SIERRA COLLEGE OBSERVATIONAL ASTRONOMY LABORATORY EXERCISE
Lab N02: Gearing up for the Sky
NAME **GROUP**

OBJECTIVE:

- Learn about the basic functions of a telescope.
- Learn about how to set up and break down a telescope.
- Learn about eyepieces.
- Learn about objects we will be observing.

INTRODUCTION:

Today we are having a crash course in how to set up and break down a telescope, how a telescope functions, and the basics of making telescopic observations.

i: How telescopes work

At the heart of a telescope is a large lens or mirror, which the telescope uses to gather light. This is called the telescope's *objective*. The size of a telescope's objective is so important that the *objective diameter* is often the primary attribute astronomers mention when describing a telescope. The larger a telescope's diameter, the more light it can gather, which means that it can let you to see fainter objects.

It is common to compare the *light gathering power* (LGP) of one telescope to another by Equation #1. This fundamental equation can be used to compare the light gathering power of any two optical systems—including binoculars and eyes!

Equation 1

Calculating the relative light gathering power of two optical systems:

$$LGP = \left(\frac{D_1}{D_2}\right)^2$$

Where:

D_1 is the diameter of the objective of the bigger diameter optical system;

D_2 is the diameter of the objective of the smaller diameter optical system.

Example calculation: Calculate the relative LGP of our laboratory telescopes (D_1 = 200 mm) to a typical pair of binoculars (D_2 = 50 mm):

$$LGP = \left(\frac{200\text{ mm}}{50\text{ mm}}\right)^2 = 4^2 = 16$$

A telescope's *objective focal length* is also very important. This is the distance it takes for the objective to bring the light to a concentrated focus.

Key parameters for our telescopes
Objective diameter: 200 mm
Focal length = 2000 mm

ii: Eyepieces and magnification

Eyepieces are essential accessories that accompany telescopes. They are small, interchangeable optical devices which, like a telescope objective, can focus light. The *eyepiece focal length* is printed on the eyepiece. These eyepieces conduct the final processing steps on the light passing through the telescope. They allow the light to be interpreted by your own eyes.

Magnification is a measure of how many times bigger something looks through the telescope, compared to your unaided eye. (Magnification is sometimes also just referred to as the "power," although the usage is subject to context.)

The eyepiece sets the magnification that the telescope provides. You can calculate the magnification obtained when using an eyepiece in a telescope, by using Equation #2.

Equation 2

The magnification of a telescope and eyepiece combination:

$$\text{Magnification} = \frac{\text{Objective focal length}}{\text{Eyepiece focal length}}$$

It is seductive to want to use the smallest focal length eyepiece, in order to get the highest magnification possible. After all, in movies, it is always possible to zoom in with extreme magnification!

But in practice, the highest magnification views tend to be unsatisfying. You are pushing the telescope to its limit, and you tend to see only a blurry image that is degraded by the Earth's atmosphere.

iii: Fields of view

In Lab N01, we learned about angular measure in degrees and arcminutes. When using a telescope, even at lowest magnification, the *field of view* is typically 0.5° (30 arcminutes) or smaller.

Very short focal length eyepieces will provide very high magnifications. As such, they will typically have extremely small fields of view. It is easy for an object to wander out of the field of view if the telescope is moved even a tiny amount. This is another reason high magnification eyepieces can be unsatisfying.

iv: Resolution

With no optical assistance, a person with normal vision can see two stars as separate, as long as they are about 1 arcminute (60 arcseconds) apart. Any closer together, and their images blur together into one star. This is called the *resolution* of our eye. Telescopes can see finer detail—if they couldn't, then a magnified image would just be a big, blurry one. The resolution of a telescope is set by the objective diameter.

v: Using the Telrad

The instructor will show you how to align the telescope at the beginning of the night, using a head-up display device called the *Telrad*. This is required for the telescope to use its automated navigation features. You will be responsible for learning how to use the Telrad.

vi: Afocal photography

If you observe very bright objects like the moon or a planet, you might be able to use your phone's camera to take a photograph. This method is called *afocal photography*. It is time consuming and may be frustrating, but depending upon your observing trip logistics, your instructor may have time for you to try this.

vii: Tips when observing

1. Always start with the lowest powered eyepiece.
2. Focus carefully for your own vision. Focus on the stars, not on nebulae (which always look fuzzy and are hard to focus on).
3. Center your object in the eyepiece for the best quality image, and especially before moving to a higher magnification eyepiece.
4. Carefully guard your night vision. Do not look at bright lights, or even your observing flashlight.
5. Try using averted vision when observing faint objects.
6. To see colors of star images, defocus them slightly.

PROCEDURE I: Telescope assembly and break down

The instructor will demonstrate all aspects of setting up and breaking down the telescope. Take careful notes, as you will be responsible for setting up your equipment.

Despite its large size and great mass, the telescope is an exquisitely sensitive and fragile apparatus, so you must be extremely carefully handling it. If you ever have questions regarding appropriate procedures, ask the instructor or the telescope technician.

PROCEDURE II: Objects to observe

Research the various types of objects noted below. Use Wikipedia, your textbook, or other resources as provided by your instructor. Write a paragraph about each type of object, describing its key characteristics. Your instructor may provide alternate or additional types of objects. One has been completed as an example.

Table A: Objects to observe

Double star
Open star cluster
Globular star cluster
Planetary nebula
(Star formation) nebula A giant glowing cloud of mostly hydrogen, some helium, and small amounts of other gases. These gas clouds are usually associated with star formation. In some, dark clots or clumps caused by dense clouds of dust are also nearby. Some glow bright red because of hydrogen emission.
Spiral Galaxy
Elliptical Galaxy

VOCABULARY:

Objective	**Magnification**
Objective diameter	**Field of view**
Light gathering power	**Resolution**
Objective focal length	**Focus**
Eyepiece	**Telrad**
Eyepiece focal length	**Afocal photography**

QUESTIONS/ANALYSIS:

1) A pair of binoculars has an objective diameter of 35 mm, while the human eye has an objective diameter of about 5 mm. Calculate the LGP of the binoculars vs. the human eye. Show your work.

2) The human eye has an objective diameter of about 5 mm. Calculate the LGP of one of our laboratory telescopes vs. the human eye. Show your work.

3) The human eye has a resolution of about 60 arcseconds. Telescopes like ours have a resolution of about 100 x better than that. As such, when using our telescopes, how close could two stars be, so they could just barely be observed as being two separate stars instead of one star? (Neglect the effects of our atmosphere.) Show your work.

4) The longest focal length eyepiece you will use in lab is 40 mm. What magnification will this provide, when used with our telescopes? Show your work.

5) The shortest focal length eyepiece you will use in lab is 6.4 mm. What magnification will this provide, when used with our telescopes? Show your work.

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