Quasar Mirages

Radio Astronomy

Gravitational Lens and Magnifiers

Grade Level:

Time: One 45 minute class period

By

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Objective

Students will be able to describe the way an image is changed by using different types of lenses, and the distortions that can occur.

Prior knowledge

Students should have a basic understanding and prior classroom experience involving
light refraction.

Standards and Benchmarks

Science 5-8

<u>Content Standard 2</u>

<u>Benchmark: </u> design and develop models.

Performance Standard: Develop an understanding that models take many forms and have explanatory power. Choose a concept or process and identify a useful model. Use models to explain the concepts or processes at work and the objectives of the experiment.

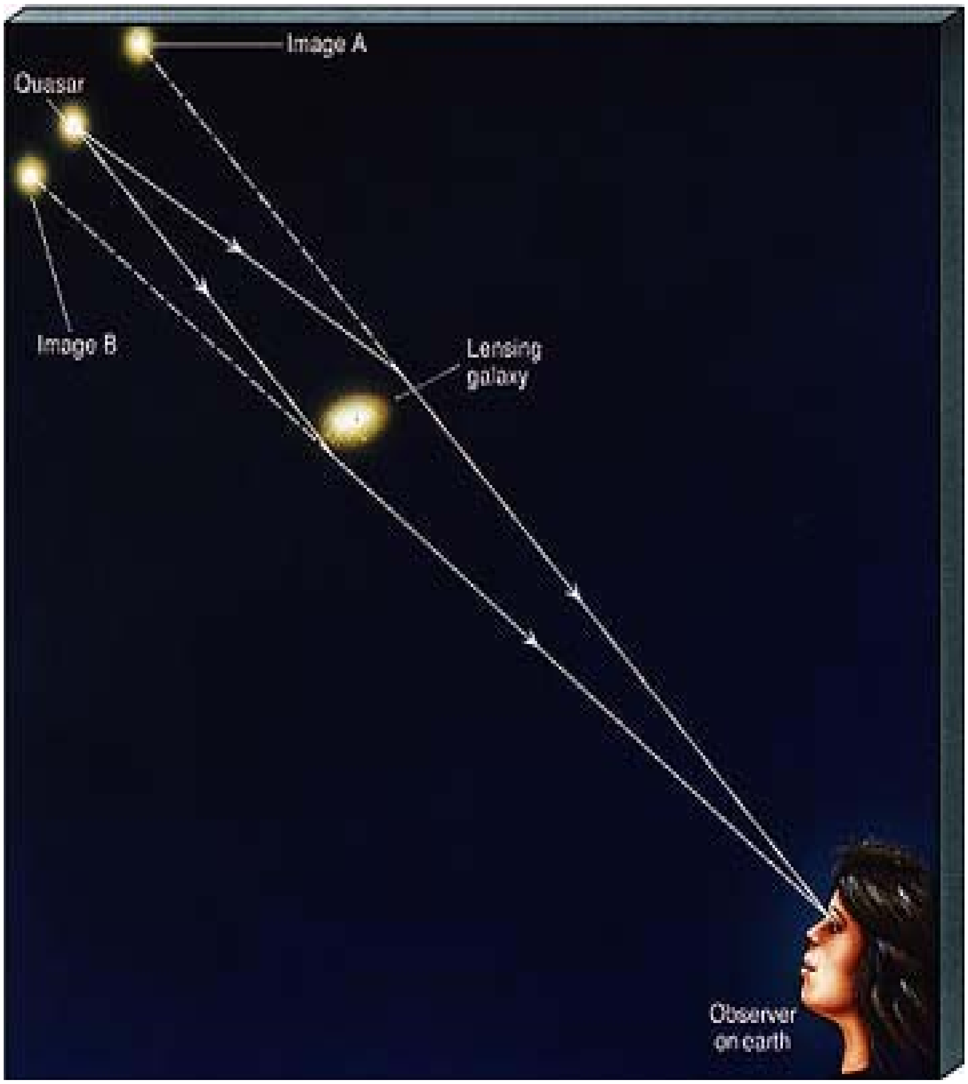
Content Standard 5
Benchmark: Employ equipment, tools, a variety of techniques and information sources to gather, analyze, and interpret data.
Performance Standard: Locate, read, listen to, and view forms of information to interpret and evaluate: organize information in text, tables, and graphs: use methods, forms, and technologies to describe the meaning and implications of information.

Content Standard 13
Benchmark: Describe the elements of the universe including stars, galaxies, dust clouds, and nebulae.
Performance Standard: Describe galaxies, dust clouds, and nebulae.

Background

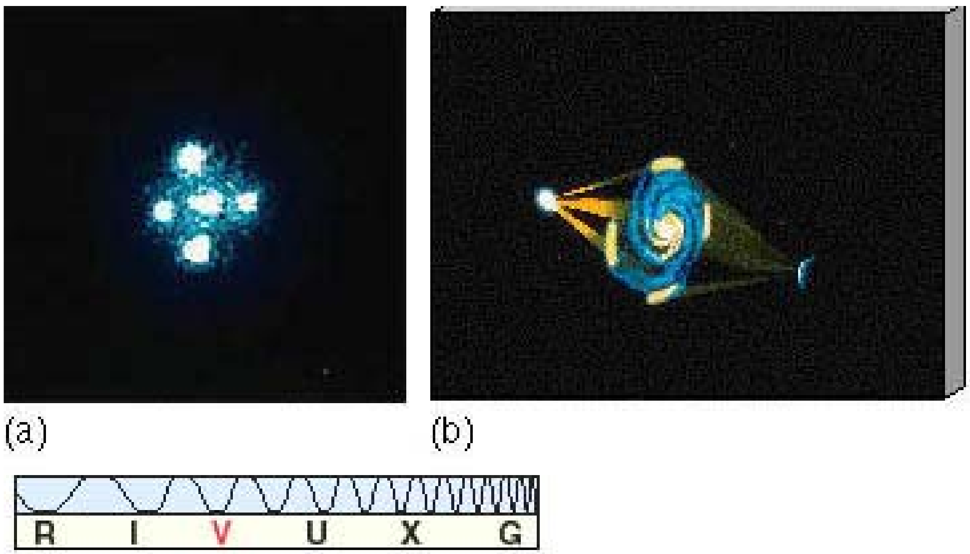
Vocabulary

- gravitational lens: The effect when light from a distant object, such as a galaxy, is bent by the gravity of a massive object, such as another galaxy, before it reaches the Earth.



In 1979, optical astronomers noticed two very similar quasars close together and wondered if they could be the same object. They were right. A galaxy was directly in the path of their view from Earth and it created a warping or distortion of the radiation as it passed through the space around the galaxy. A gravitational lens can also magnify objects so that they appear much brighter than the original source would without the lens. When the alignment of the background object, the lens galaxy, and the

Earth, is not perfect, multiple images can be formed.



- Einstein Ring: The perfect alignment of two distant objects as seen from earth as a ring. Its existence was predicted by Einstein in his theory of General Relativity. A group of scientists at the VLA made an image of a radio-emitting object known as MG1131+0456. It showed an oval structure with bright spots at either end. This was the first proof of an Einstein Ring. Later studies have shown that the object consists of a distant quasar whose light is being bent by the gravitational pull of a galaxy between the Earth and the quasar. The lens effect can create multiple images of background objects and can highly distort and magnify. The distortion and magnification occurs when the galaxy between the Earth and the far object is not perfectly aligned. By long-term monitoring of these lenses, astronomers can measure mass and shape of distant galaxies, and can also measure Hubble's constant (the relationship between a galaxy's speed of recession from Earth and its distance).

- quasar: objects of small angular size and immense power output. Some quasars (quasi-stellar objects or QSOs) are strong radio sources. Radio-emitting quasars were the first to be discovered. These are some of the most distant objects in the Universe, and are believed to be fueled by super massive black holes residing in Ancient galaxies.

Discussion

The goblet refracts light, because as light passes through, it slows down. More bending is apparent with more glass. The goblet is symmetrical as is the point mass, but this is not the case of a gravitational lens. In a regular lens like the ones used in this activity, the image is focused uniformly due to the symmetrical shape of the lens. The image is focused at different points because the lens is not a uniform shape, much like a fun house mirror, which bends and distorts the image depending on the placement of the observer.

Materials/Supplies

1. two clear long stemmed goblets of differing stem lengths
2 two pieces of paper and a black marker for each group
3 student task worksheet (one sheet per group)

Procedures

1. Provide each group of students with a long-stemmed and short stemmed goblet.
2. Read background material orally, then allow plenty of time for discussion and questions.
3. Select groups of 2 or 3 students.
4. Hand out student task sheets.
5. Have students in each group take turns recording data to avoid one student doing all the writing.
6. Encourage discussion between students while their observations are being made.

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Student Task Sheet

Items: One long-stemmed goblet and one shorter stemmed goblet

1. Place a large black dot (about 1 cm in diameter) on two (2) separate pieces of paper. Label the dots "A" and "B," then center each goblet upside down over each dot. View the dots by standing directly over the base of the glass.

2. Describe the image or images of the dots that you see.
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3. Does the image change with the length of goblet stem?
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4. Draw the image that you see standing directly over the center of the base of each glass.

Goblet A   Goblet B

5. Place one of the glasses off-center of the dot. How does this affect the image?

References

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