🟣 **See Chandru Grading Comments from 11/4/23 below**

1. Nice work!

✅ **You have a 100% grade on this notebook**

✅ **Correct Any Errors identfied above for an improved grade**

Measuring Astronomical Objects

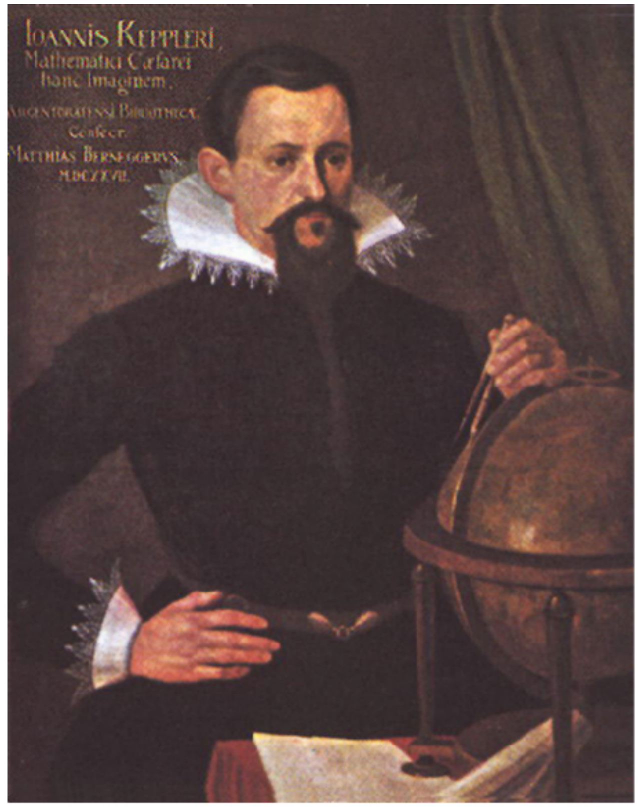
Tycho Brahe's Observatory

Three years after the publication of Copernicus' De Revolutionibus, Tycho Brahe was born to a family of Danish nobility. He developed an early interest in astronomy and, as a young man, made significant astronomical observations. Among these was a careful study of what we now know was an exploding star that flared up to great brilliance in the night sky. His growing reputation gained him the patronage of the Danish King Frederick II, and at the age of 30, Brahe was able to establish a fine astronomical observatory on the North Sea island of Hven (Figure 3.2). Brahe was the last and greatest of the pre-telescopic observers in Europe.

Johannes Kepler

Johannes Kepler was born into a poor family in the German province of Württemberg and lived much of his life amid the turmoil of the Thirty Years' War (see Figure 3.2). He attended university at Tubingen and studied for a theological career. There, he learned the principles of the Copernican system and became converted to the heliocentric hypothesis. Eventually, Kepler went to Prague to serve as an assistant to Brahe, who set him to work trying to find a satisfactory theory of planetary motion—one that was compatible with the long series of observations made at Hven. Brahe was reluctant to provide Kepler with much material at any one time for fear that Kepler would discover the secrets of the universal motion by himself, thereby robbing Brahe of some of the glory. Only after Brahe's death in 1601 did Kepler get full possession of the priceless records. Their study occupied most of Kepler's time for more than 20 years.

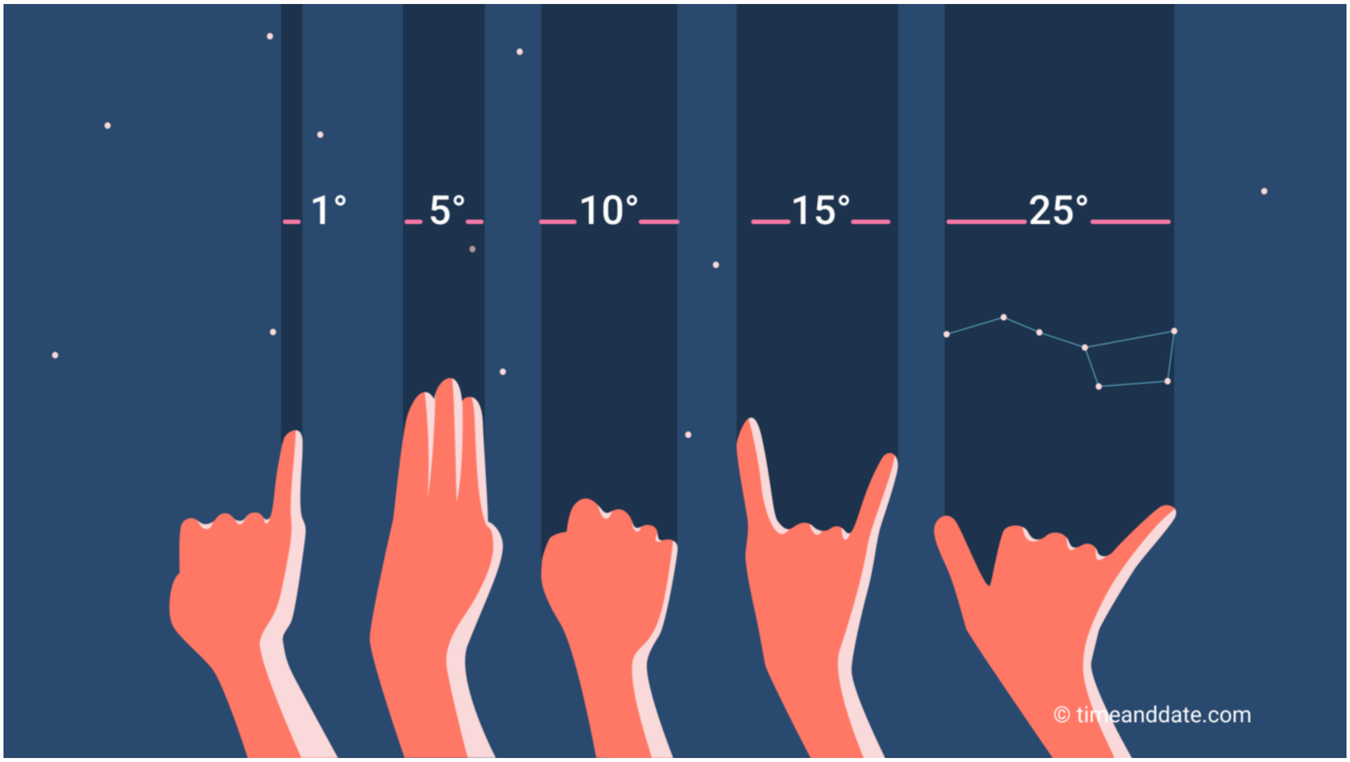
(a)



(b)

In this project we will learn how to roughly measure Astronomical objects in the sky. When we look at the stars, we can use our eyes, out hands and our fingers to approximately estimate the angular extent of objects in the sky in degrees, minutes and seconds of arc. If you already know the distance to the object, you can estimate its actual size in distance measures such as light years or even km in the case of the sun, moon.

A Handy Guide to Measuring the Sky



You can even approximately estimate your lattitude on Earth by measuring the altitude of Polaris from the horizon by simply using your fist!

But, wait! You can do a lot more from a **FITS (Flexible Image Transport System)** image you can obtain from a telescope. We will be measuring the extents of Galaxies, Nebulae, Globular Clusters, and Double Stars from the images we obtainted through the Bush Telescope!

To do this we will download specific images obtained by you during our observing sessions via the Bush Telescope in September 2023 from the **Bush Astro Dropbox** below. We will also be using The School's Observatory's **Astrolab Stellar** application generously offered to our class from the Liverpool John Moores University

Bush Astro Drop Box

Astrolab Stellar Viewer

Project: Measure Size of Astronomical Target

1. Each team of 4 will measure 4 separate targets. Each of you will measure your target and capture a screenshot from Astrolab Stellar application and embed in your Jupyterlab notebook. Please collaborate and obtain help from each other on your team in completing this. You need to do these in your own individual notebook.

2. The camera we used to obtain these images has a pixel size in microns (micrometer or 1-millionth of a meter. We will need this to convert pixels to an angle (arc-seconds) in the sky. We will also

need the focal length of the telescope. All of these can be obtained from the Astrolab Stellar application by taking a screenshot of the FITS header.

3. The 2 steps above are shown in the video linked here.

4. Then create a code cell with the formula below to calculate Image Scale (use variable name image_scale) and print it out as a f-string.

5. Image scale [arc-sec/pixel] = 206.265 * Pixel size[µm] / Focal length[mm]

6. You will then look up the actual target in Sky Safari app on your phone or wikipedia to find the distance to the object in light years. Create a variable (target_distance) and set it equal to the distance in light years.

7. Then create another variable (target_angular_extent) to calculate the angular extent of your target (embed the jpg image of this in your notebook). As you have seen before from the measuring the diameter of the Sun project, the distance is easily obtained by first converting the 'target_angular_extent' from degrees to radians and multiplying that by target_distance. This is your final result - the extent of your astronomical target! You can verify this and calculate a %error estimate by looking it up in Wikipedia!

8. Follow my example below!

Target is Albireo - A Double Star

Image Information

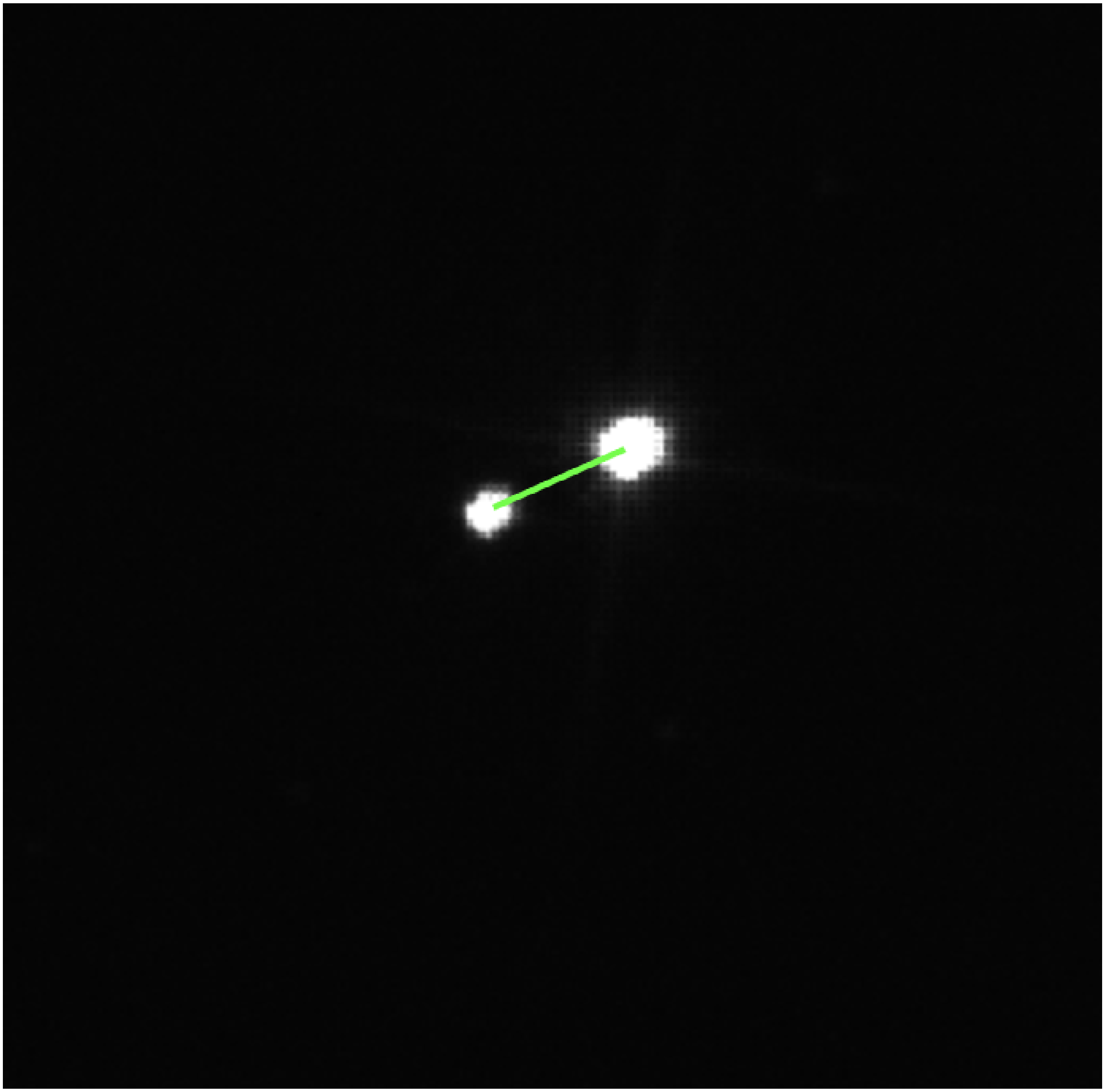
Object name: **Not known**
Telescope: **EQMod Mount**
Observation taken for: **Not known**
Instrument: **ZWO ASI224MC**

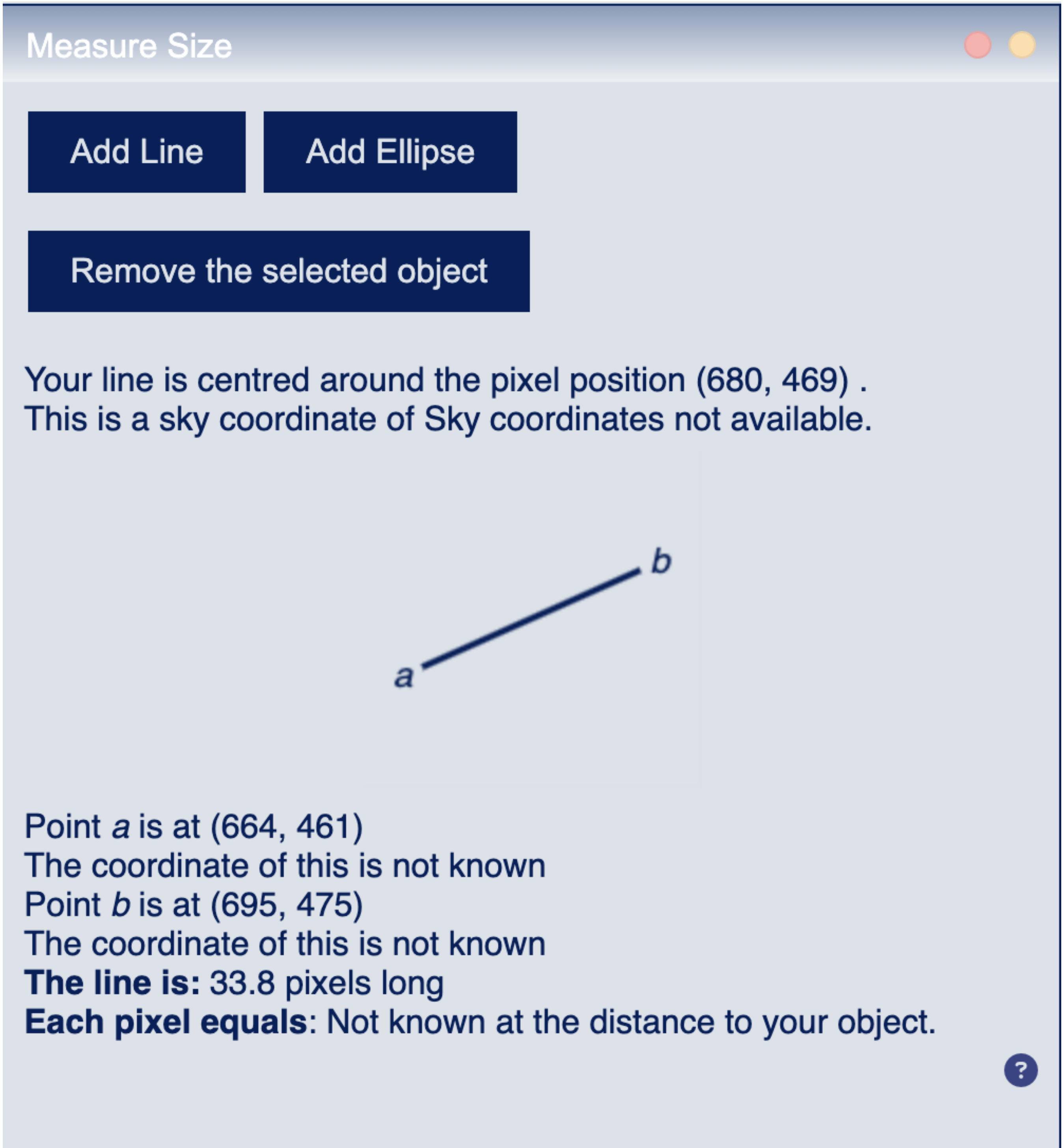
Date and time (GMT): **9/23/2023 at 4:58:19 AM**
Date and time as MJD: **Not known**
Coordinate (RA/Dec): **Not known**
Distance to the object: **Not known**

Exposure time: **0.200 seconds**
Filter: **Not known**
Image size: **1304 x 976 pixels**

Location of the telescope: **Not known**
Air temperature: **Not known**
Wind speed: **Not known**
Humidity: **Not known**

RA/Dec: 'RA' stands for Right Ascension, 'Dec' stands for Declination. These are coordinates that astronomers use to mark a position in the sky.
Instrument: Telescopes can have different tools called instruments, which each take different kinds of measurements.
Exposure time: How long the telescope spent looking at the object.
Filter: A filter is a special piece of glass which only lets a certain type of light into the telescope.






```
Measured distance between Albireo A and B = 33.8 pixels
Image Scale = 0.9668671875 arc-sec/pixel
Measured distance between Albireo A and B = 32.68 arc-sec or 0.54 arc-min or 0.000158437
64882677382 degrees

Albireo is 4.300e+02 Light Years away

Distance between Albireo A and B  = 0.07 Light Years

AU in a lightyear = 6.3072e+04

actual seperation of albireo components = 0.07 lightyears
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```
Percent error = 2.341337810795903%
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