of the tube, to the eyepiece; otherwise, his head would get in the way of incoming light. Also, you might think that the secondary mirror would block some of the image, but because it is so small compared to the primary mirror, which is gathering a great deal of light, the smaller mirror will not block the image.



Compound or catadioptric telescopes are hybrid telescopes that have a mix of refractor and reflector elements in their design.

Telescopes must be supported by some type of stand, or mount -- otherwise you would have to hold it all of the time. The telescope mount allows you to:

- Keep the telescope steady
- Point the telescope at the stars or other object (birds)
- Adjust the telescope for the movement of the stars caused by the Earth's rotation
- Free your hands for other activities (focusing, changing eyepieces, note-taking, drawing)

There are two basic types of telescope mounts:

- Alt-azimuth
- Equatorial

The alt-azimuth mount has two axes of rotation, a horizontal axis and a vertical axis. To point the telescope at an object, you rotate it along the horizon (azimuth axis) to the object's horizontal position, and then tilt the telescope, along the altitude axis, to the object's vertical position. This type of mount is simple to use, and is most common in inexpensive telescopes.

The equatorial mount also has two perpendicular axes of rotation -- right ascension and declination. However, instead of being oriented up and down, it is tilted at the same angle as the Earth's axis of rotation. When properly aligned with the Earth's poles, equatorial mounts can allow the telescope to follow the smooth, arc-like motion of a star across the sky.

An eyepiece is the second lens in a refractor, or the only lens in a reflector. Eyepieces come in many optical designs, and consist of one or more lenses in combination -- they are almost like mini-telescopes themselves.

The purposes of the eyepiece are to:

- produce and allow you to change the telescope's magnification
- produce a sharp image

When we look through a telescope with our eyes we can only see the light that is arriving at that moment. A camera is needed to make a permanent record of the observation. Also, for some objects that are very far away there is not enough light for us to be able to see them properly. Cameras work by collecting the light from an object over a much longer time so that it builds up to make a much better and brighter picture. This lets us look at things that are much further away. There are two types of cameras that are used a lot today. These are called charge-coupled devices (digital cameras) and photographic plates (film cameras).

Ask Mission Team members to share their telescope picture. If you have a large group you may want to have small groups share with each other to save time. Ask: Does everyone’s telescope look the same? What do all these telescopes seem to have in common? List parts: mirrors, lenses, tubes, mount, tripod or base of some sort etc. Record all responses on the board or butcher paper.

Ask: Telescopes can look very different but what are the things that we want all telescopes to do? With some luck Mission Team members will at least recognize that telescopes need to make things look brighter and bigger. The amount of direction you give them in uncovering more sophisticated concepts such as resolution is up to your own teaching style and your level of understanding. Record all responses on a piece of butcher paper. Try for some degree for agreement among the group as to what will be put on the list.

One more question: Why do you think there are so many different telescopes? If the class has difficulty you may prompt them with a question such as: Why is there more than one kind of automobile? Come to a consensus about the answer and write it on the butcher paper as well.

Inform the Mission Team members that they will be doing a series of investigations that will allow them to explore the different properties of a telescope that they listed, possibly discover a few more and determine how each effects the image you get. Eventually, they should also have a good understanding about what kind of telescope would be most useful for a particular target.

Important terms

- Aperture describes the size (usually diameter) of primary lens or mirror.
- Focal Length describes the distance from the primary lens or mirror to point or plane of focus.
- Focal Ratio is calculated by dividing the focal length divided by aperture diameter.
- Image is the “picture” created by the optical systems, either detected by a person’s eye at Magnification for purposes of visual observing is calculated by dividing the focal length of the telescope by the focal length of the eyepiece.
- Field of View (FOV) refers to the angular measure of the sky seen by an observer at the eyepiece or captured by a camera.

Mission Team Leader’s notes.

There are several activities that can be conducted as part of this mission. First, Galaxy Explorers can try mirrors and optics to learn about telescopes. Second, mission team members can build simple working refractor telescopes. The cost for the letter activity ranges from two dollars each if home supplies are used to seven dollars each if refractor kits are supplied from Federation of Galaxy Explorers Headquarters. Of course, a Star Party (night viewing event) should be conducted in support of this mission. The Sector Leader will coordinate this event with local astronomers.

An amazing collection of lenses and mirrors can be obtained at little or no cost through creative scrounging. Ask an optometrist or eyewear store if they will save damaged eyeglass lenses for you. Although not of a quality useful for eyewear, these lenses are very suitable for classroom use. Bifocals and trifocals make fascinating magnifying lenses. Aluminized mylar plastic stretched across a wooden frame makes a good front surface plane mirror. A Plexiglas mirror can be bent to make a "funhouse" mirror. Low reflectivity plane mirrors can be made from a sheet glass backed with black paper. Ask the person in charge of audiovisual

equipment at the school to save the lenses from any broken or old projectors that are being discarded. Projector and camera lenses are actually made up of many lenses sandwiched together. Dismantle the lens mounts to obtain several usable lenses. Ask students to try to locate old lenses for study as well as different objects that work like lenses. Check rummage sales and flea markets for binoculars and old camera lenses. A wide assortment of lenses and mirrors are also available for sale from school science supply catalogs and from the following organization:
Optical Society of America
2010 Massachusetts Avenue, NW
Washington, DC 20036
(202) 223-8130

4. **ACTIVITY**

a. Use a variety of objects to investigate lenses and mirrors. The objective is to show how lenses and mirrors can bend and reflect light waves.

Materials
Old eyeglass lenses
Projector lenses
Christmas tree ornament
"Baby moon" hubcap
Soft drink can bottom
Broken optical instruments
Glass flask and water
Clear plastic rods
Styrofoam food trays
Rubber cement

Procedure:
1. Have Mission Team members experiment with the optical properties of old lenses and mirrors and other objects that reflect or bend light.

2. Make a simple and nearly indestructible magnifier glass out of Styrofoam food trays, rubber cement, and old eyeglasses. Cut a three-piece "sandwich" from the Styrofoam tray. The pieces should look like ping pong paddles. Lay a lens in the center of one of the pieces. Cut a hole in the Styrofoam exactly the size of the lens. Cut slightly smaller holes in the other two pieces. Glue the three pieces together with rubber cement.

3. Make a concave mirror by polishing the bottom of an aluminum soft drink can. Obtain polishing compounds from a hardware store. Use the compound and a damp rag to achieve a mirror finish.

4. Fill a spherical glass flask with water to make a lens. Water-filled cylindrical glass or plastic bottles make magnifiers that magnify in one direction only.

5. A grazing-incidence mirror of the kind used for infrared, ultraviolet, and x-ray spacecraft can be simulated with a piece of flexible reflective plastic such as a thin Mylar plastic mirror. Roll the plastic, with its reflective surface inward, into a cone. The small end of the cone should be open so that you can look through it. Point the cone like a telescope and look at a light bulb several meters away. Adjust the shape of the cone to increase the amount of light that reaches your eye.
6. Make crude telescopes by aligning old camera and projector lenses inside a paper tube.

7. Observe the images produced with a silver glass Christmas ornament or a Baby Moon hubcap (available for a few dollars from an auto supply store) Use a baby moon hubcap as a convex mirror. Aim a camera at the reflections on the hubcap to take "fish-eye" pictures.

b. Build a simple telescope using a kit from the Federation of Galaxy Explorers.

5. TRAINING AIDS

- Telescope system for demonstration
- Pictures and diagrams of telescopes
- Star charts and astronomical images
- Overhead projector
- Blackboard or flipchart
- Telescope kit