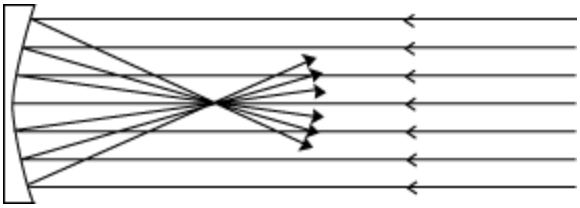
Using a Concave Mirror to focus Radiation

Objective

- Students will demonstrate the ability to explain how different forms of electromagnetic radiation can be focused using a concave mirror, and how HST's mirror functions.

Engage

Ask students why we use telescopes to study the universe. Answers may center on the power of various telescopes and their ability to show distant objects close up. Tell students that while telescopes do give us visually magnified images of distant objects, this isn't really their main function.



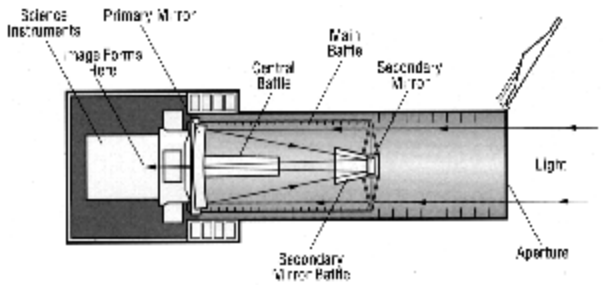
Explore/Explain

Explain that astronomers learn about objects in space by studying and analyzing the radiation that comes to us from these objects. The more radiation an astronomer can collect from an object, the more he or she can learn about that object because radiation is the carrier of information. So, really, astronomers are not as interested in the power of a telescope as in how much visible light and other radiation the telescope can collect and concentrate for study. This amount is usually far greater than can be achieved with the human eye alone. In this Activity, students will be able to calculate how much more radiation the HST can concentrate for study than can their own unaided eyes. They will see how a concave mirror, like that in the HST, focuses or concentrate radiation.

Materials

For use in demonstrations by the teacher:

concave mirror
candle or other small, bright light source
thermometer and/or the heat-sensitive paper
source of Ultra Violet radiation
piece of tracing paper or wax paper
electric space heater
small jar of fluorescent luminous paint or the UV-sensitive beads



Procedure

Sketch on the chalkboard how a concave mirror focuses radiation using a simple ray tracing diagram, as shown above. Explain that the HST's primary mirror is curved like the drawing on the board, and like the demonstration mirror you have acquired for this activity.

Proceed with one or more of the following demonstrations:

1. Focusing Visible Light

Darken the classroom as much as possible. Light the candle or other small, bright source of light and place it several feet away from the mirror. Hold the mirror in one hand and the piece of tracing or wax paper in the other. Adjust the position of the mirror and paper until the candle flame or other light source is focused on the paper for the class to see.

2. Focusing Infrared Radiation

For this demonstration, the classroom can be fully lit. Explain that concave mirrors such as this one, and that on the HST, are also capable of focusing infrared (IR or heat) radiation from objects on Earth and in space, just as they do visible light. At this point produce a safe and handy source of infrared radiation such as an electric heater. Since infrared radiation is invisible to the unaided eye, challenge the students to suggest ways that you can know whether or not the mirror is indeed focusing this radiation from the heater. If a student suggests using the thermometer or heat-sensitive paper, let them go ahead and do the demo for you! If not, produce an answer by holding up the thermometer. Note the general temperature in the room. Then place the heater several feet away from the mirror at the same spot where you had placed the candle in the last demonstration and turn the heater on. After a few minutes, hold the mirror in one hand and the thermometer in the other. Place the thermometer at the same point where you placed the paper in the last demonstration. (Hint: as preparation you may want to have a C-clamp or other stand so that you can precisely mark the place to hold your detector in this and the following demonstration.) Have one or two students read off the temperature. It will rise as the mirror focuses the heater's otherwise invisible infrared radiation at this point in space. To parallel the first demonstration more precisely, use the heat-sensitive paper: it will turn white where the mirror focuses the IR radiation, and then turn colored once more when removed.

3. Focusing Ultraviolet Radiation

Explain that concave mirrors such as the one on the HST are also capable of focusing ultraviolet radiation from objects on Earth and in space. Hole up the ultraviolet lamp for the class to see, plus the UV-sensitive beads or the jar of fluorescent luminescent paint and a small piece of plain paper. Explain that the paint and/or beads contain special chemicals that glow or change color when exposed to ultraviolet radiation. Apply the paint to the paper.

This time, darken the classroom as much as possible, if you use the paint rather than the beads. Turn on the UV lamp and place it in the same position as the candle and heater in the previous demonstrations. Hole the mirror in one hand and place the beads or painted piece of paper at the same place where you placed the tracing or wax paper. Students will begin to observe the beads change color or the paint glow from the concentrated UV radiation. Removing the beads or paper from the focus of the mirror will cause the glow to become reduced or to cease.