Telescopes

ASTR 1010

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Overview

In this activity you will explore how the aperture size and focal length influences telescope properties and do basic research on the general properties of a major research.

Objectives

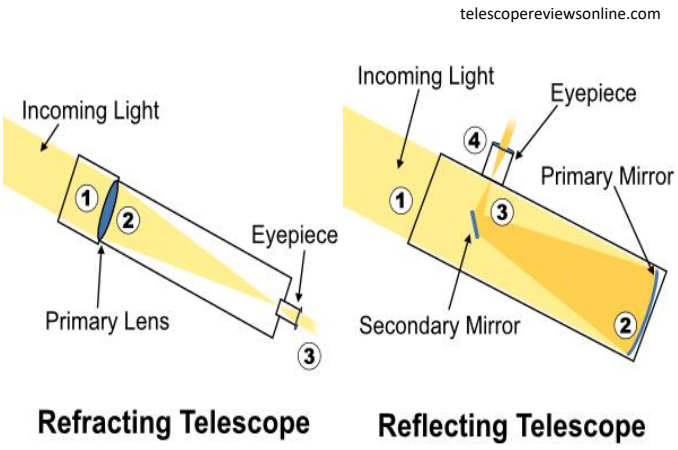
After completing this activity students will be able to:

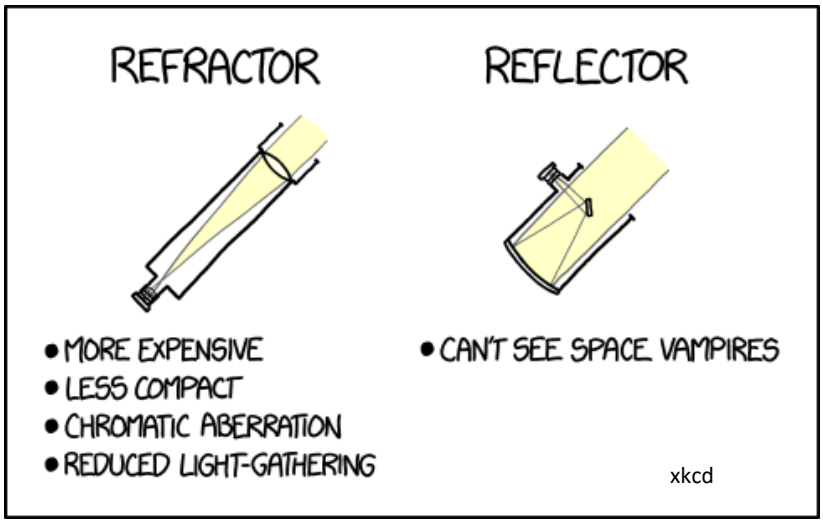
- Describe how telescopes aperture and focal length affect the properties of light gathering ability, angular resolution, magnification, and field of view.
- Select a personal telescope based on how they intend to use the telescope, for example viewing planets or view star clusters and nebulae.
- Investigate and relay information about a major research telescope of their choosing.

Definitions

Here are some terms from lecture that we will be using today in lab:

- **Light Gathering Power (LGP)** – a measure of a telescope's ability to collect light. It is proportional to the area of the primary mirror or lens. The greater the LGP, the fainter objects the telescope can detect.
- **Angular resolution** – how clearly a telescope can resolve small details. The smaller the angular resolution, the smaller the details that can be observed.
- **Magnification** – the process of enlarging the apparent size of an object. In astronomy, magnification depends of the focal length of the objective lens of the telescope (F_o) and the focal length of the eyepiece (F_e).
  Mathematically, $\text{Magnification} = {F_o}/{F_e}$
- **Refracting telescope** – telescopes that use lenses to collect and focus light. The simplest form of this telescope consists of a tube with an objective lens at one end and an eyepiece lens at the other.
- **Reflecting telescope** – telescopes that use mirrors to collect and focus light. The common form of this telescope consists of a primary mirror at the base of the tube which reflects the light to a secondary mirror which reflects the light out to the eyepiece.



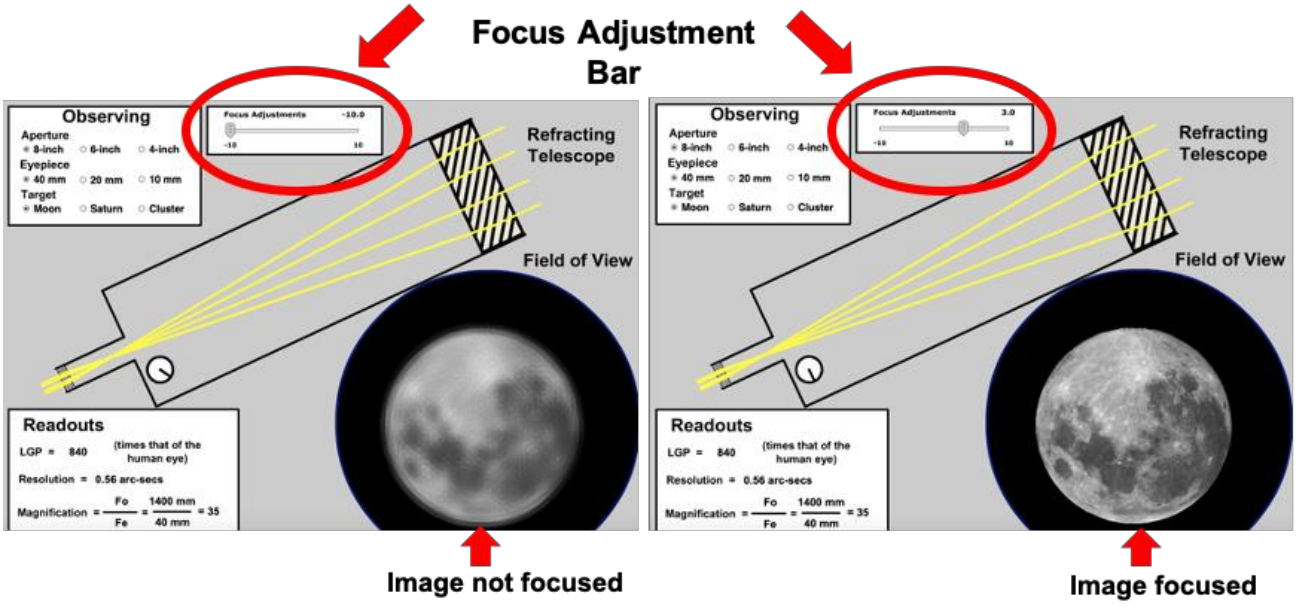


Part 1: Properties of Telescopes

For the first part of this activity, you will be using the Telescopes simulator from the University of Nebraska – Lincoln. The simulator can be found here:

https://astro.unl.edu/classaction/animations/telescopes/telescope10.html

Note. After the simulator opens you may need to use the slide the 'Focus Adjustments' bar at the top center to focus the image. Move the bar until the image in your field of view becomes clear and sharp. See example below!



Light Gathering Power (LGP)

As you may know a large bucket catches more rain than a smaller bucket. Telescopes can be thought of light buckets and so a larger diameter telescope catches more light than a smaller diameter telescope.

Start with the 8-inch diameter (aperture) telescope using a 40mm eyepiece and record the number of light rays entering the telescope and the LGP. Repeat for both the 6-inch and the 4-inch telescopes. Record your answers in Table 1.

Table 1. Light Gathering Power of simulated telescopes

Telescope	8-inch	6-inch	4-inch
Number of rays	4	3	2
LGP	840	475	210

1. Describe how the light gathering ability of these telescope change as the aperture decreases.

As the aperture decreases, the telescope is collecting lesser light, meaning the light gathering ability is proportional to the aperture size.

2. Again, start with the 8-inch telescope and describe how the brightness of the image changes as the telescope aperture gets smaller.

The brightness reduces because as the aperture decreases, so does the amount of light it takes in.

Angular Resolution

Angular resolution refers to how clearly a telescope will show tiny details such as planetary features and stars that are very close together.

Starting with the 8-inch telescope record the angular resolution in arcseconds and record your answers in Table 2.

Table 2. Angular resolution of the simulated telescopes

Telescope	8-inch	6-inch	4-inch
Angular resolution (arcsec)	0.56	0.75	1.12

In the 'Observing' box in the upper left corner of the applet, switch target from 'Moon' to 'Star Cluster'. You will need to refocus using the 'Focus Adjustments' bar.

3. Starting with the 8-inch telescope using a 40mm eyepiece, describe how the clarity of detail visible and the magnification of the image change as you switch to the 6-inch and then the 4-inch telescopes.

Starting with the 8-inch telescope, the image is clear and large enough to see. At 6 inches, the image is a little less clear but seems distant. Finally, at 4inches, the image is not as clear compared to the other two apertures and the image seems

4. Which telescope allows you to see the smallest details in its image?

The telescope with 8-inch aperture, 10mm eyepiece, and -3.3 focus adjustment shows the smallest details in the image (for cluster specifically).

Magnification

The magnification of a telescope depends on the focal length of the objective lens, or mirror, and the focal length of the eyepiece being used to view the image. The magnification of a telescope is calculated using the equation:

$$\text{Magnification} = {}^{F_o}/_{F_e}$$

where F_o is the focal length the objective lens and F_e is the focal length of the eyepiece.

In the 'Observing' box in the upper left corner of the applet, switch target back to 'Moon'. Be sure to refocus the telescope. Starting with the 8-inch telescope and the 40mm eyepiece record the magnification for each of the telescope and eyepiece combinations listed in Table 3.

Table 3. List of magnifications for the telescopes in the simulation

Telescope	Eyepiece focal length (mm)	8-inch	6-inch	4-inch
Magnification	40	35	30	25
	20	70	61	51
	10	140	122	102

5. Which of these telescope and eyepiece combinations provides the highest and lowest magnifications?

Highest: 140 (8-inch (1400mm), 10mm)

Lowest: 25 (4-inch (1020mm), 40mm)

View the Moon and Saturn with each telescope and eyepiece combination, focusing as you switch between telescope and eyepiece combinations.

6. In your opinion, which telescope/eyepiece combination provides the best viewing image of planetary detail?

In my opinion, the combination of 8-inch and 10mm provides the best viewing image with a crisp detail

7. Using the information previously learned about light gathering ability, angular resolution, and magnification justify your selection for the best planetary telescope.

This combination of 8-inch and 10mm is the best for a planetary telescope because it has the highest LGP of 840, best angular resolution of 0.56 arc-secs, and highest magnitude of 140 m—making it the best telescope.

Field of View (FOV)

Every telescope/eyepiece combination has a field of view. This basically means that some combinations provide the ability to see the entire moon or only a piece of the moon. The field of view tells you how much of the sky is viewable in the telescope. Usually, the field of view is expressed as an angle such as degrees.

In the 'Observing' box make sure the target is set to 'Moon'. Starting with the 8-inch telescope and the 40mm eyepiece record the field of view for each of the telescope/eyepiece combination listed in Table 4.

Table 4: Field of view for the telescopes and eyepieces in the simulation

Telescope	Eyepiece focal length (mm)	8-inch	6-inch	4-inch
Field of View (degrees)	40	1.22	1.42	1.76
	20	0.72	0.85	1.02
	10	0.42	0.49	0.58

8. Which of these telescope and eyepiece combinations provides the widest and smallest field of view?

Widest: 4-inch with 40 mm equaling

Smallest: 8-inch with 10 mm equaling

View the star cluster with each telescope and eyepiece combination to confirm which telescope provides the widest and smallest field of view. Don't forget to focus the telescope as needed.

9. Using the information from Tables 3 and 4, how does magnification affect the field of view?

Looking at the field of view and magnification for each combination, it seems that as magnitude increases, the field of view decreases.

Part 2: Scientific Telescopes

For the second part of this activity, you will use the internet to find information about a major research telescope of your choosing. If you don't have a particular telescope in mind, this Wikipedia page is a good place to start:

https://en.wikipedia.org/wiki/Lists_of_telescopes

You can choose a telescope of any wavelength range (radio to gamma rays), any location (whichever continent to space-based) and it can be a currently active telescope or a historical telescope. Choose something that you find interesting!

Note. Please use your own words when relaying information about the telescope you choose.

Please DO NOT copy and paste information!

That falls under Academic Dishonesty and you will receive a zero for this activity. The TAs can read what other people have to say on the internet – we want to know what **YOU** find interesting!

10. What telescope did you choose?

Harlan J. Smith Telescope

11. Where is the telescope located?

McDonald Observatory, Texas, USA

12. What wavelength(s) does the telescope observe? Note. This answer could be a wavelength range or a wavelength category (ex. visible/optical, infrared, X-rays, etc).

The Harlan J. Smith Telescope has a wavelength coverage from 370nm to 1000nm.

13. What are some interesting facts/information about your telescope? This could include things like historical events or important discoveries made by the telescope, instruments on the telescope that do different things, interesting things about who the telescope is named after, were you able to find any cool images taken by the telescope and what were they, etc. **Your answer needs to be a minimum of 50 words.**

- Named after Harlan James Smith (director and American astronomer)
- The telescope was vandalized when a hired worker accidentally fired shorts at the telescope, reducing the telescope ' s size but fortunately didn ' t affect the quality.
- The telescope was used to find a supermassive black hole in the Leo 1 dwarf galaxy.