Outdoor Lab 2 - Dialing in the Stars

Objectives: To introduce some practical aspects of using an astronomical telescope.

1 INSIDE PREPARATIONS

1.1 Telescope basics

Optics. The telescopes we will use today are equatorial telescopes, and have an aperture of 8 inches diameter, which allows them to collect much more light than the human eye Question: How much more light? the Human pupil size in the dark can be as large as 9mm. Recalling that there are 25.4 mm in 1 inch, how much more light can we gather with these telescopes than with our naked eyes? The amount of light is proportional to the collecting surface: the AREA of the lens collecting the light. Show your calculation below.

Ratio of light collected by telescope to light collected by eye =____

Since we can collectmore light with these telescopes than with our eyes we can see much fainter objects. Now recall the formula that relates brightness to magnitude:

$$\mathrm{m_{object}} - \mathrm{m_{reference}} = -2.5\ \log_{10}\left(\frac{\mathrm{I_{object}}}{\mathrm{I_{reference}}}\right) \tag{1}$$

Assume you can see to magnitude 3 with the naked eye. What is the faintest magnitude you can see now that you can use this telescopes? Show your calculations below.

Faintest magnitude visible with 8” telescope =____

The optics of the Schmidt-Cassegrain equatorial telescope are quite complicated. At the front is a transparent plate, and in the center a small secondary mirror pointing inwards. The main optical component is a converging mirror at the other end of the telescope. The light from a distant star passes through the glass plate, bounces off the primary mirror, comes back up the tube, is reflected back down the tube by the secondary and passes through a hole in the primary mirror to the eyepiece. There is a knob on the back of the telescope that focuses the optics. Once set up, this does not need to be adjusted unless you change the eyepiece.

Magnification. When you look through the eyepiece the view is magnified. We will not be concerned with this aspect today, but for completeness note that the magnification is given by the formula m = fo /fe where fe is the focal length of the eyepiece and fo is the focal length of the objective or primary optical component. fe is usually written on the eyepieces in mm. fo for our telescopes is about 2000 mm. So for a 25 mm eyepiece the magnification is 2000/25 = 80.

Finder. Attached to the side of the telescope is a small finder telescope - it acts a bit like the sights on a rifle. It has a magnification of 6, and sees about 5° of the sky - much more than through the main eyepiece. When you look though the finder there is a cross hair, that should be aligned so that a star on the cross hair appears in the eyepiece. Thus one way to observe a star is to line up the telescope roughly in the direction of the star; then line up the star in the finder. It should then appear in the main eyepiece.

Control. The telescopes we will use have two moving axes that correspond to the sky coordinates RA and Dec. Each axis has a scale which enables you to dial in and point at a star of known coordinates. The Dec circle is marked in degrees; the RA circle in hours, with smaller 5 min ticks. To move over large angles: release the axis brake; move the telescope; then reset the break gently - not tightly. For precision setting, there are control knobs for each axis that move the telescope over small angles.

A correctly set up telescope can move in RA and Dec because it is mounted at an angle so that one axis is aligned with the polar axis. When you turn the telescope about this axis you are turning it in RA; when you turn it about the other axis you are turning to different Decs at the same RA. When you have set on a star, a motor inside the telescope turns the polar axis to keep track of the star (i.e., it keeps it pointing to the same RA and so compensates for Earths rotation). We also have on the roof several 10 inch diameter telescopes, of the alt-az variety (rather than equatorial). These telescopes do not track without using their electronic devices (which we wont do). However, they do have better optical quality. We will use them in later labs. Before going out, review the recipe below as you will have to do it outside. Also please remember:

- Dont touch any part of the telescope optics
- Dont force any mechanical part of telescope
- Only put the axis brakes on gently

1.2 Recipe for setting up telescope

1. First choose an eyepiece. Recall that you will want to be able to easily find your bearing, so you do not want a very high magnification image thus you want a long focal length eyepiece. The instructors will give you a tour of the lab room when you arrive on the roof, and tell you where everything is.
2. Locate Polaris with the naked eye. (We will assume that it is exactly at the NCP).
3. Rotate the telescope about the Dec axis so that it reads 90°.
4. Turn the whole tripod of the telescope until the fork points at Polaris.
5. Level the telescope by adjusting the legs and using the spirit (or bubble) level on the top of the tripod. (This step is not essential).
6. Find Polaris in the finder, If it is off to one side or not visible, readjust the tripod so that Polaris falls close to the cross hair in the finder. Make sure the dial still reads Dec = 90° , and readjust the legs if the telescope is no longer level according to the bubble. You may have to repeat this process a few times; the roof is not exactly horizontal! (If Polaris remains always much too high or too low in the finder so you cannot center it, consult the instructor the wedge needs readjustment).
7. Once Polaris is centered make sure the telescope is switched on. Look for Polaris through the main eyepiece. If it appears fuzzy, focus it with the focus knob. If Polaris does not appear in the eyepiece when centered in the finder, consult the instructor the finder needs re-aligning. When this is done return to (2).
8. Once you have reached here, the telescope is approximately aligned with the polar axis. Do not move the tripod from now on. Locate by eye the reference star of known coordinates well away from the NCP (see Section 3). Turn the telescope about both axes (releasing brakes gently) to center the star in the finder, then in the eyepiece. With the star centered, slide the RA circle around until the RA reads the RA of the star. The Dec should already be OK to within a degree or so.

It is done: the setting circles roughly correspond to RA and Dec on the celestial sphere. A star of known coordinates can be found by moving the telescope until the dials read correctly (this should be accurate enough to place the star in the finder). Conversely, the coordinates of a star can be found by centering it, then reading the dials. Remember - be gentle with the brakes.

2 OUTSIDE

2.1 Setup

Set up the telescope according to the recipe given above, using as reference star for RA that given below. The stars listed here are appropriate for January or February lab times.

NAME:Pollux RA: 07h 45m 19s Dec: $28°01'35''$

2.2 Measuring coordinates

Measure the coordinates of each of the stars in the table below. In turn: locate the star by eye (e.g., using the sky maps in the field guide after p 53); move the telescope so that the star is centered first in the finder, then in the eyepiece; read off the stars coordinates from the setting circles to within 5 min and 1° in RA and Dec, respectively.

Star	Measured RA	Measured Dec
Sirius		
Betelgeuse		
Castor		
Algol		

2.3 Dialing Objects

The table below lists the coordinates of four objects. Dial them in on the setting circles, report what you see at these locations, and sketch it in the next page, taking a guess at the type, and at the size of the object (remember what the size of your field of view is?). If you dont see anything obvious on the first one, you probably have set up your telescope wrong!

RA	Dec	Report
(a)7h 39m	$+5°13'$	
(b)3h 49m	$+24°6'$	
(c)5h 52m	$+32°33'$	
(d)5h 35m	$-5°26'$	