CRLS Astrophysics Lecture Series

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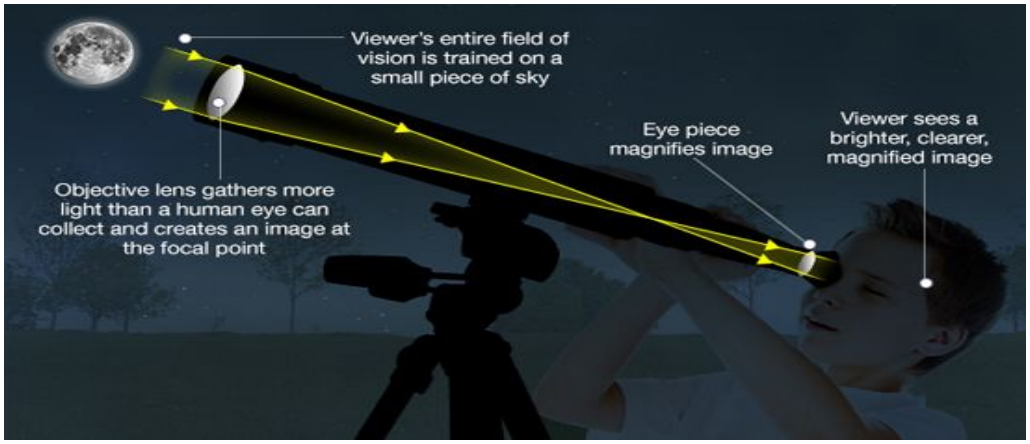
Become an Astronomer

You will make your first astronomical observation. We will gather together at the rooftop of the Harvard-Smithsonian Center for Astrophysics where the 9-inch Clark Telescope is located. You will follow a checklist to prepare the telescope for observation as astronomers do. You will mount the CCD camera and point the telescope at the Moon. You will make a splendid image of your favorite craters on the Moon. In the end, you will follow the checklist to shut down the observatory.

Telescopes

The illustration below shows the simplest telescope design you could have. A big lens gathers the light and directs it to a focal point and a small lens brings the image to your eye.



A telescope is an amazing device that has the ability to make faraway objects appear much closer. Most of the telescopes you see today come in one of two flavors:

- The refractor telescope, which uses glass lenses.
- The reflector telescope, which uses mirrors instead of the lenses.

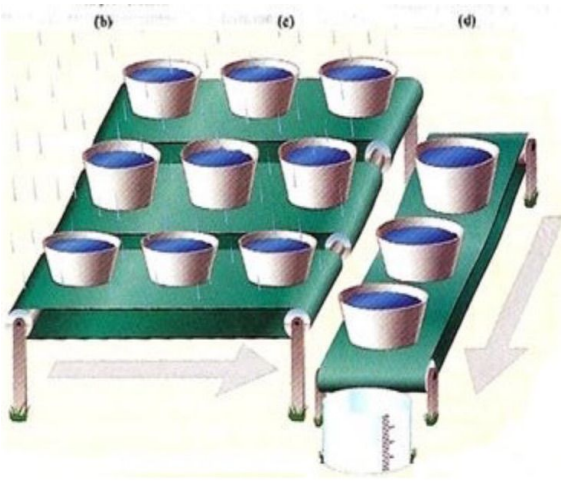
The lens (in refractors) or primary mirror (in reflectors) collects light from a distant object and brings that light, or image, to a point or focus. An eyepiece lens takes the bright light from the focus of the objective lens or primary mirror and "spreads it out" (magnifies it) to take up a large portion of the retina. This is the same principle that a magnifying glass (lens) uses; it takes a small image on the paper and spreads it out over the retina of your eye so that it looks bigger.

A telescope's ability to collect light is directly related to the diameter of the lens or mirror -- the aperture -- that is used to gather the light. Generally, the larger the aperture, the more light the telescope collects and brings to focus, and the brighter the final image. The telescope's magnification, its ability to enlarge an image, depends on the combination of lenses used. The eyepiece performs the magnification. Since any magnification can be achieved by almost any telescope by using different eyepieces, aperture is a more important feature than magnification.

You will perform your observation with the 9-inch Clark Telescope. The checklist you will use to operate the telescope is attached at the end of this guide. Please print it, read it, and bring it with you. **http://hea-www.harvard.edu/~jcm/cfa/tel.pdf**

Materials:
http://www.bbc.co.uk/science/0/20937803
http://science.howstuffworks.com/telescope1.htm

CCD Cameras



Charge coupled devices (CCDs) are sensors used in digital cameras and video cameras to record still and moving images. The CCD captures light and converts it to digital data that is recorded by the camera. CCDs come in a wide variety of sizes and types and are used in many applications from cell phone cameras to high-end scientific applications, such as astronomy and medicine.

The function of a CCD can be visualized as an array of buckets (pixels) collecting rainwater (photons). An number of buckets (pixels) are distributed across a field (focal plane of a telescope) in a square array. The buckets are placed on top of a series of parallel conveyor belts and collect rainfall (photons) across the field. The conveyor belts are initially stationary, while the rain slowly fills the buckets (during the course of the exposure). Once the rain stops (the camera shutter closes) the conveyor belts start turning and transfer the buckets of rain, one by one, to a measuring cylinder (electronic amplifier) at the corner of the field (at the corner of the CCD).

Advantages of CCD cameras:

- record up to 90% of the photons that fall on them,
- are linear over nearly their entire range (double the light, double the counts),
- have high dynamic range (they can record very faint and very bright features at the same time)

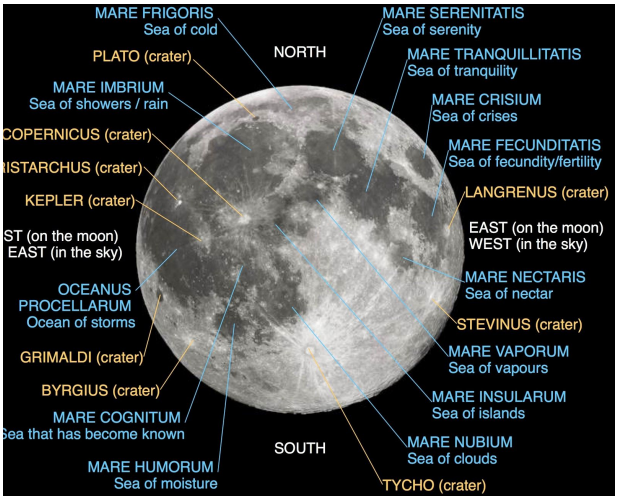
All of the above advantages make CCD cameras perfect for astronomical observations.

The image above shows the type of CCD camera that we will use. Our images will be in ‘fits’ file format. This file format can be viewed and modified using the SAO DS9 software package that is designed to work with astronomical images.

Materials:
DS9: http://ds9.si.edu/site/Home.html
https://en.wikipedia.org/wiki/Charge-coupled_device
http://www.skyandtelescope.com/astronomy-resources/astrophotography-tips/the-abcs-of-ccd-imaging/

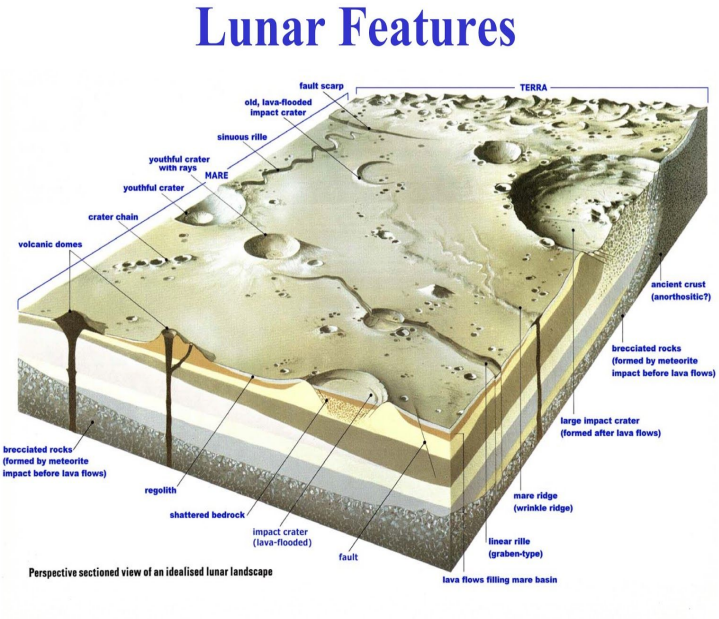
The Moon

"the moon is no maiden, but a scarred and wrinkled crone; she is not white, and she bears no fire."
-- Cecelia Payne-Gaposchkin,
"*Introduction to Astronomy*," 1954



The surface of the Moon is very different from the Earth's surface. There is little or no tectonic movement on the Moon like on the Earth. The Moon's surface has remained the same for billions of years. The following features can be identified on the Moon's surface:

MARE or "SEAS" - These are relatively smooth, dark, and large areas that are filled with lava. The mare formed when craters, which were formed by large asteroid impacts, were filled by lava. Most mare are more than 3 billion years in age. They can be easily seen on the Moon using a telescope from Earth.



MOUNTAINS AND MOUNTAIN RANGES - The Moon's mountains are large, rounded "bumps," which look much like old, eroded mountain ranges on Earth. The Moon's mountains are even older than the mare, dating back as far as 4.4 billion years.

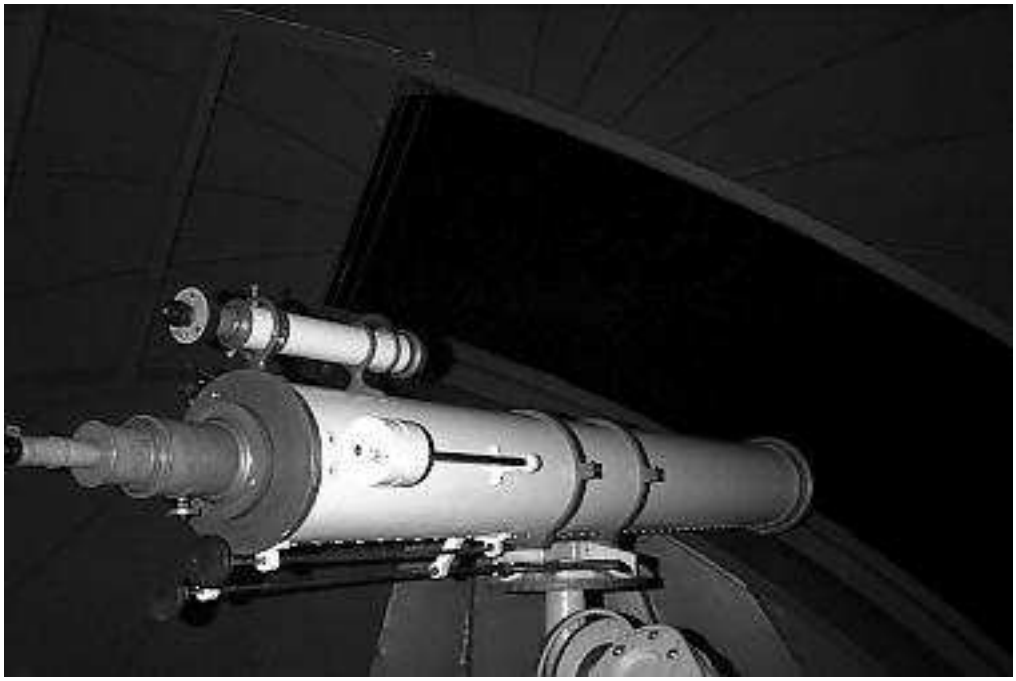
CRATERS - These roughly circular depressions formed when meteoroids struck the Moon at high speeds. The Moon's surface has hundreds of thousands of craters. The craters can be large (hundreds of kilometers) or as small as one meter.

RAYS - Rays are bright streaks of debris that radiate from some large craters. They may be as long as 3000 km.

RILLS - These are cracks in the surface of the Moon, probably produced by movement of the surface similar to faulting on the Earth.

Materials:
https://www.nasa.gov/multimedia/imagegallery/image_feature_2110.html
http://www.phy.olemiss.edu/~luca/astr/Topics-Solar/Moon-N.html
http://cpt.phys.utk.edu/~th/Astro151/Lecture11.pdf
https://www.msnucleus.org/membership/html/k-6/uc/earth/2/uce2_3a.html
https://en.wikipedia.org/wiki/List_of_lunar_features

9-inch Clark Telescope Checklist



- You must be checked out on the telescope by one of the telescope committee. Your CfA entry card will then be able to open the telescope door.
- You may use the standard CfA room reservation form to reserve the telescope.
- Emergency number: Jonathan at 617-447-9618

9-inch Clark Telescope Checklist

STARTUP CHECKLIST

1. Swipe card key in door.

   YOU ARE NOW RESPONSIBLE FOR THE TELESCOPE. If you go home when there are still people there, make one of them (who must have access rights) swipe their card so that they take over responsibility.

2. Lights on. There are two sets of lights, red and white. Each has a switch by the door and a switch on the pier.

3. **BEGIN LOGBOOK** entry. Record your presence in the logbook, giving date and time and number of people present.

4. **DOME ROTATION POWER ON**. Lower dome box on north wall, turn key.

5. **SLIT POWER ON**. Slit Box on dome next to slit; use stairs to reach it, and turn key. Note orange electrical strip around base of dome, and don't stick your fingers in it.

6. **UPPER SLIT OPEN.** Hit top left black button on slit control panel. Yellow light will come on during 3-second delay.

7. **LOWER SLIT OPEN**. Wait till upper slit has moved at least 30 cm. Hit bottom left black button on slit control panel.

8. **ADD EYEPIECE**. The telescope is stored with a film canister in the tube instead of an eyepiece. Use one of the standard eyepieces or bring your own. Turn the clamp to make sure the eyepiece is in tight.

9. **ROTATE DOME.** Rotate dome to correct part of sky, using Dome Box buttons. At least move the dome a little bit, so that any debris (snow, leaves..) falls in before telescope lens is exposed. Before changing direction, use red STOP button and wait for dome to stop moving.

10. **TELESCOPE TO HORIZONTAL.** Rotate telescope to horizontal, making sure you are holding on to it at all times. Telescope should not go below horizontal. Dome should be already open.

    WHENEVER MOVING TELESCOPE:

    - Move it slowly and make sure it is always under full control.
    - Check there are no obstacles in the path of either end of the telescope, like the movable stairs or your friend's head.
    - Don't move it holding the movable part of the eyepiece end as you will lose focus and potentially damage the mechanism.
    - *NEVER NEVER NEVER* under any circumstances touch the main lens.

11. **LENS CAP OFF:** Carefully place stairs at lens cap end; rotate cap and pull; store cap on table.

12. **DRIVE ON.** Turn on telescope drive using small switch on W side of pier. Check that red light comes on. It's fine to move the telescope with the drive on.

13. **FINDER CAP OFF**. Push the lever on the finder scope and rotate finder cap.

You are now ready to observe.

9-inch Clark Telescope Checklist

OBSERVING CHECKLIST

1. Locate object approximately in sky.
2. Move dome to approximate location.
3. Sight along finder and move telescope to approximate location.
4. Locate object with finder and main telescope. We like to 'star-hop' using the finder and a star atlas, starting from a bright star and iterating to your target. It is also possible to use the setting circles to align the telescope on a given RA and Dec. Use a low power eyepiece in the main telescope when searching for your object.
5. Adjust focus using knob on side of tube.
6. Be very careful when changing eyepieces: first remove old eyepiece and store it carefully on the table, then put new eyepiece in and tighten the clamp. Don't try and juggle two eyepieces in your hand at the same time!
7. The clock drive should keep the object centered for a while, but eventually you will need to adjust the pointing, either by very gently moving the whole telescope or by twiddling the slow motion control knobs.
8. IF THE WEATHER DETERIORATES: Close the dome if it looks like it will start raining, or in the presence of very strong winds. Close the dome AT ONCE and shut down the telescope if any precipitation begins.
9. IN CASE OF PROBLEMS: Email Jonathan McDowell (jcm@cfa), David Aguilar (daguilar@cfa) or any other telescope committee member giving details on the problem. If the dome slit will not close due to electrical failure, the telescope should be covered by a tarp. In a major emergency (potential damage to telescope) you can try calling Jonathan at 617-447-9618.

9-inch Clark Telescope Checklist

SHUTDOWN CHECKLIST

1. **DRIVE OFF.**
2. **FINDER CAP ON.**
3. **LENS CAP ON.** Place cap slits over tube pegs and rotate to lock in place.
4. **TELESCOPE VERTICAL**. Stow on W side of pier.
5. **LOWER SLIT CLOSED.** Push lower right button on slit box. Upper slit will not close until lower slit close is complete.
6. **UPPER SLIT CLOSED**. Wait..... ok. Now push upper right button on slit box.
7. **SLIT BOX POWER OFF.** Turn key on upper box.
8. **DOME BOX POWER OFF.** Turn key on lower box. Dome position does not matter.
9. **EYEPIECE STORED**. Remove eyepiece and put in film canister (AKA Anti-Spiders-Device).
10. **LOGBOOK.** Complete logbook entry for the evening, giving closing time. Add at least a sentence describing your evening, and sign entry.
11. **LIGHTS OFF.**
12. **FINAL CHECK.** Did I really, really switch off the drive?
13. **CLOSE DOOR**. Make sure door is firmly locked.