Field of View of a Small Telescope
Observational Astronomy

Name: ____

Introduction

How much can you see? This question could be interpreted in several ways. An astronomer might answer in terms of the faintest object, smallest object, or largest object he or she can see. Tonight we'll investigate the last of these: field of view (FOV).

In astronomy, the field of view is the amount of sky you can see, whether with your unaided vision, binoculars, or a telescope. Field of view is measured as an angle, in degrees ($^\circ$), minutes ($'$), and seconds ($''$) of arc ($1^\circ = 60' = 3600''$). If you had eyes on all sides of your head, you would have a 360° field of view. (Some insects actually do!) If you include peripheral vision, your naked eye field of view is nearly 180°, but with varying quality across this field. A telescope will have a much smaller field of view, but it has significant advantages, such as greater magnification and light-gathering power.

Pre-test

1. What do you think determines a telescope's field of view? The aperture size? The focal length? The eyepiece used? The person looking through it? Write down what you think.

2. What do you think is a typical field of view for a small telescope? (For reference, the full Moon is roughly half a degree in angular size.)

Using a small telescope

There are two main types of telescope mounts: equatorial and altazimuth. The 16-inch telescope and several of the small scopes use equatorial mounts, while the other small scopes uses altazimuth mounts. Equatorial mounts must be set for the observers latitude, aligned to the north pole, and balanced properly. Their axes of motion then correspond to coordinates on the celestial sphere. Remember, right ascension (RA) is celestial longitude, and declination (Dec) is celestial latitude. Since the Earth turns, the right ascension directly overhead (at zenith) is constantly changing. An equatorial mount makes it especially easy to compensate, since only one axis of the telescope needs to move.

On the other hand, altazimuth mounts only need to be leveled properly. Their axes of motion correspond to compass direction (azimuth) and elevation (altitude). Tracking an object requires motion along both axes, but computerized tracking systems can easily do this. It should be clear that equatorial mounts have advantages over altazimuth mounts, but are harder to use, as well as being bulkier.

That being said, it's probably best to use an equatorial scope tonight. They should be set up and aligned properly out on the roof. Move the telescope around a bit to get a feel for it. There are knobs that must be loosened to move the scope (one for each axis); retighten them once you are pointing where you want. Note the small finder scope attached to main tube. This has a much larger field of view than the main scope and is aligned with it, making it easier to center in on objects. Try looking around campus or at the Moon (if it's visible) to get an idea of the finder's field of view.

Next, look at where the eyepiece goes. There will be one or two screws to hold the eyepiece in place. Loosen these to remove the eyepiece (but not too far, or they will fall out)! Retighten them to hold the new eyepiece in place. Once an eyepiece is securely in place, look for the focusing knobs which move the eyepiece barrel back and forth. Point at any bright star (remember to use the finder first, then look through the eyepiece) and turn the focusing knob back and forth. A star is in focus when it appears to be a bright point of light.

Congratulations, you've mastered the basics of using a small telescope!

The drift method

In order to measure field of view, you will be using the drift method. This takes advantage of the fact that the Earth turns 360° in 24 hours. This means that a star on the celestial equator takes 24 hours to travel back to where it started.[1] So we have:

$$\frac{360^\circ}{24\text{ hr}} = \frac{360^\circ}{24\text{ hr}} \cdot \frac{1\text{ hr}}{60\text{ min}} \cdot \frac{1\text{ min}}{60\text{ sec}} \cdot \frac{60'}{1^\circ} = \frac{1'}{4\text{ sec}} \tag{1}$$

This means that every four seconds, the Earth turns through one minute of arc. So, if you timed how

[1] This is not quite true since the Earth also goes around the Sun. The time it takes the star to its position in the sky (the so-called *sidereal day*) is actually 23 hours, 3 minutes, and 56 seconds. For our purposes, this correction is insignificant.

long it took a star to move through the eyepiece and divided the result in seconds by four, you would know the field of view in arcminutes. Now, this result is only valid for objects at the celestial equator. Think about a spinning globe. A point on the equator moves a lot farther and faster than a point near the poles. This is easily fixed by multiplying the result by the cosine of the object's declination (δ):

$$\text{FOV } (') = \frac{1}{4} \cdot \text{time (sec)} \cdot \cos\delta \tag{2}$$

Measuring field of view

Pick two eyepieces with which to measure field of view. A long focal length will make you wait longer, but a short focal length will be harder to use. The 25, 14, and 9.5 millimeter eyepices are all good choices.

Now, you need a star on which to use the drift method. You want it to be relatively near the celestial equator (so it moves faster) as well as bright (so it's easy to find). In the fall, the best choice is Altair in Aquila the Eagle, with a declination of $8°53'$.

Find Altair using the supplied chart (Figure 1). Center it, then tighten the declination knob. Move the telescope in right ascension and make sure that it travels across the broadest part of the eyepiece. Make sure someone is ready with a watch to time the drift.

1. Move the telescope just past Altair (to the west) and begin timing when it appears in the eyepiece. Stop timing when it leaves the eyepiece. Record this time and calculate the field of view using Formula 2. Also make a note of which telescope and eyepiece you are using.

2. Repeat the drift time measurement and field of view calculation for your second eyepiece.

Conclusions

3. How big were your calculated fields of view compared to your estimate at the beginning?

4. What effect did changing the eyepiece have on the field of view? What seems to be the relationship between eyepiece focal length and field of view?

5. You can find the *magnification* when using a given eyepiece by dividing the focal length of the telescope by the focal length of the eyepiece. Calculate the magnification for the two eyepieces you used.

6. Each eyepiece has an *apparent field of view* which is intrinsic to the eyepiece. When used with a telescope, this will become a smaller *true field of view*. The true field is found by dividing the apparent field by the magnification. Calculate the apparent field of view for the two eyepieces you used. If you can compare with another group which used the same eyepieces with a different scope, share your apparent fields of view. Are they the same?

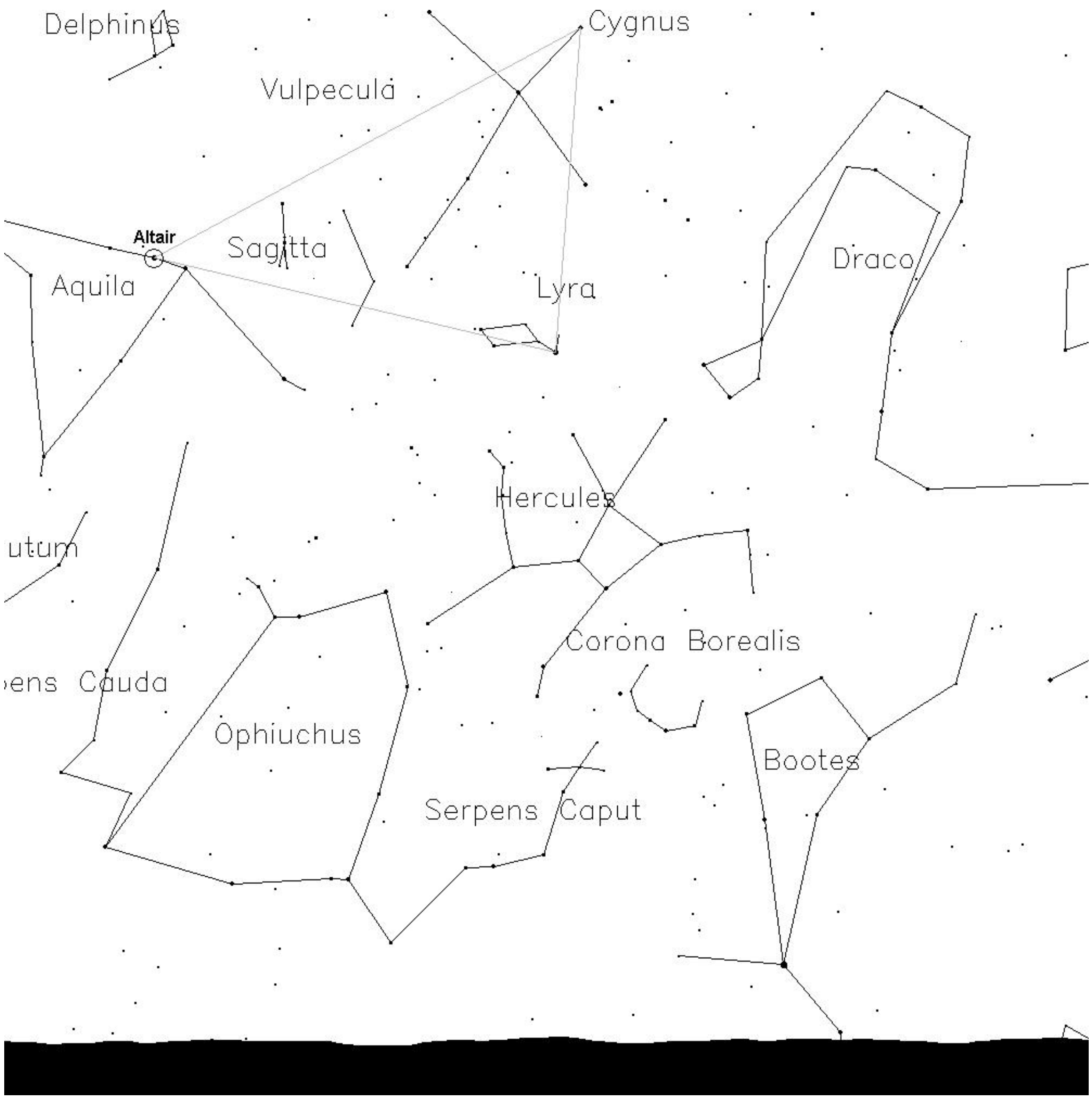

Figure 1: Looking west at 9pm on October 1st. Altair is at one vertex of the prominent Summer Triangle of bright stars. The others are Vega in Lyra the Harp and Deneb in Cygnus the Swan. (Image from http://www.fourmilab.ch/yoursky.)