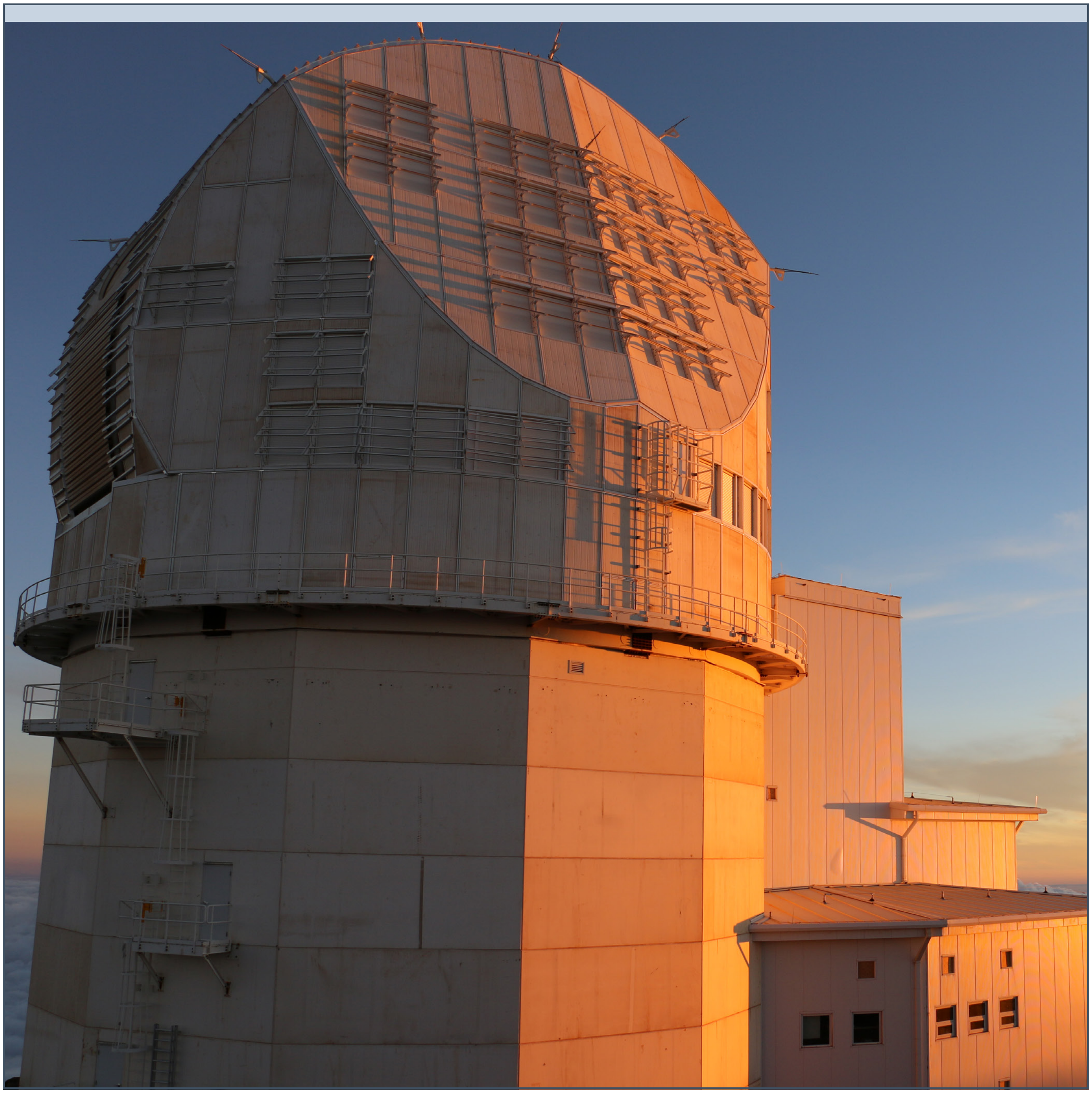
Journey To The Sun
Teacher Guide
Lesson 6

Grades: 6 - 8
Duration: 1-2 class periods
Standards: MS-ETS1-3.4.1
SC.8.2.1



Observing the Sun

Funded by the National Science Foundation

www.nso.edu

Objectives

At the end of this lesson, students will be able to:

1. Describe the scientific tools used in observing the Sun
2. Differentiate between types of telescopes and their abilities
3. Explain how lens or aperture size is related to image quality
4. Explain trade-offs and why they occur so often in science and society decision making

Standards

MS-ETS1-3.4.1
Analyze and interpret data to determine similarities and differences in findings.

SC.8.2.1
Describe significant relationships among society, science, and technology and how one impacts the other.

Key Vocabulary

Aperture

Lens

Refractor

Reflector

Telescope

Trade-off

Materials

- Lesson Packet: www.nso.edu/educators/jtts-curriculum
- Slideshow: "***Observing the Sun***"
- How Telescopes Work.mp4 (included)
- Activity Materials (See activity sheets)

Background

The invention of modern reflector telescopes has changed the ways in which scientists observe the Sun and space in a revolutionary way. In this lesson, students learn the basics of light collection, optics, and technologies involved in seeing the most distant objects on the Sun and in space. Following this interactive lesson, students practice tracking sunspots and graphing real data from professional telescopes. See the follow-up activities: "Sunspot Tracking" and "Sunspot Graphing Practice".

Directions

Using the slideshow provided, review with students the information provided on each slide.

Slide #

2. Students think critically to answer the question "Why do your pupils get bigger in the dark?" Students can share out their ideas in a number of ways, including think-pair-share, small group sharing, or writing answers on the board.

3. Facilitate the quick demonstration outlined on the slide. Students sit in the dark (or cover their eyes), then observe each other's pupils as the light is turned on.

4. Explain that the bigger your pupils get, the more light photons are captured. This is why pupils get bigger in the dark. This is the same reason for larger lenses and apertures in cameras and telescopes.

5. Lead a short discussion comparing images captured by human eyes vs images captured by cameras. Be sure to draw attention to the size of a human pupil vs camera lens size and how this relates to image quality.

6. In order to see very faint, very distant objects in space, large telescope mirrors and lenses are required.

7. Interactive slide / check for understanding. Students match lens sizes with images of different qualities. If students understand the content thus far, they will match the largest lens size with the best quality image.

8. Answers to the matching activity on the previous slide.

9. The black and white picture is the surface of the Sun at the level of detail as would be observed through a telescope with a 4m aperture or mirror. Be sure to point out that the image taken is of an area of the Sun comparable to the size of Earth.

10. Introduce the two basic types of telescopes: Refractor and Reflector.

11. Compare and contrast refractor and reflector telescopes.

12. Most professional telescopes are reflectors because they can be built larger. Thus, they provide brighter, clearer images.

13-22. Students identify refractor and reflector telescopes. Suggestion: convert these slides into an electronic survey or quiz using kahoot.it, where students can "buzz in" their answers.

23. Not only are there different types of telescopes (i.e. mirror vs lens), but different telescopes also observe different wavelengths of light.

Directions Cont...

Slide #

24. Point out that NASA's Fermi Gamma-ray observatory observes light in the gamma ray wavelength range of the electromagnetic spectrum.

25. Ask students to discuss the differences they observe between the solar images taken at different wavelengths by different telescopes.

26. Introduce students to the concept of "Space-Based" and "Ground-Based" telescopes

27. This infographic details the limitations of ground-based or space-based telescopes when observing different wavelengths of light. The higher the atmospheric opacity, the less observable the wavelength is through Earth's atmosphere. For example, Earth's upper atmosphere blocks gamma rays, x-rays, and UV light. These are best observed in space using space-based telescopes.

28-30. Discuss the differences and trade-offs between ground-based and space-based telescopes.

31. Introduce students to the concept of "trade-offs". A trade-off is like a compromise. If one thing increases, some other thing must decrease. Slides 28-30 detailed trade-offs between ground-based and space-based telescopes. For example: Space based telescopes can observe images in x-ray and gamma-ray more clearly than ground based telescopes, the trade-off is that they are more expensive to launch and repair.

32. Have students demonstrate their understanding of trade-offs by thinking of as many as they can, either regarding telescope technology or any other general topic, like doing homework for example.

33-39. Belief Circle. Give students the opportunity to identify and discuss their beliefs about a number of topics in science and society. Each slide gives a statement and students are to choose whether or not they agree with it. After a statement is given, have each thumbs up student pair with a thumbs down student and allow them to discuss and analyze their differences of opinion.

40. Introduce the follow-up activities: "Sunspot Tracking" & "Sunspot Graphing Practice", where students analyze data obtained by real, professional, telescopes and observatories. In the activity "Student Solar Observations", students gather, record, and analyze their own data using the Coronado Personal Solar Telescope.

Activity - Sunspot Tracking

Adapted by NSO from NASA and the European Space Agency (ESA).
https://sohowww.nascom.nasa.gov/classroom/docs/Spotexerweb.pdf / Retrieved on 01/23/18.

Objectives

In this activity, students determine the rate of the Sun's rotation by tracking and analyzing real solar data over a period of 7 days.

Materials

- ☐ Student activity sheet
- ☐ Calculator
- ☐ Pen or pencil

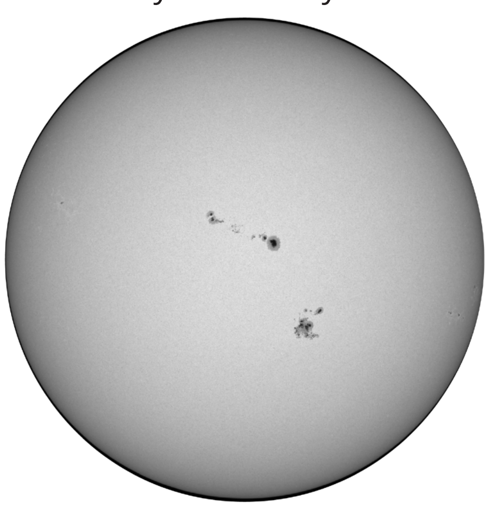
Background

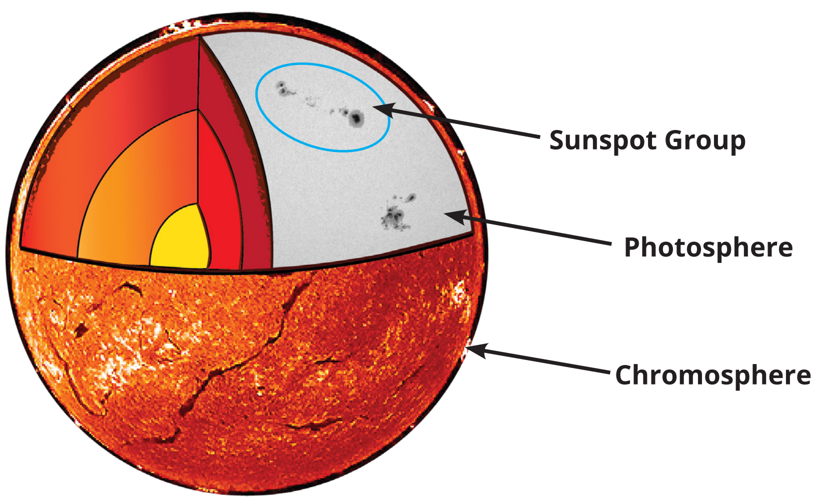
In this activity, you'll observe and track sunspots across the Sun, using real images from the National Solar Observatory's: Global Oscillation Network Group (GONG). This can also be completed with data students gather using www.helioviewer.org. See lesson 4 for instructions.

GONG uses specialized telescope cameras to observe different layers of the Sun in different wavelengths of light. Each layer has a different story to tell. For example, the chromosphere is a layer in the lower solar atmosphere. Scientists observe this layer in H-alpha light (656.28nm) to study features such as filaments and prominences, which are clearly visible in the chromosphere.

For the best view of sunspots, GONG looks to the photosphere. The photosphere is the lowest layer of the Sun's atmosphere. It's the layer that we consider to be the "surface" of the Sun. It's the visible portion of the Sun that most people are familiar with. In order to best observe sunspots, scientists use photospheric light with a wavelength of 676.8nm.

The images that you will analyze in this activity are of the solar ***photosphere.*** The data gathered in this activity will allow you to determine the rate of the Sun's rotation.





Directions

This activity can be completed individually or in groups of 3. Each student in a group will track one of the 3 visible sunspot groups (A, B, or C). If a student works individually, they will track all 3 sunspot groups.

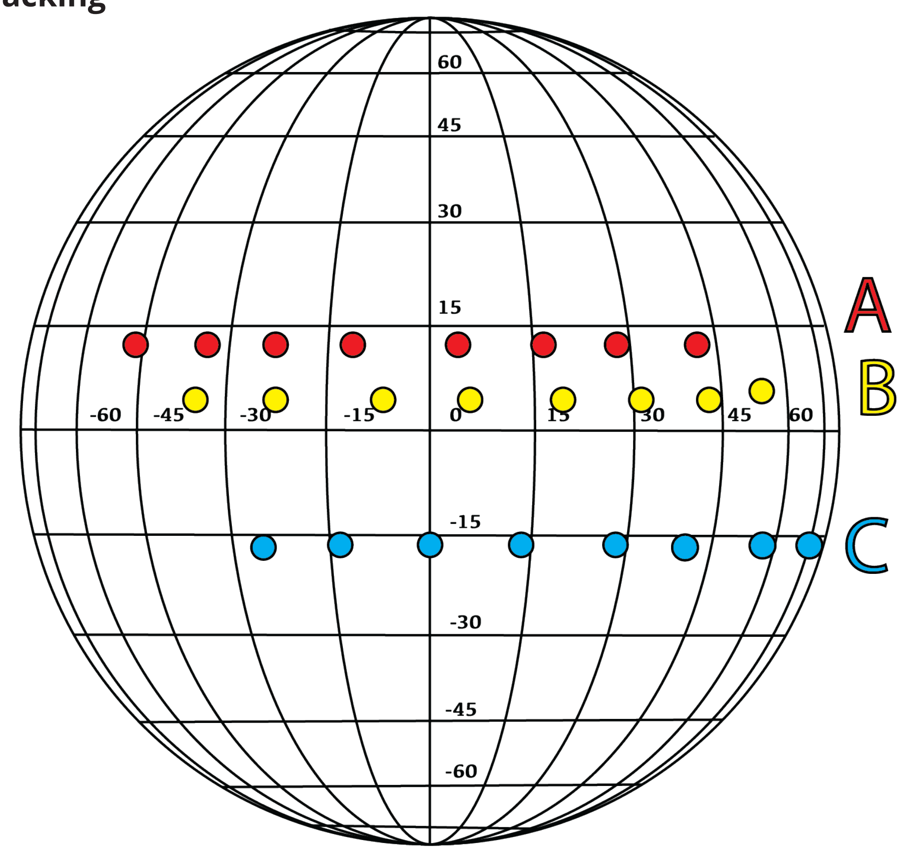
1. Print out the Sunspot Tracking Data Sheet. Each student or group of students will need one.

2. Observe the sunspot images from September 1st to September 8th.

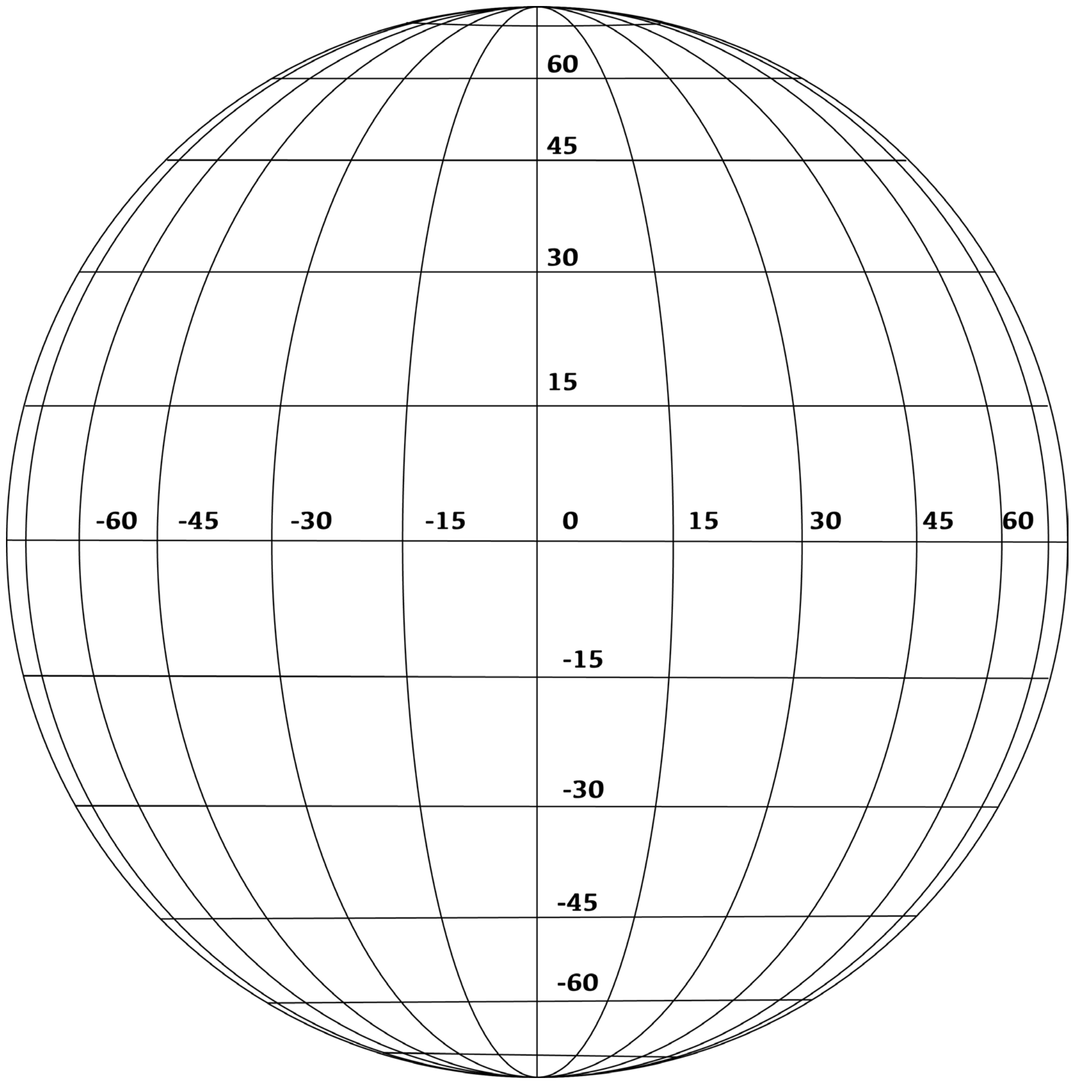
3. For each day, mark where the sunspots appear on your mapping grid. Note the date and any changes in shape or size. Also, write down each sunspot's position in terms of longitude.

This activity is meant to simulate stepping outside at the same time each day and observing sunspots with a solar telescope. NSO images are provided to use in the event that there are no actual sunspots present on the sun at the start of this activity.

Sample Tracking Grid

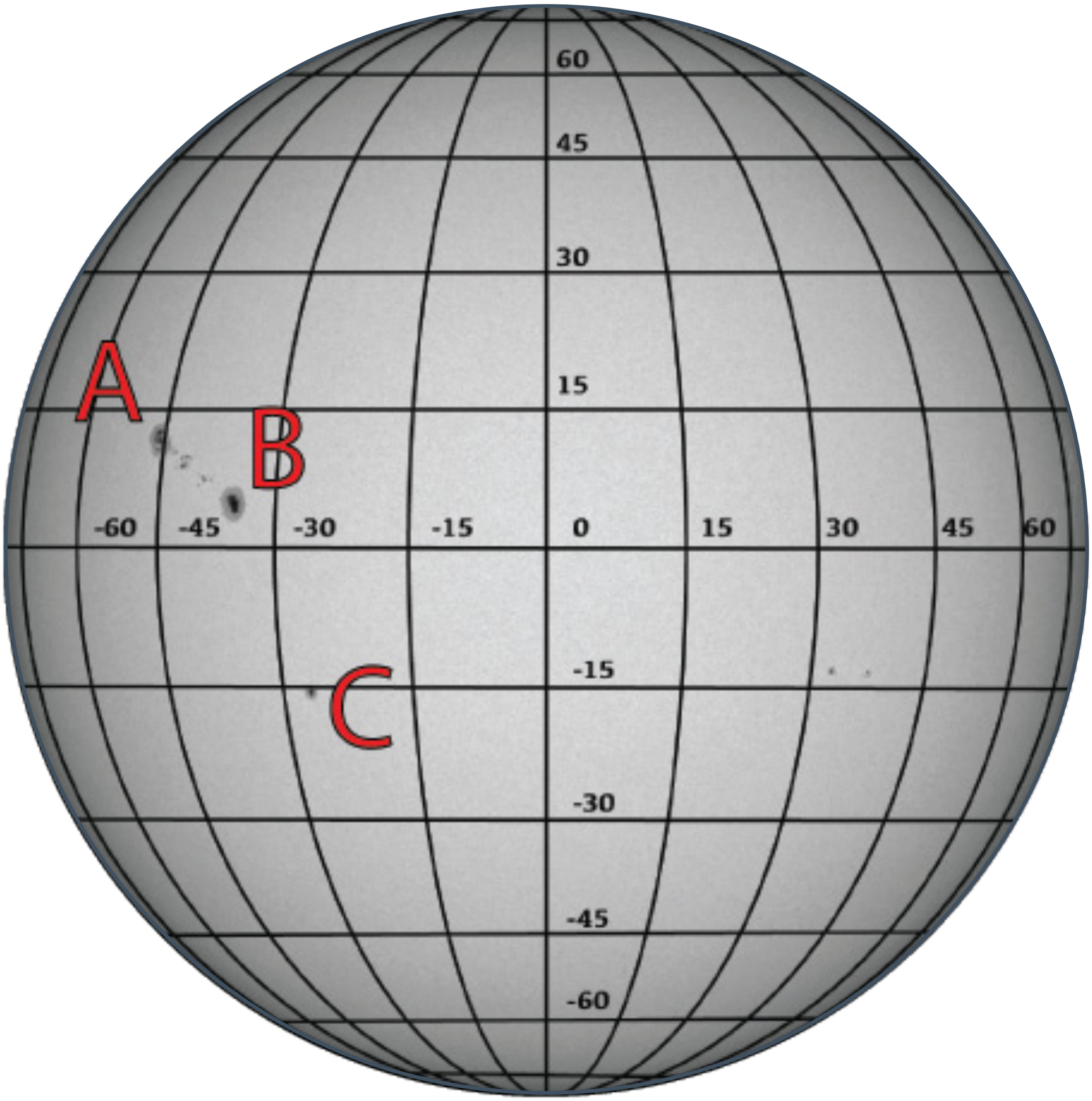


Sunspot Tracking - Student Data Sheet

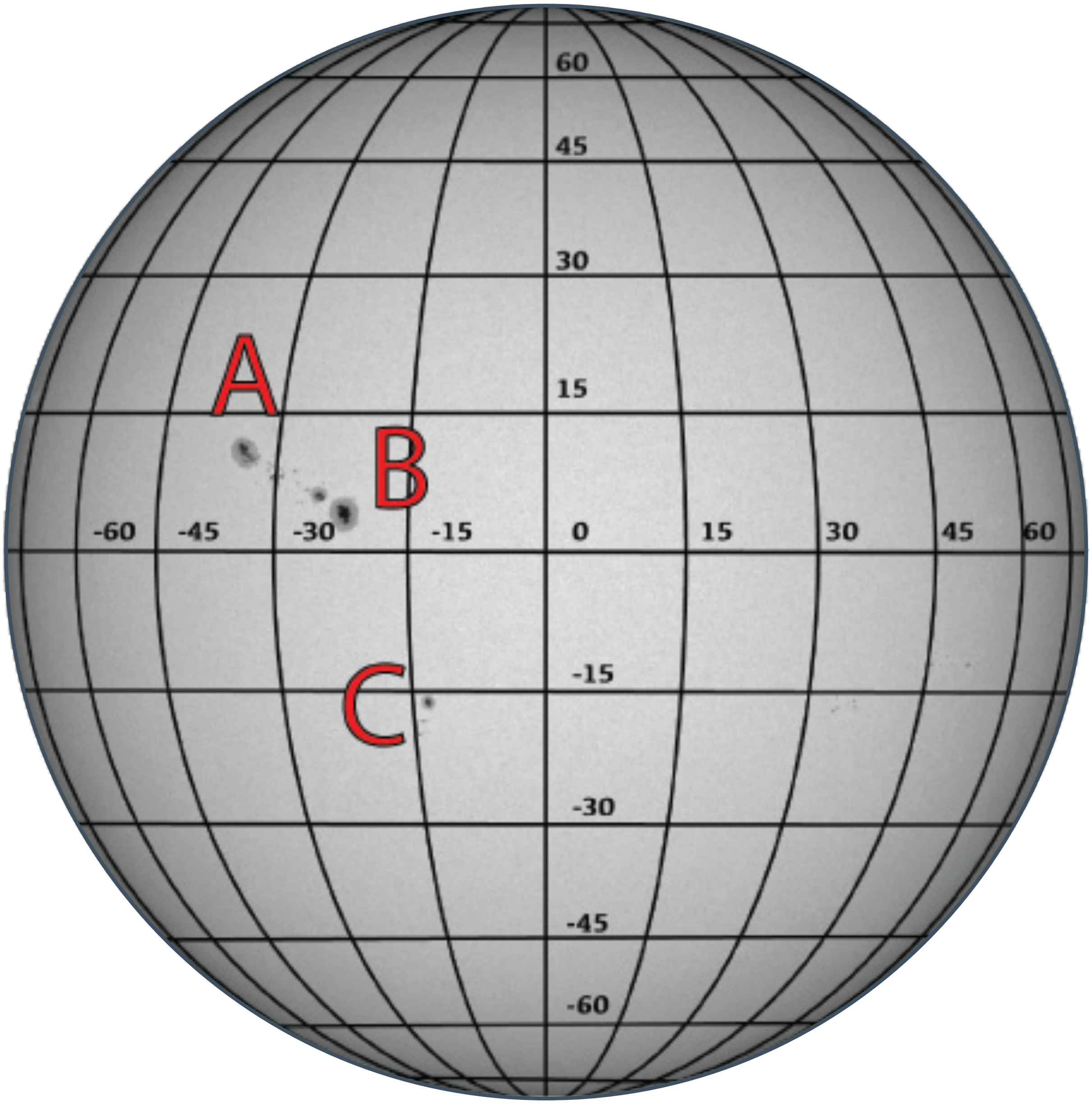


DAY	Sunspot Longitude (degrees)			Number of degrees sunspots moved from previous day		
	A	B	C	A	B	C
1						
2						
3						
4						
5						
6						
7						
8						

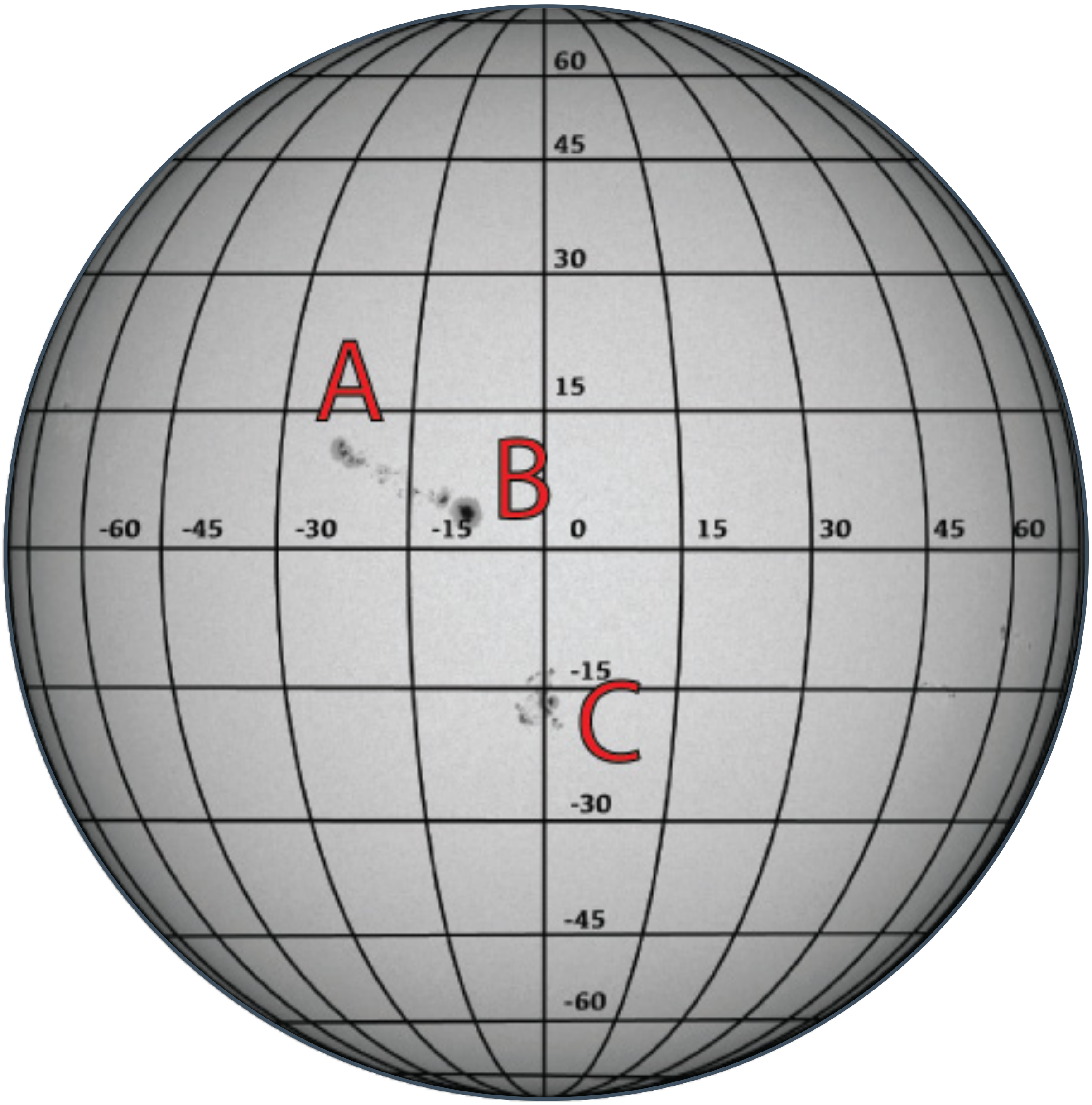
September 1st



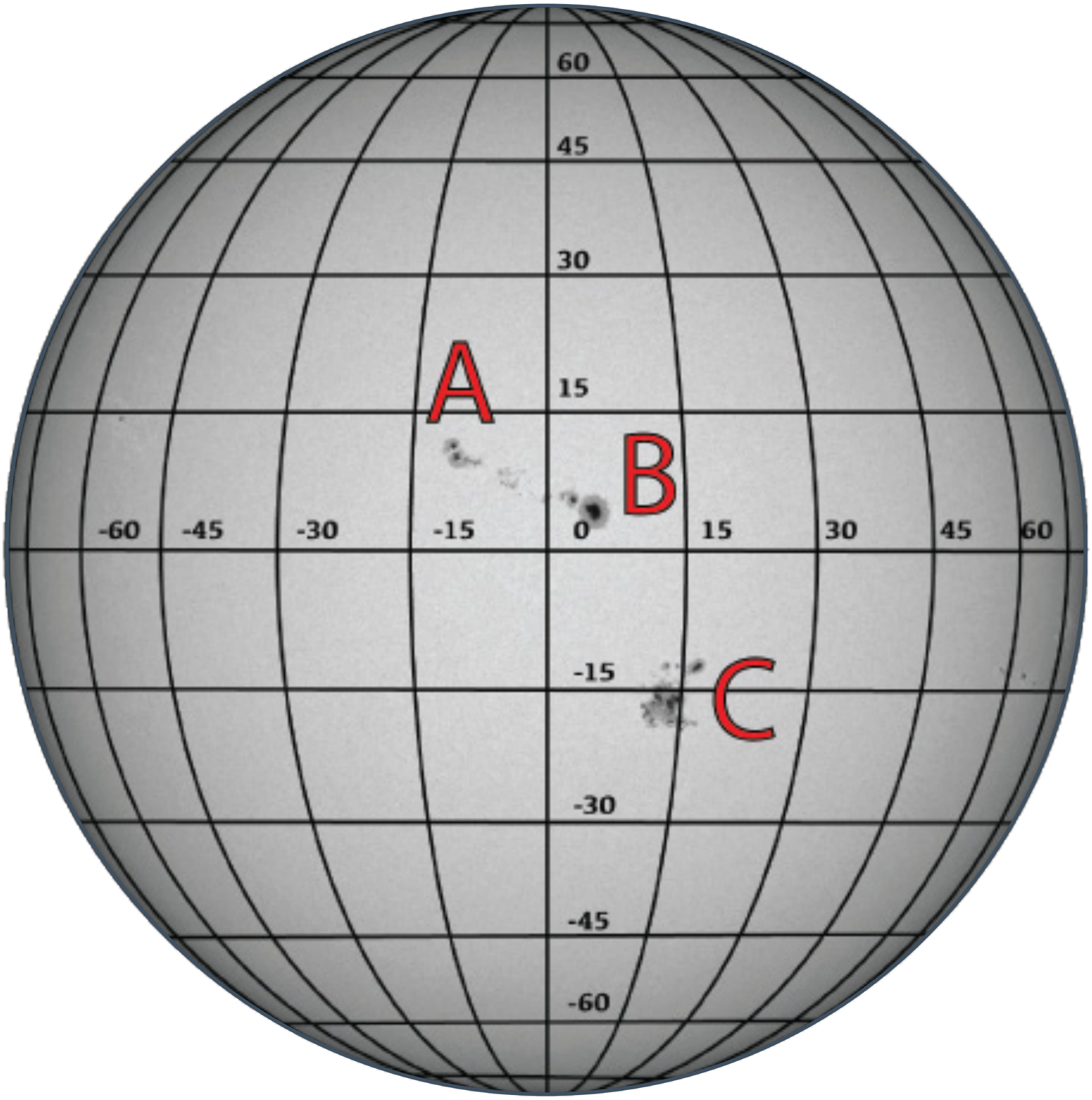
September 2nd



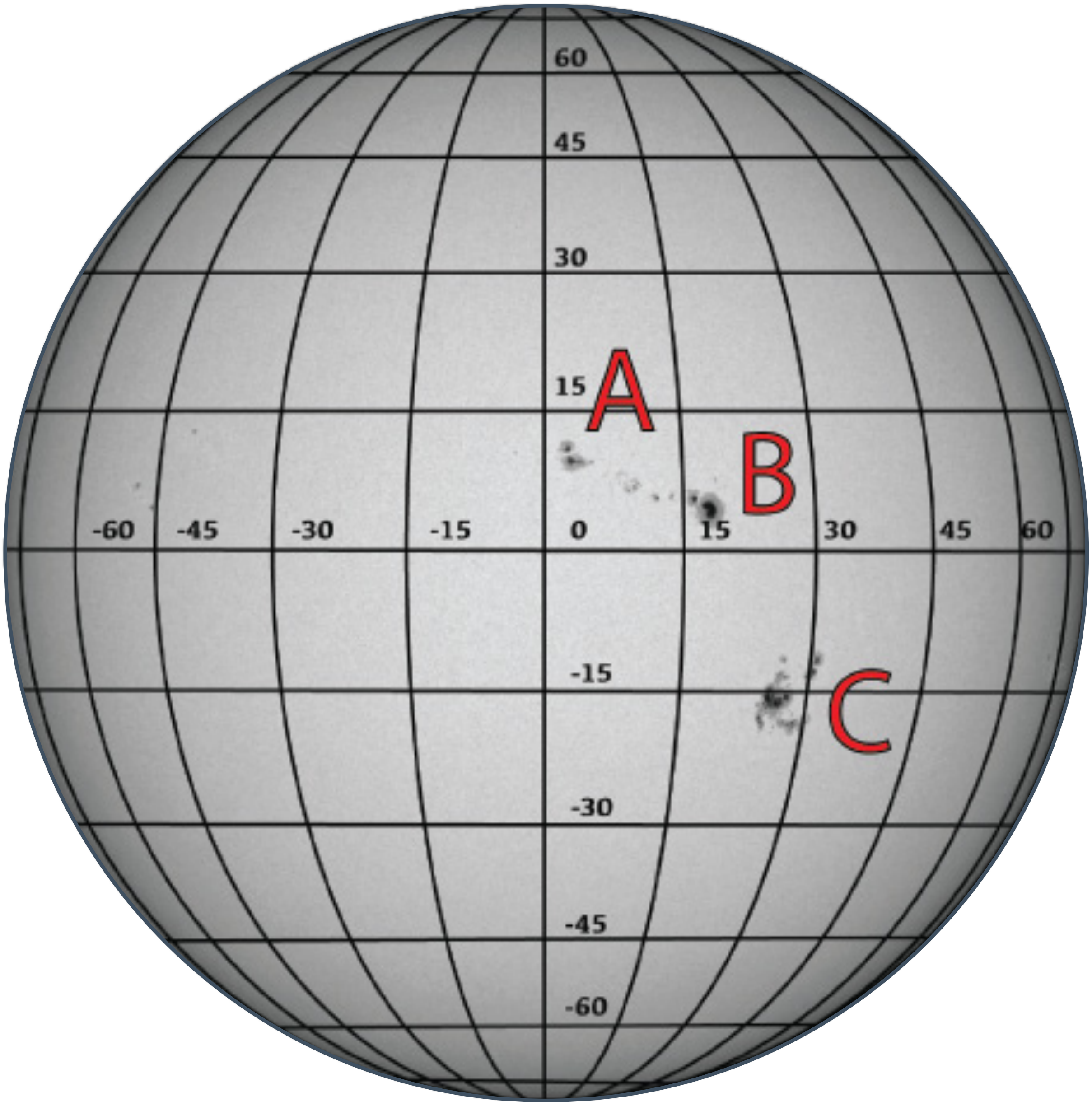
September 3rd



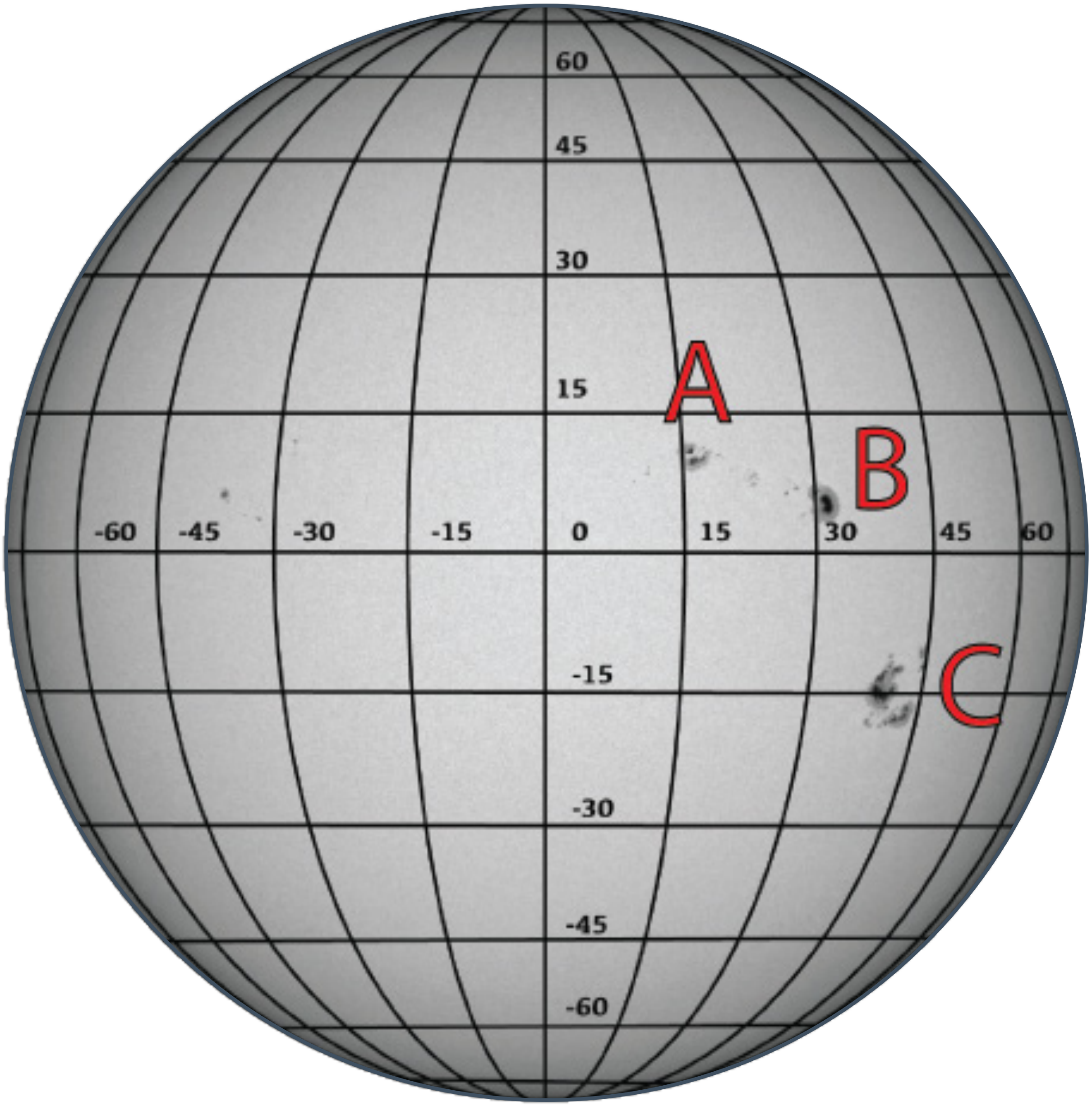
September 4th



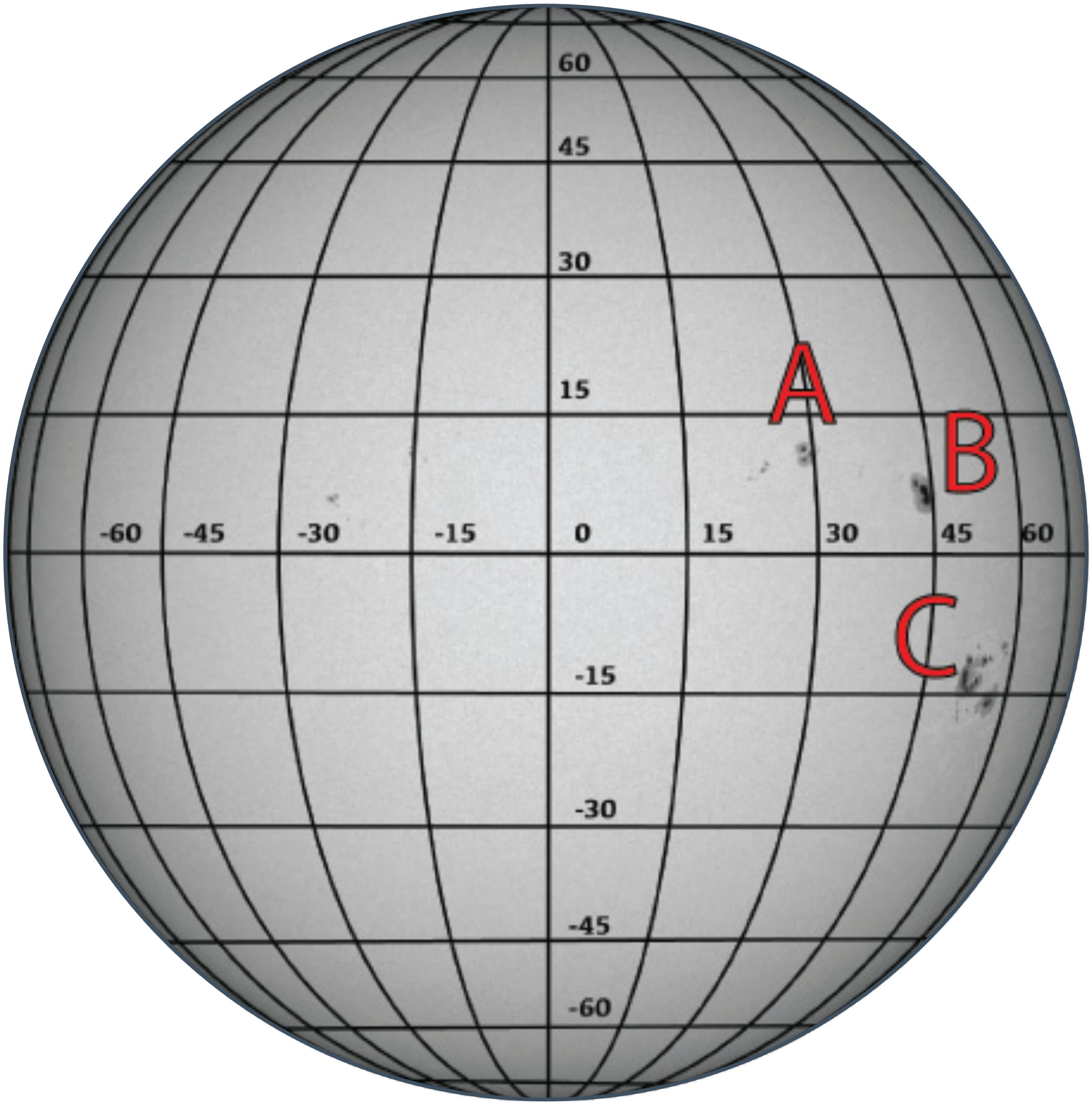
September 5th



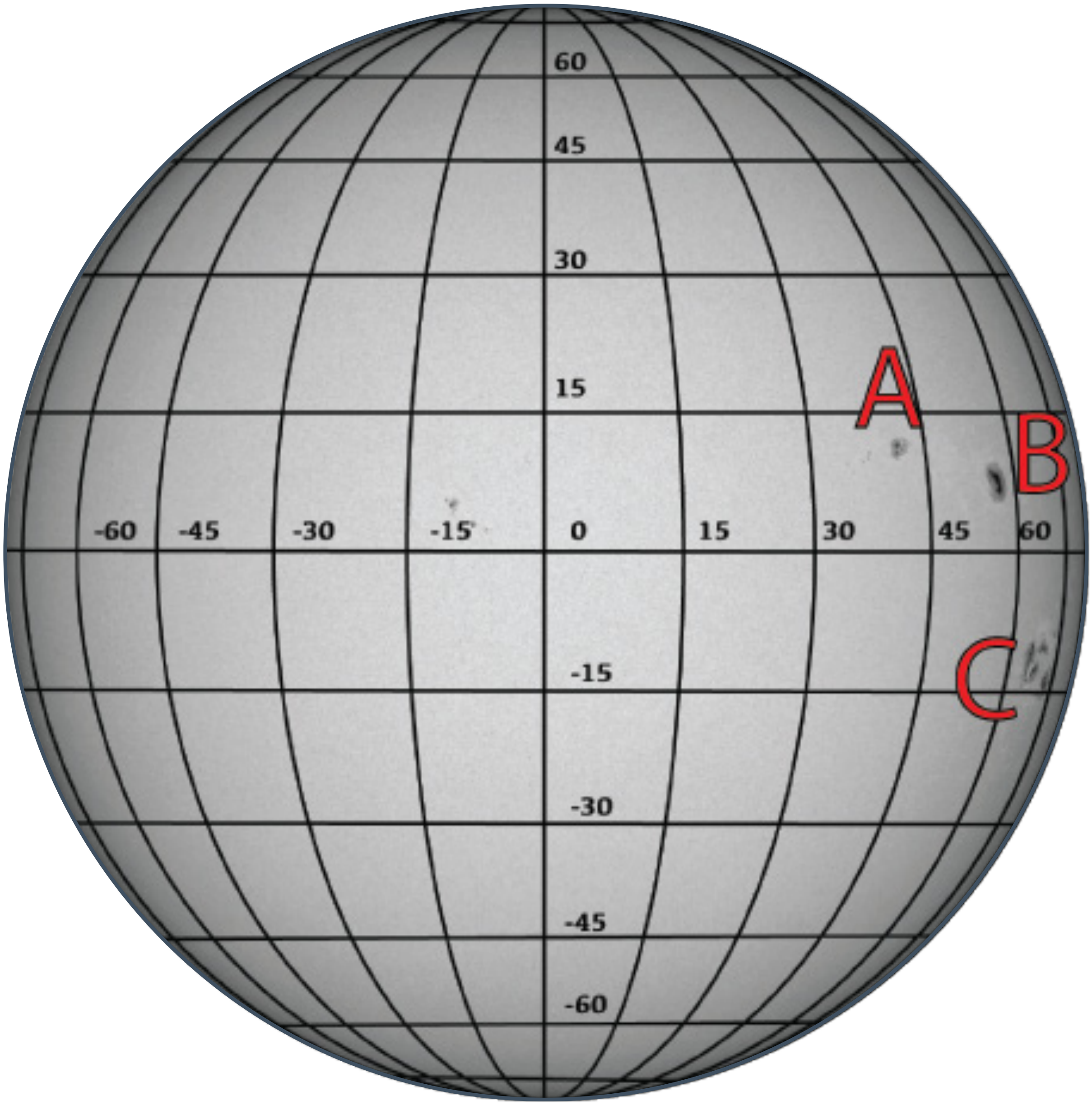
September 6th



September 7th



September 8th



Analysis

What is the average daily rate of sunspot movement?

To answer this, determine the total degrees of change from one day to the next. For example, if you noted the sunspot at -60° on Monday, than at -45° at the same time on Tuesday, then you can conclude that the sunspot moved 15° in one day. Repeat this calculation for each 24-hour period. Then, add the daily movement values together and divide by the total number of days (24-hour periods) over which the changes took place.

Example:

DAY	Sunspot Longitude (degree)	Number of degrees sunspot moved from previous day
Day 1	-60	
Day 2	-50	(60-50) = 10
Day 3	-40	(50-40) = 10
Day 4	-30	(40-30) = 10

Total number of degrees moved = (10+10+10) = 30

Total number of observation days = (4-1) = 3 days

Average rate of sunspot movement = 30 degrees / 3 days = 10 degrees per day.

**Remember, this is just an example, Sunspots do NOT actually move at a rate of 10 degrees per day. You will calculate the actual rate using the data that YOU gather.*

Fill in with your ACTUAL data:

Total Number of Degrees Moved from Day 1 to Day 8 =

A:____ B:____ C:____

Total Number of Days (24-hr. periods between day 1 and day 8) = 7

Rate of Sunspot movement =

A: ______ degrees per day

B: ______ degrees per day

C: ______ degrees per day

Average Rate of Sunspot Movement between groups A, B, and C:

__________________ degrees per day

How long does it take the Sun to make one full rotation of 360°?

To answer this, first we need to recognize that the Earth moves around the Sun in the same direction at about 1° per day:

Earth revolves 360° around the Sun in about 365 days.

Thus:

360/365 = 0.99° per day (approximately 1 degree per day)

Therefore, because our telescopes are located on Earth, it seems like the Sun is rotating slower than it really is. We have to correct for this; we must add 1° per day to our initial calculation.

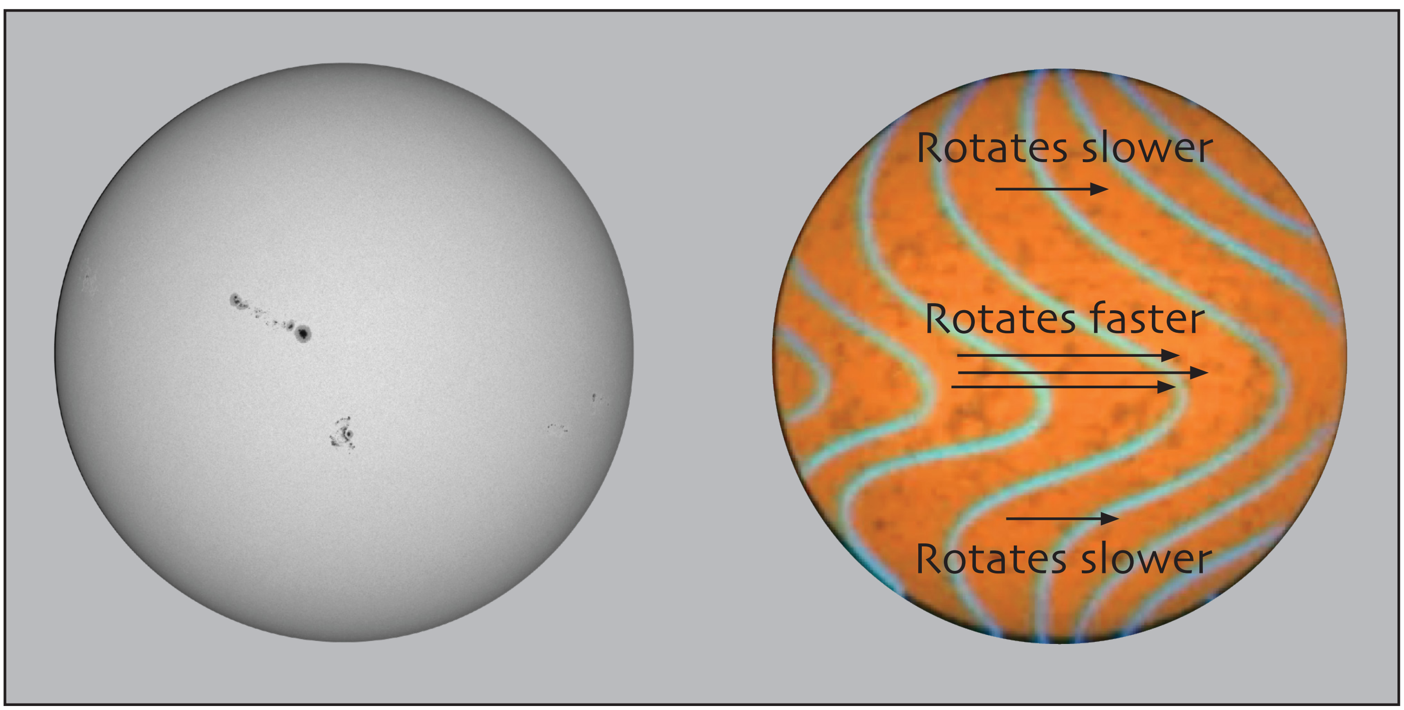
For example: If your initial calculation gave you a sunspot rate of 12° per day, the corrected rate would be 13° per day.

Lastly, use this information to draw your conclusion.

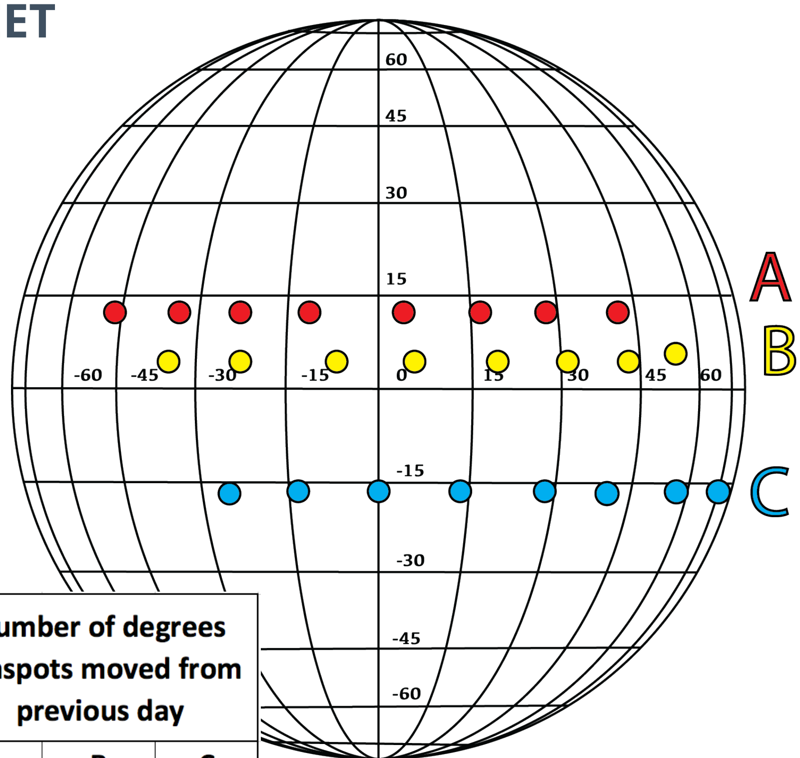
How long does it take the Sun to rotate 360°?

The Sun rotates once every ____ days

Note the Sun isn't a solid object, therefore it does not rotate at the same rate everywhere on its surface. The Sun rotates slightly faster at the equator than it does near the poles.



Sample Answer Sheet



DAY	Sunspot Longitude (degrees)			Number of degrees sunspots moved from previous day		
	A	B	C	A	B	C
1	-46	-35	-24			
2	-34	-23	-13	12	12	11
3	-24	-7	0	10	16	13
4	-12	5	14	12	12	14
5	3	17	29	15	12	15
6	16	31	40	13	14	11
7	28	38	59	12	7	19
8	41	49	75	13	11	16

Total Number of Degrees Moved from Day 1 to Day 8 =
A: 87 B: 84 C: 99

Total Number of Days (8-1) = 7

Rate of Sunspot movement =
A: (87/7) = 12.43 degrees per day
B: (84/7) = 12 degrees per day
C: (99/7) = 14.14 degrees per day

<u>How long does it take the Sun to rotate 360 degrees?</u>
Average degrees per day = (12.43 + 12 + 14.14) / 3 = 12.86
Account for the Earth's revolution (12.86 + 1 = 13.86)
360 degrees / 13.86 degrees per day = 26 days

*Remember, this is not a precise measurement. The Sun rotates at different speeds between the poles and equator.

Activity - Student Solar Observations

Objective

In this activity, students gather, record, and analyze their own data using the Coronado Personal Solar Telescope.

Materials

- ◻ Coronado Personal Solar Telescope
- ◻ Observation Data Sheets (included)
- ◻ Camera or cell phone for taking pictures (optional)
- ◻ Internet access (to verify observations)
- ◻ Pen or pencil

SAFETY WARNING

Never look at the Sun through an ordinary telescope without a solar filter. This can lead to severe eye damage and blindness. Only specialized SOLAR telescopes/filters should be used to view the Sun.

Background

NEVER TRY TO OBSERVE THE SUN WITHOUT EYE PROTECTION, IT CAN LEAD TO BLINDNESS!

The Sun radiates so much light that in order to observe it safely, we must use telescopes with special filters that only let some of the light through. The filter you will be using is called a "Hydrogen-alpha" filter, which only lets wavelengths of approximately 656nm (red light) through. This filter should allow you to see solar prominences, filaments, flares, and even sunspots!

In the activity, you will:

1. Observe the Sun using a Coronado Personal Solar Telescope, which uses an H-alpha filter.
2. Sketch images of the Sun either daily, weekly, or monthly.
3. Demonstrate that the Sun rotates, by recording sunspot positions over time.
4. Record the number of sunspots visible on the Sun on any given day.

Telescope Make: Meade Coronado
Telescope Model: Personal Solar Telescope (PST)
Aperture Size: 40mm
Focal Length: 400mm

Directions

1. Determine where the Sun rises. Find a reference point where you will know to look when trying to find the Sun on its path. What times did the Sun rise and set on the day of your observation?
2. Observe through a solar telescope
3. How many sunspots can you see? What are their locations?
4. How many filaments can you see? What are their locations?
5. How many prominences can you see? What are their locations?
6. List some differences between what you observed yesterday and today. Sketch what you see.
7. Verify your observations. Visit National Solar Observatory's H-Alpha Monitor:

   halpha.nso.edu

8. Write a quick journal entry about the day's observations.
   - Did you notice anything different or special?
   - What was your favorite observation?
   - Make predictions about what you'll see the next day, week, year...
9. Record your responses on the observation data sheets provided.

Student Data Sheet

Date: ______________

Time: ______________

Scientist (student name): ____________________

Weather conditions ________________________

Sky conditions _____________________________

Telescope make & model:

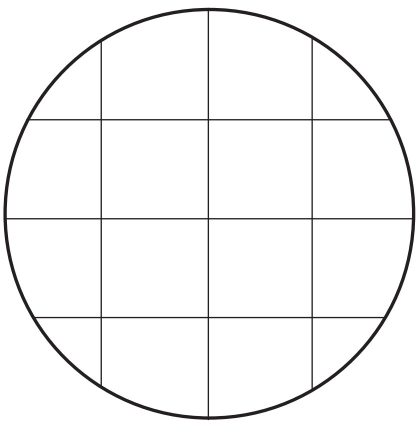
____

Aperture size: _______________________

Focal Length: _______________________

Observe the Sun:

Carefully sketch what you observe through the telescope. Draw as many features as you can.



# of Sunspots visible: _____

# of Filaments visible: _____

# of Prominences visible: _____

Written description of observations:

(colors, sizes, and locations of features) ___________________________

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Verify your observations with the following websites:

http://halpha.nso.edu
www.helioviewer.org

Does what you observed through the telescope match what you found online? Explain.

Additional observations from the online resources:

Journal Entry:

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The National Solar Observatory (NSO) is the national center for ground-based solar physics in the United States and is operated by the Association of Universities for Research in Astronomy (AURA) under a cooperative agreement with the National Science Foundation Division of Astronomical Sciences.

The National Science Foundation (NSF) is an independent federal agency created by Congress in 1950 to promote the progress of science. NSF supports basic research and people to create knowledge that transforms the future. Please refer to www.nsf.gov.

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