

TELESCOPE FIELD OF VIEW

Purpose: This lab is designed to help you learn how to use the telescope to make simple observations about apparent size and directions, when viewed through the viewing tools of the telescope. The drift timing mechanism introduced here will be used throughout the rest of the course.

It will be very helpful to see the Drift Timing information on page **Error! Bookmark not defined..**

Hopefully, you will complete this task early enough to learn how to correctly polar align telescopes to track apparent motion of the stars throughout the night.

Introduction

When looking through a telescope, there are two basic questions you should know how to answer: 1) How big is the object I'm looking at? [Or, for multiple objects, how far apart are they?] 2) Which direction is which? In other words, how does your view through the telescope compare to your view of the sky without the telescope.

We will attempt to answer the second question by determining where north, south, east, and west are in the telescope viewing tools. You will discover that the exact orientation of the directions will be neither intuitive nor constant between viewing tools.

In the second part of the lab, we will measure how big your telescope's field of view is for various magnifications/configurations of the viewing tools. Recall that the magnification of a telescope is the focal length of the telescope system (2000mm in our case) divided by the focal length of whatever eyepiece you are using (written on the eyepiece).

1. Determining East and West

Start by roughly polar aligning your telescope, by setting it to view Polaris. Make sure your instructor verifies that you are roughly polar aligned.

You should already know the answers to the following questions.

- 1) In what approximate direction is the Sun when it rises?
- 2) In what approximate direction is the Sun when it sets?
- 3) Why does the Sun appear to move between these two directions in the sky?
- 4) Do the stars appear to move this way also? Why or why not?
- 5) Why do we plug the telescopes into the electrical outlets?

Think about these questions – understanding the answers is an important part of understanding the sky. To encourage you to think about the questions, the answers appear on the next page, not this one. Take some time to think about these questions now. You won't be graded on your answers... (In fact, you won't submit them.)

To figure out which direction is east and which is west through a viewing tool, you will need to pick a bright star near (i.e. less than 10 degrees away from) the celestial equator (i.e. $\delta = 0^\circ$ -- anywhere 90° away from Polaris). Bright stars near the equator include: Altair ($\delta = 10^\circ$) in the summer triangle (and the constellation Aquila), any of the stars in Orion's belt (the westernmost [i.e. rightmost as you look at it] star, Mintaka, is closest to the equator), or Spica in Virgo. Pick a star visible during class and write it down on an observation form where the form says "Object." Fill out the rest of the information on the observation form.

The Sun, stars, and any object seen in the sky rise somewhere near east and set somewhere near west (with a few exceptions – circumpolar stars). Exact locations of rising/setting depend on the object's declination. During the time between rising and setting, the object must move from east to west, as we observed during the Constellation Lab. This apparent motion is caused by the Earth's rotation. Because the sky is apparently rotating, we must plug our telescopes in so that a single motor can counteract this rotation. The motor does this by steering the telescope to follow an object's apparent circular motion. If the motor turned off, the telescope would stay put, while objects drift EXACTLY westwards across the sky. (West is defined by the direction of the Earth's rotation.)

Thus, to determine east and west, place your star at the east edge of the viewing tool. (True – you don't know which way east is, yet. There will be a slight amount of trial and error involved!) Turn off the motor. The star will drift exactly west, towards the center of your viewing tool (hopefully).

What to do:

On your observation form, draw an arrow at the star's starting point that points in the direction the star moves when the motor is turned off. [Don't forget to turn the motor back on after you've determined the direction! But let it drift for a bit.] Repeat this for all three viewing tools: the Telrad (which is completely transparent), the finder telescope (with 2 lenses), and the 40 mm eyepiece. Use a separate observation circle for each viewing tool.

Note that it may take a while to notice the westward drift of the star. It is also possible the star will drift out of your field of view, rather than towards the center. If that is the case, you guessed "east" unwisely. Revise accordingly, and make a note (in the "notes" section of the observation form) of what you did, both originally, and "finally." There is no penalty for poor guessing. But you should honestly record what you did. That's one nice thing about science: it's ok to be wrong, as long as you admit your mistakes and correct them.

2. Determining North and South

On the sky (i.e. on the celestial sphere), north is defined to be the direction towards the North Celestial Pole (which is very near Polaris, the North Star). The North Celestial Pole has a celestial latitude (i.e. *declination*, represented by the symbol δ) of exactly 90° , by definition, just like the latitude of the North Pole on Earth is 90° by definition of latitude.

If you are properly polar aligned, changing the telescope's declination closer to 90° moves the telescope northwards. If the telescope moves north, stars in the field of view of *any viewing tool* will appear to shift towards the south. By pointing your telescope at an object and moving the telescope towards Polaris, stars should appear to move SOUTH in your viewing tool. (One of the lab questions asks you why this backwardness occurs.)

Determining NSEW (a.k.a. cardinal directions)

On each observation sheet, confirm your west direction before proceeding. When you have done that, center on the star and have your partner unlock the declination and move the telescope towards Polaris while you are watching through the viewing tool. On your observation sheet, indicate where the star begins and draw and label an arrow in the direction of the star's motion, which is SOUTH. You already have west, so fill in the other cardinal directions on this circle Repeat for the other two viewing tools.

Note: North may not be straight up or down and east/west may not be exactly right/left – the orientation angle (i.e. place where North is relative to "up") will depend on how the elbow reflector (the thing the eyepiece is screwed into) is oriented and where you are standing. The important relationship here is the RELATIVE direction between north and east. One thing that won't change: the cardinal directions will always be perpendicular.

From now on, you will be expected to determine these cardinal directions (i.e. north, south, east, and west) each time you begin a new part of any experiment.

3. Field of view measurements

Preliminary information

Our next objective (pun intended) is to figure out how much of the sky we can see when we look through the telescope. The amount of sky that you can see when looking through the eyepiece is called the *field of view* (abbreviated FOV). We can measure our field of view using our knowledge of the rotation of the Earth.

Measuring the field of view

We will use the drift-timing method, described on page **Error! Bookmark not defined.**

Supplement to the Drift-timing handout instructions: Measure how long it takes your star to travel all of the way across your field of view for each of the 3 eyepieces. Once your star is outside the field of view (it should be only slightly east of the FOV and still centered north/south) turn off your telescope motor. When the star enters the field of view, start timing. Stop timing when the star leaves the field of view. If time permits, you may compute the FOV for the finder telescope for **extra credit**. If you have even more time, try doing the same for the circles in the Telrad for **even more extra credit**.

Final Task

Your last task, one that we will repeat nearly every class from now on, will be to polar align the telescope. Have your instructor verify your polar alignment – refer to page **Error! Bookmark not defined.** for this procedure. Polar alignment is necessary so that the telescope is pointed at true north (i.e. the north celestial pole) when it “thinks” it is (i.e. when the declination is set to 90°). This alignment will allow the telescope to perfectly track objects as they move across the sky. In the past, we did a very rough polar alignment, and therefore roughly tracked objects throughout class.

What to submit

- 1) Observation sheets with the NSEW directions labeled for all 3 viewing tools
- 2) Answers to the questions on the next page
- 3) The completed table found on the page after that. (Copy the answers onto the “Drift Timing” page, **Error! Bookmark not defined.**, before you submit this lab. You will need that information for future labs.)
- 4) Include any calculations you did. In other words, show your work, so I can give you partial credit and correct your mistakes (if any exist).

Questions

1. [1 pt] A) Why do stars appear to move towards the south if the telescope moves towards north? (*Hint*: will stars in the eyepiece actually be further north or south after moving? Another hint: which way do stars appear to move in your eyes' fields of view if you look up?)
B) Give another, non-telescope, example of this phenomenon.
2. [1.5 pt] A) How do the RELATIVE directions between north and west in the Telrad compare to a compass? When comparing directions, ignore rotations, just check if they are in the same relative order. (i.e. east to the right of north) B) Why are(n't?) they different? (*Hint*: when viewing a map, you are looking down on the Earth from above. What are you doing with a telescope?)
3. [1 pt each comparison – 2 pts total for part A] Your instructor should show you a ray diagram of the telescopes used in class, as well as discussing the effects of lenses and mirrors before you answer this question. A) Compare the relative directions in the eyepiece and finder to the compass directions. Comment on any differences between the viewing tools and a compass. Again, ignore rotation, and you must elaborate if you say “opposite” or something similar. Be specific.
[2.5 pt] B) If the relative order is different, how so and why do you think that is? (*Hints*: #1 Any changes between the Telrad, eyepiece, and finder are due to the mirrors/lenses. #2 When you raise your hand while looking in a mirror [or at a friend, who mirrors you], which hand is your mirror image raising? #3 What happens if there are two mirrors? [Try using 2 friends, standing back to back, mirroring you if you can't vision this.] #4 How many mirrors are in the various viewing tools? You should investigate this while at the telescope! Also: lenses do not experience this same effect as mirrors – as we discussed in class, the image formed by a lens is only rotated 180° relative to the source.)
4. [1/2 pt] A) Why did you align your star in the center of the eyepiece before moving it off to the side? (One answer is “To determine which way is west.” You are to give the other answer, from the FOV part of the lab.)
[1/2 pt] B) Why did you move the star outside of the field of view before starting the timing, instead of leaving them near the edge and starting from the inside edge? Be specific. Answering “To get better [or “more accurate”] results” will not earn you any credit. What makes the results better or more accurate?
5. [1 pt] A) How did the fields of view of the eyepieces change as the magnification of the eyepieces increased? In other words, summarize the trend. B) Explain why this trend occurs.
6. [1 pts] A) How and why would your measurements for the drift times have differed if you had picked a star with a declination of 60 degrees instead of one near zero degrees? B) Why did we pick a star near the equator (i.e. far from Polaris)? (*Hint*: what would happen if we picked a star with $\delta = 90^\circ$?) C) Explain your answers.
7. [1 pt] Through how many degrees do stars near the equator move during our 3 hour class?
8. [1 pt] The Full Moon is about 0.5° across. Which eyepiece would you use to view the entire Moon and why?
9. [1 pts] How could we improve our measurements of the fields of view? In other words, what were the largest sources of error in the measurements and how, specifically, could we reduce them, using the equipment we had available? (Human error is not a source of error. How did the humans err?) Put some real thought into this.

Optional: A) What did you think of this lab? B) What improvements would you suggest for future classes? C) Are there any other remarks you would like to share?

Star _____

Correct orientation for Telrad _____ (instructor use only) [1 pts]

Correct orientation for Finder _____ (instructor use only) [1 pts]

Correct orientation for Eyepiece _____ (instructor use only) [1 pts]

(#1) 40mm eyepiece Compute magnification _____ (no mm units)
Time to drift across FOV (min. and sec.) A) _____, B) _____, C) _____
Average time _____ Convert to seconds _____

(#2) 26mm eyepiece Compute magnification _____ (no mm units)
Time to drift across FOV (min. and sec.) A) _____, B) _____, C) _____
Average time _____ Convert to seconds _____

(#3) 17mm eyepiece Compute magnification _____ (no mm units)
Time to drift across FOV (min. and sec.) A) _____, B) _____, C) _____
Average time _____ Convert to seconds _____

Average F.O.V. in *arcseconds* #1) _____ #2) _____ #3) _____

Convert measurements to *arcminutes* #1) _____ #2) _____ #3) _____

Convert your answers to *degrees*. #1) _____ #2) _____ #3) _____

[#1 = 1 pt each, #2 & #3 = 2 pts total]

EXTRA CREDIT: [2 pts] Compute FOV of the finder telescope: _____ degrees.
 [2 pts] Compute FOV for inner or outer circle in Telrad. _____ degrees.

Don't forget to compute the calculations using the magnification formula. [1/2 pt each]

Don't forget to copy your values onto the drift timing handout, so you have the numbers available for future labs. On that handout, you will also want to record telescope number and eyepiece details.