Astronomy I: Close to Home Name ____________________
SCI 140 Date ____________________

Lab 8 – Telescopes

Goal: To understand the properties of telescopes.

Theory

The main purpose of a telescope is to gather light. The telescope's light gathering power depends upon the area of the primary lens or mirror, given by Equation 1.

$$A = \pi r^2 \qquad r = \tfrac{1}{2} d \qquad \text{Eq. 1}$$

The second most important quality of a telescope is its resolution, which is the smallest angle that the telescope can see. This is given by Equation 2 (in arcseconds), and the smaller the answer the better.

$$Resolution(arc\sec) = 3600 \sin^{-1}\left(\frac{1.22\lambda}{D}\right) \qquad \text{Eq. 2}$$

However for a telescope to be useful by eye it must also magnify the image. Magnification can be calculated three different ways, as given by Equations 3-5.

$$M = \frac{\text{focal length of objective}}{\text{focal length of eyepiece}} = \frac{f_o}{f_e} \qquad \text{Eq. 3}$$

$$M = \frac{\text{angular size of image}}{\text{angular size of object}} = \frac{\theta_i}{\theta_o} \qquad \text{Eq. 4}$$

$$M = \frac{\text{distance to object}}{\text{distance to image}} = \frac{d_o}{d_i} \qquad \text{Eq. 5}$$

And don't forget percent difference can be used to tell whether values are close to each other.

$$\%diff = \frac{|Meas1 - Meas2|}{Average} \times 100\% \qquad \text{Eq. 6}$$

Materials

- ☐ Ruler
- ☐ Tape Measure
- ☐ Orion Telescopes
- ☐ Eyepieces
- ☐ Object on far wall
- ☐ Copy of object

Procedure

1) Two or more telescopes will be set up for you in the hallway or classroom. A object of known size will be taped on the far wall from the telescope.
2) Determine what type of telescope you are using and make a cutaway sketch of the path the light will take (see textbook Section 5.1: Figures 5.5 and 5.6).
3) Record the diameter of the primary (found on the side of the telescope), and calculate the collecting area using Eq. 1, and the resolution of the telescope using Eq. 2. (HINT: For λ, pick a wavelength typical of visible light, and use the value in meters, not *nm* or *Å*.)
4) Record the focal length of the objective (f_o), and the focal length of the eyepiece (f_e), found on the side of the telescope and the eyepiece, respectively. Calculate the magnification via Eq. 3. (HINT: Convert the two focal lengths to the same units.)
5) Measure and record the distance from your telescope's eyepiece to the object on the far wall (d_0).
6) While standing at the telescope, hold a ruler in your hand at arms length in front of the object. Comparing the object to your ruler, determine how big the object appears to be and record this as θ_o.
7) Look through the eyepiece of your telescope at the object on the far wall. Make a sketch of the object to indicate which way is up on it. It may help to close or cover the other eye while looking through the telescope. If the image is fuzzy, use the focusing knob to adjust the focus.
8) While looking through the telescope with one eye, hold a ruler in your hand at arms length (the same as in Step 4) and compare the apparent size of the object *through the telescope* to the ruler. Determine how big this image appears to be and record this as θ_i.
9) Calculate the magnification via Eq. 4.
10) While looking through the telescope with one eye, have one of your partners hold a second copy of the object and walk away from the telescope until the original object through the telescope and the copy of the object not through the telescope appear the same size. Measure the distance from the eyepiece to the copy of the object, and record this as d_i.
11) Calculate the magnification via Eq. 5.
12) Repeat Steps 4-11 for a second eyepiece in the same telescope.
13) Repeat Steps 2-11 for a different telescope.

Questions

1. For each of the three situations, do your three values for the magnification agree? Use percent difference to make your case.

2. Which method do you think gives the most accurate value for the magnification? Why?

3. If you want a higher magnification from a telescope, should you use an eyepiece with a large focal length, or a small focal length?

4. What wavelength did you use to calculate the resolution? Why?

5. Some people think that if a secondary mirror blocks the view, that the images of objects should have holes in them. What did you actually see and why?

6. Which telescope would be best for bird watching? Why?

7. Which telescope would be best for astronomy? Why?

8. Why do we need eyepieces for telescopes? You can draw a diagram to explain.

9. Compare the collecting power of a telescope with a 10cm diameter mirror to that of the human eye. Assume the diameter of your eye's pupil is about 5mm (=0.5cm).

Check-Out

I. **Data** – table at the end (be sure to include units), sketch of the type of telescopes, sketch of which way is up

II. **Calculations** – samples of how you calculated magnification and resolution

III. Questions

Calculations:

Astronomy I: Close to Home
SCI 140-01

Name ___________________
Date ___________________

	Telescope 1	Telescope 1a	Telescope 2
Telescope Brand			
Telescope Style			
Diameter			
Collecting Area			
Resolution			
f_o			
f_e			
$M = f_o / f_e$			
θ_o			
θ_i			
$M = \theta_i / \theta_o$			
d_o			
d_i			
$M = d_o / d_i$			

Name ___________________
Date ___________________

(spare table)

	Telescope 1	Telescope 1a	Telescope 2
Telescope Brand			
Telescope Style			
Diameter			
Collecting Area			
Resolution			
f_o			
f_e			
$M = f_o / f_e$			
θ_o			
θ_i			
$M = \theta_i / \theta_o$			
d_o			
d_i			
$M = d_o / d_i$			

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