UNIVERSITY OF SCIENCE AND TECHNOLOGY OF HANOI

DEPARTMENT OF SPACE AND APPLICATION

INTRODUCTION TO ASTRONOMY

INSTRUCTOR: PHAN THANH HIEN

PRACTICAL REPORT

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1. Introduction

The course "Introduction to Astronomy" is a foundational science subject offered within the curriculum of the Department of Space and Applications at the University of Science and Technology of Hanoi. This course aims to equip students with fundamental knowledge of astronomy and the universe, laying the groundwork for further exploration and research in this field while igniting a passion for the cosmos.

During practical sessions, students are instructed on the proper usage and assembly of telescopes. This skill enables them to observe celestial objects such as the Sun, the Moon, Jupiter, Saturn, DSO, etc.

In this practical report, our group provides a comprehensive overview of telescopes, including detailed information about their components. Additionally, we offer step-by-step instructions on how to use them to observe the Sun. Following the observational activities, we will delve into a discussion of the obtained results, analyzing and interpreting the observations in light of the specific objectives and parameters of the study.

2. Instruments

2.1. Telescopes

Figure 1: Celestron NexStar Evolution 9.25

2.2. Eyepieces

Figure 2: 5mm, 7mm, 9mm, 23mm, 40mm, 56mm

2.3. Software

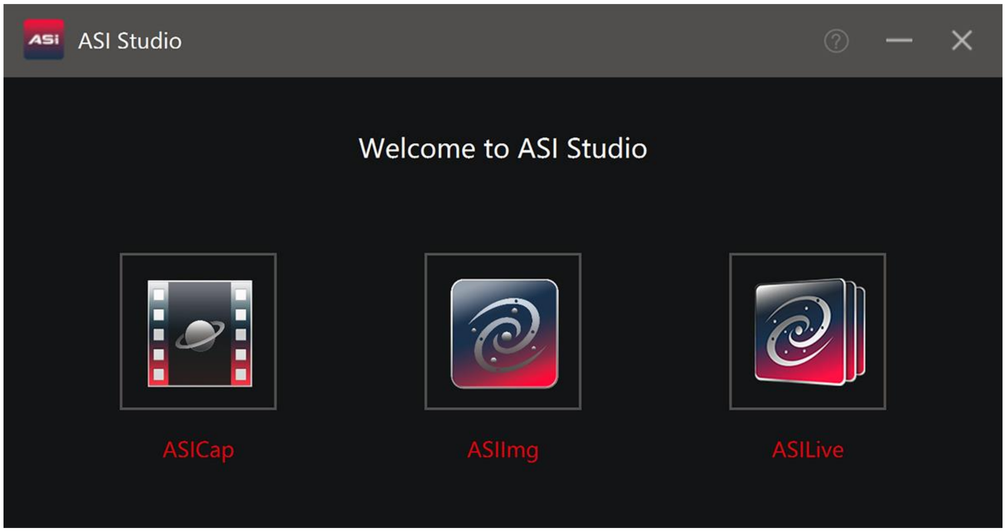

Figure 3: ASI Studio

2.4. Mobile app

Figure 4: SkySafari

3. Procedure

3.1. 08/12/23: Setting up telescopes and observing the Sun

3.1.1. Setting up telescopes

Step 1. Unpack the tripod and its components from their storage bag or box. Ensure that all the necessary parts, such as the tripod legs and mounting plate, are present.

Step 2. Extend the tripod legs by releasing the locking tightening screws. Extend the legs to a height that is comfortable for the observing position.

Step 3. Adjust the leg spread to provide a stable base for the telescope.

Step 4. Level the tripod using a bubble level feature. Adjust the leg lengths as needed to achieve a level position. A level tripod helps maintain stability and accuracy during observations.

Step 5. Attach the mounting plate head of the telescope to the top of the tripod. The mounting plate connects the telescope to the tripod and allows for movement and adjustments.

Step 6. Once the mounting plate is attached, tighten any screws or locking mechanisms to secure it firmly in place. Ensure that the mounting plate is tightly secured to prevent any movement or wobbling during observations.

Step 7. Gently apply pressure to the telescope or mount to check for stability. If there is excessive wobbling or instability, verify that all connections and adjustments are properly tightened.

Step 8. Make any necessary adjustments to the tripod legs or mounting plate to achieve the desired stability and observing position. Ensure that the telescope is level and pointing in the desired direction.

Step 9. Double-check that the tripod is stable and secure before proceeding with telescope observations. Ensure that all connections are tight, and the tripod remains level and steady.

Step 10: Place the mount onto the tripod head and align the holes on the mount with the holes on the tripod. Insert the screws through the holes and tighten them securely to attach the mount to the tripod.

Step 11: Attach the Optical Tube Assembly (OTA) to the Mount. Place the optical tube onto the mount's dovetail saddle. Slide the OTA forward until it is securely attached and tighten the locking screws to hold it in place.

Step 12: Attach the finderscope to the OTA using the provided brackets and screws. Align the finderscope with the main telescope by adjusting the screws until the crosshairs are centered on a distant object.

Step 13: Select an appropriate eyepiece based on the observing needs. Insert the eyepiece into the visual back of the telescope. Secure it in place by tightening the thumbscrew on the visual back.

Step 14. Connect the provided power cord to the power input jack on the mount. Plug the other end of the power cord into a power source or insert the required batteries into the battery compartment.

Step 15: Locate the power switch on the mount and turn it on..

Step 16: Select an object near the observers as a reference point, such as a building, a window, etc. Align the telescope to that position. Adjust the finder until the red dot points exactly on that position. Adjust the focus of the telescope until we can see the object clearly.

Step 17. Using the control panel or a compatible smartphone app, input the required information to the controller to align the telescope accurately.

3.1.2. Observing the Sun

Note: Safety first! Never attempt to observe the Sun without proper eye protection. Looking directly at the Sun can cause severe eye damage or blindness.

Step 1. Safely attach the solar filter to the front aperture of the telescope. Verify that the solar filter covers the entire front opening of the telescope, blocking all direct sunlight from entering the optical system.

Step 2. Perform a standard alignment procedure for the telescope.

Step 3. Once the telescope is aligned, use a low magnification eyepiece (preferably 25mm or higher) to start observing the Sun. Gradually increase the magnification if desired. Use the telescope's focusing mechanism to achieve a sharp and clear image of the Sun.

Step 4. Observe sunspots and features. Sunspots are darker areas on the Sun's surface caused by magnetic activity. Look for these dark spots and observe their shapes, sizes, and positions. Pay attention to other solar features such as prominences, filaments, solar flares, or granulation (small-scale texture on the Sun's surface).

Step 5. Take breaks between observations to rest your eyes and prevent eye strain.

Step 6. After observing the Sun, carefully remove the solar filter from the telescope and store it in a safe place to prevent damage or scratches.

3.2. 21/12/23: Observing the Moon

Step 1. Setting up telescopes

Step 2. Turn on the power switch on the telescope and wait until the control is ready.

Step 3. Press the Enter button to begin the alignment process, the menu will appear showing the many different methods of alignment.

Step 4. Scroll down to "Solar System Align" and press Enter

Step 5. Provide information of current location to the hand-control.

Step 6. Using the finder to align the telescope with The Moon, when the red dot of the finder is on the Moon, press Enter. Using the eyepiece, start calibrating the telescope so that the Moon is at the center. Then, press Align.

Note:

- *The Moon must not be directly above our head in order for the alignment to be accurate. Otherwise, we must choose another object for alignment.*
- *Adjust the Focus Knob to adjust the focal point for a sharper image.*

3.3. 22/12/23: Observing Jupiter/ Saturn and Double Stars

3.3.1. Observing Jupiter/ Saturn

Step 1: Set up the telescope.

Step 2: Turn on the power switch.

Step 3: Press Enter to start.

Step 4: Select ‘Solar System Align’ after rolling through various different methods.

Step 5: Select ‘Standard Time’, then choose UTC+7 time zone and enter the date.

Step 6: Select Jupiter/Saturn in the ‘Select Object’ section.

Step 7: Adjust the Red Dot Finder so that the red dot coincides with Jupiter/Saturn.

Step 8: Focus Jupiter/Saturn at the center of the eyepiece and press Align.

Step 9: Observe and take pictures.

Note: Saturn may be hard to see in the sky, so we should use applications like SkySafari to find its position and a laser pointer pen for red dot adjustment.

Which eyepieces can be used to observe Jupiter and Saturn?

We use 9mm and 25mm eyepieces for the observation. A 25mm eyepiece helps us to observe a bigger sky than a 9mm one, so we can spot it more easily. After that, we use 9mm to take pictures.

3.3.2. Observing Castor Double Stars

Step 1. Setting up telescopes

Step 2. Turn on the power switch on the telescope and wait until the control is ready.

Step 3. Press the Enter button to begin the alignment process, the menu will appear showing the many different methods of alignment.

Step 4. Roll and select Sky Align, press Enter to continue.

Step 5. Select the Standard Time.

Step 6. Select zone 7 for time zone, then enter the date.

Step 7. Look up in the sky with the naked eyes and choose three bright stars.

Step 8. Use the Finder to adjust the telescope in order to merge the center of the red dot with the stars, then press Enter.

Step 9. Use the buttons to center the stars in the eyepiece and press Align.

Step 10. Wait for the hand control to calculate the alignment. After a few seconds, the telescope is now aligned.

Step 11. Use the Stars button to choose Castor.

Which eyepieces can be used to observe those double stars?

In general, because of the large distance between the Earth and the double stars, we can not use the low magnification to observe them. In this case, we use a 7mm eyepiece for observing Castor double stars.

4. Results and Discussion

4.1. The Sun

- Time: 2:15 p.m. (GMT +07)
- Date: 08/12/2023
- Distance: 0.985118 AU
  147.4 million km
  8.19 light min
- Celestial coordinates:
  + Azimuth: 221° 30’ in the southwest
  + Altitude: +33° 30’ above horizon
  + Right ascension: 16h 58.9m
  + Declination: -22° 42’

This figure shows the Sun in the color of orange. If we look closely, we can see dark spots on the Sun’s surface, which are also called sunspots. They appear darker because they are cooler than the surrounding areas due to strong magnetic activity.

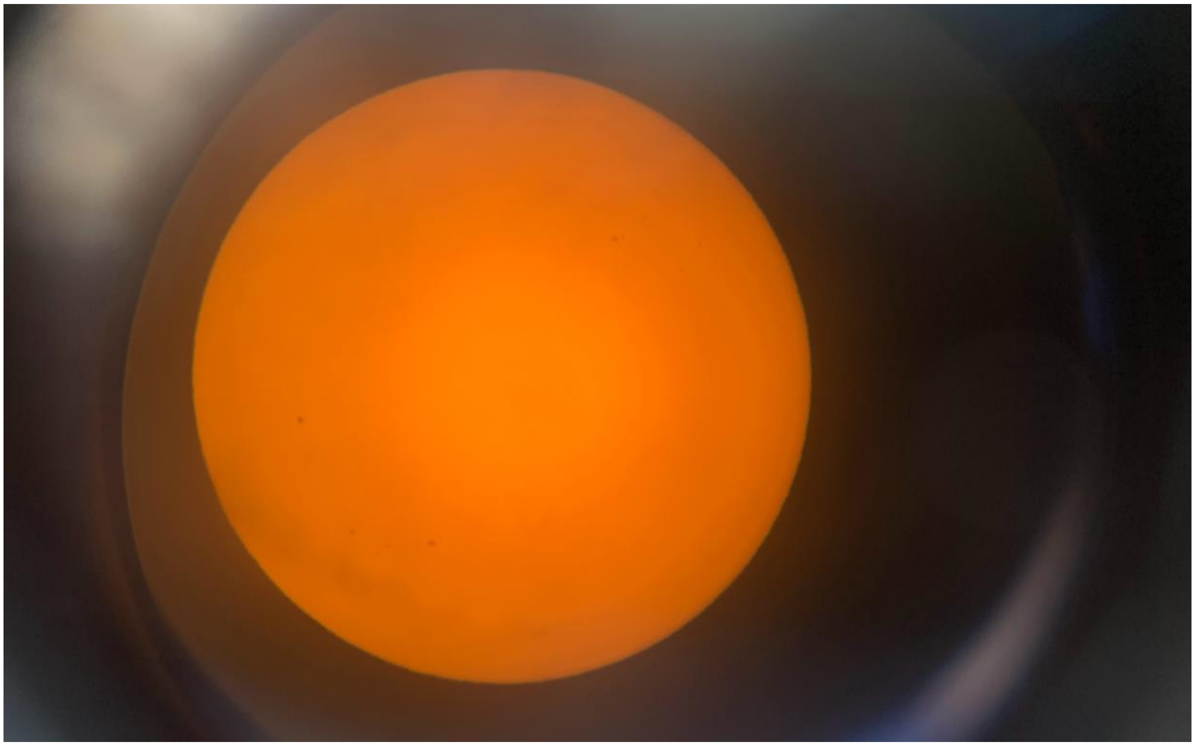

Figure 5: The Sun

4.2. The Moon

- Time: 7:25 p.m. (GMT +07)
- Date: 21/12/2023
- Distance: 368643 km

  1.23 light sec
- Celestial coordinates:
  + Azimuth: 188° 03’ in the south
  + Altitude: +77° 06’ above horizon
  + Right ascension: 01h 20.5m
  + Declination: +08° 12’

In Figure 6, we can see that the Moon is less than half bright, and we took this photo at the beginning of the month so it is in the Waning Crescent phase. Moreover, we can observe a huge number of craters which are formed when asteroids and comets collide with the Moon's surface.

Figure 6: The Moon

4.3. Jupiter and Saturn

4.3.1. Jupiter

- Time: 7:05 p.m. (GMT +07)
- Date: 22/12/2023
- Distance: 4.349193 AU
  650.6 million km
  36.17 light min
- Celestial coordinates:
  + Azimuth: 117° 17’ in the southeast
  + Altitude: +72° 27’ above horizon
  + Right ascension: 02h 15.3m
  + Declination: +12° 16’

In Figure 7, we can easily see Jupiter's belts with brown and zones with white, which are clouds of ammonia and water.

Figure 7: Jupiter

4.3.2. Saturn

- Time: 7:30 p.m. (GMT +07)
- Date: 22/12/2023
- Distance: 10.162139 AU
  1520.2 million km
  84.52 light min
- Celestial coordinates:
  + Azimuth: 240° 05’ in the southwest
  + Altitude: +31° 30’ above horizon
  + Right ascension: 22h 20.2m
  + Declination: -12° 08’

In Figure 8, we can see a planet with a remarkable ring. But when we look closer, we can see a small gap in the ring and this is called the Cassini division. Although it's a bit faint, we still can see that Saturn has not only just a ring but a system of rings.

Figure 8: Saturn

4.4. The Castor Double Stars

Time: 8:30 p.m. (GMT +07)
Date: 22/12/2023
Visual magnitude: +1.58 and +2.97
Distance: 368643 parsecs (50.9 light years)
Celestial coordinates:

+ Azimuth: 063° 16’ in the northeast
+ Altitude: +23° 24’ above horizon
+ Right ascension: 07h 36.1m
+ Declination: +31° 50’

Apparent properties of the double stars:

With the apparent magnitude of 1.58, Castor is one of the brightest stars in the night sky and appears singular to the naked eye. However, by using the telescope, showed that it’s clearly double, including two white stars while it is a multiple star system made up of six individual stars (three components) according to research.

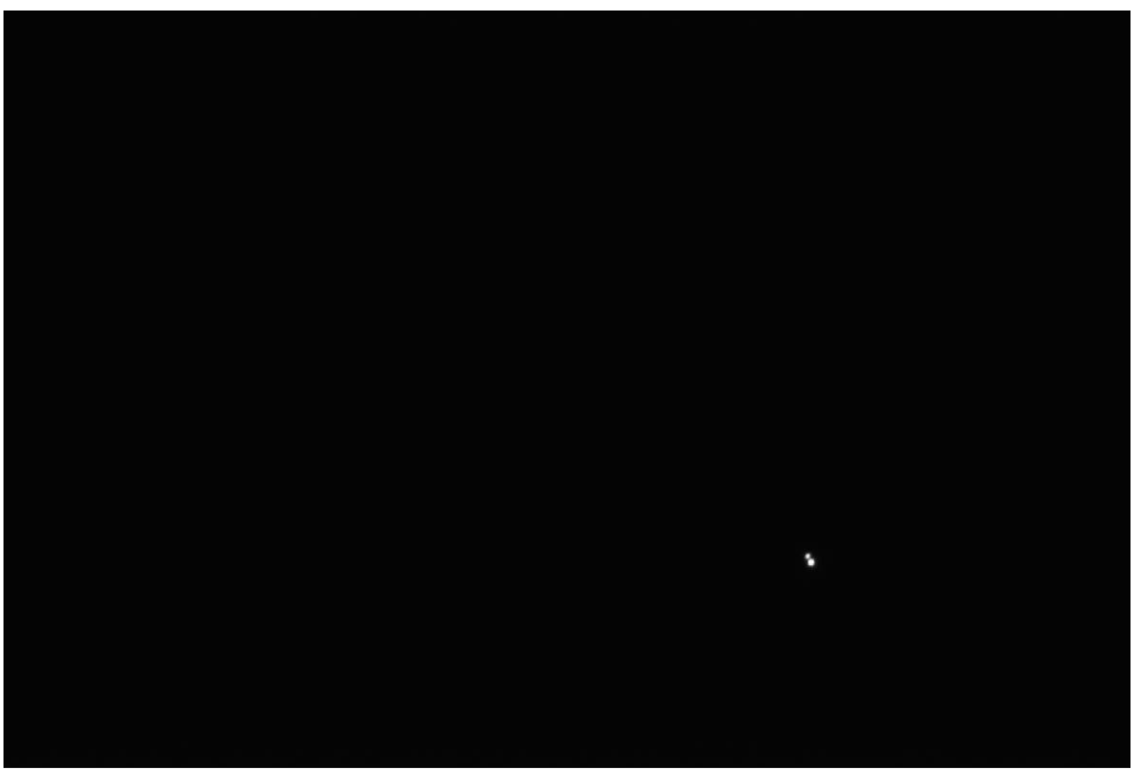

Figure 9: Castor Double Stars

The angular distance of Castor double star:

We use the ASIStudio application to take the picture of Castor in pixels, then calculate the angular distance with Python.

```
castor= io.imread('
2023-12-22-1407_5-CapObj_0000.PNG',
as_gray=True)
threshold = castor > np.max(castor)*
0.9
contours=measure.find_contours(
threshold,0.8)
contours=sorted(contours,key=len,
reverse=True)

castor_contours=contours[0]
star_contours=contours[1]

castor_center=np.mean(castor_contours
,axis=0)
star_center=np.mean(star_contours,
axis=0)

castor_y,castor_x=castor_center
star_y,star_x=star_center

pixel_dist = np.sqrt((castor_x-star_x
)**2+(castor_y-star_y)**2)
print("Pixel distance: ",np.round(
pixel_dist,2) ,"pixels")
```

```
fov_long=1.01
fov_short=0.68

img_width=castor.shape[1]
img_height=castor.shape[0]
ang_dist_long = pixel_dist*fov_long/
img_width
ang_dist_short = pixel_dist*fov_short/
img_height
ang_dist = np.sqrt(ang_dist_long**2+
ang_dist_short**2)
print("Angular distance: ",np.round(
ang_dist,2),"degrees")
```

Figure 10: Our code to calculate the angular distance of Castor Double Stars

The results:

Pixel distance: 19.08 pixels

Angular distance: 0.01 degree

4.5. Discussion

4.5.1. How many ways are there to align a telescope?

1. Sky-Align: works by aligning on any three bright stars or planets in the sky.
2. One Star Align: uses the entered time/ location information and allows the user to select one alignment star. Provides a fast alignment, at the expense of less pointing accuracy.
3. Two Star Align: uses the entered time/location information and allows the user to select which two alignment stars the telescope will automatically slew to.
4. Auto Two Star Align: will display a list of visible daytime objects (planets and the Moon) available to align the telescope.
5. Solar System Align: will display a list of visible daytime objects (planets and the Moon) available to align the telescope.
6. Quick-Align: will ask you to input all the same information as you would for the Two Star Align procedure.
7. EQ North/ EQ South Alignment: is used when polar aligned on an optional equatorial wedge. Similar to the altazimuth alignments described earlier, the EQ alignments give you the choice of performing an AutoAlign, Two-Star alignment, One-Star alignment, or Solar System alignment.

4.5.2. How to align the telescope?

In order to align the telescope, we set the hand control according to the following steps:

- Turn on the power switch on the telescope and wait until the control is ready.
- Press the Enter button to begin the alignment process.
- A menu will appear showing the many different methods of alignment. Roll and select Sky Align, press Enter to continue.
- Select Standard Time.
- Select zone 7 for time zone, then enter the date.
- Look up in the sky with naked eyes and find three bright stars.
- Use the hand control button to move the telescope toward the first star. Look through the finder and move the telescope to center the red dot in the finderscope. Press Enter.
- Use the buttons to center the star in the eyepiece and press Align.

- Repeat the procedure for the second and third star.
- Wait for the hand control to calculate the alignment.After a few seconds, the telescope is now aligned.

4.5.3. Why do we need to have a finder attached to the telescope?

Finderscopes are generally very low in magnification between 6x and 9x the naked eye- while some have no magnification at all. Without the finder scope, locating objects simply by looking in the main telescope would be very difficult. Even at a telescope's lowest magnification, it is still far too much magnification for locating objects easily. Basically, a finder scope is a tool for bringing objects into your telescope's field of view.

4.5.4. What are the main features of each planet? How can we observe them? Describe those features with captured images.

The surface of Jupiter and Saturn

Jupiter and Saturn are both gas giants, so they don’t have true surfaces. Their surfaces are mostly composed of hydrogen and helium. They consist of an outer layer of compressed molecular hydrogen surrounding a layer of liquid metallic hydrogen. The outermost portion of their hydrogen atmosphere contains many layers of visible clouds that are mostly composed of water and ammonia. The reason why their surfaces are gaseous is because they are formed in regions with higher temperatures and greater distances from the Sun. In these colder regions, hydrogen and helium could remain in a gaseous state rather than condensing into solids.

Jupiter’s Great Red Spot

The Great Red Spot is 16,350 kilometers wide, which is about 1.3 times the width of the Earth. The Great Red Spot is an anticyclone, rotating counterclockwise once about every six days, and produces winds up to 580 mph. No one knows for sure exactly how or when the Great Red Spot formed. Also, researchers aren't entirely sure what causes the spot to appear red. Some of them think it could be due to chemicals like ammonia in the upper part of the storm.

Although it’s quite difficult to spot, we can slightly see there is an enormous red spot as we circle in Figure 11 below:

Figure 11: The Great Red Spot

Saturn’s Rings

The rings of Saturn are the most extensive ring system of any planet in the Solar System. They consist of countless small particles, ranging in size from micrometers to meters, that orbit around Saturn. The ring particles are made almost entirely of water ice, with a trace component of rocky material. The ring system is extremely huge as it has seven main rings. From the planet outward, they are D, C, B, A, F, G and E. With a 9mm eyepiece, we can simply notice the ring system. However, to observe exactly each ring and gaps within them, we need to use stronger eyepieces.

References

Astronomy 06: Astronomical Instruments