

Student Guide to Activity 4: The Sun's Period of Rotation



Problem: How can we determine the Sun's period of rotation?

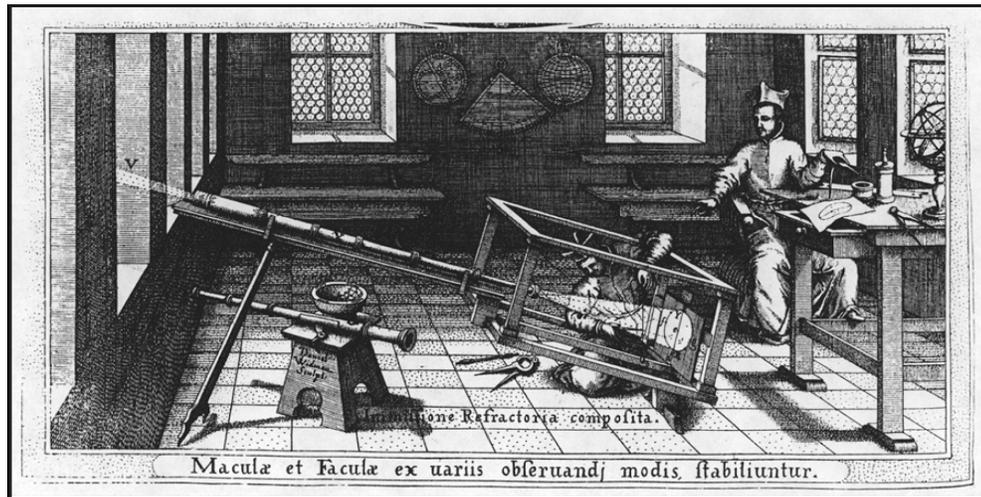
Introduction

You and your buddy are having a “camp out.” It’s 4:00 AM. You’ve awakened so many times that you’ve lost count. What was it this time? Was there some little sound, the tent flapping in the gentle breeze, or the purr of a cat, or maybe the snapping of a twig? You feel safe enough in your own back yard, snuggled warmly in your sleeping bag. You aren’t really scared, but you hear every tiny sound that never before seemed so loud; night seemed to drag on forever. Finally, the first hint of daylight appears as your eyelids grow heavy and your brain starts wondering, “What causes day and night?”

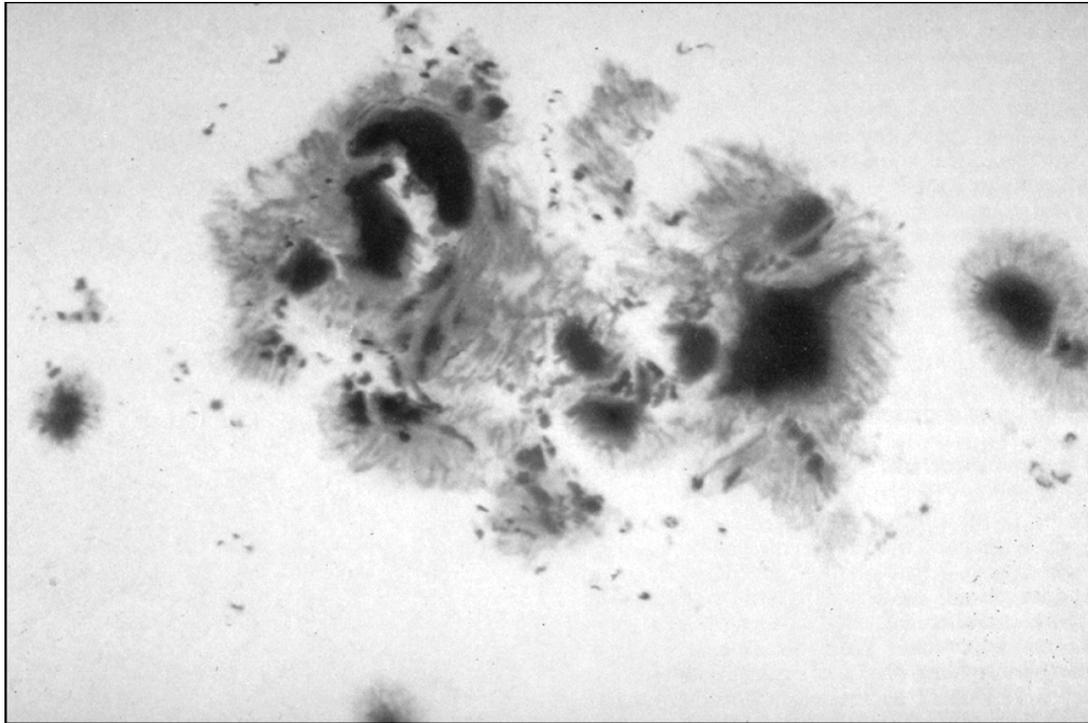
You might answer, “Earth’s rotation,” but you’ve heard others say, “Earth’s revolution.” Which response is correct? If you mean Earth’s spinning on its axis, then “rotation” is correct. As Earth rotates, the Sun comes into view at daybreak. Earth continues to spin, so that the Sun appears to move across the sky until it sets at night. The Sun is no longer visible, but Earth continues to rotate until the Sun comes into view the next morning. One complete rotation takes about 24 hours, or one day. In contrast, “revolution” means the motion of a body around a point in space or another body. Earth’s tilt on its axis and its revolution around the Sun give us seasons. After about 365 rotations, or one year, our Earth has revolved around the Sun one time.

We know from personal experience that Earth rotates because we experience day and night and we know that the Sun does not revolve around Earth. What about our Sun, that sphere of glowing gas rising just beyond the eastern horizon? Does it rotate? To find out, we can use one of the Sun’s most prominent features, sunspots.

Ancient Chinese, Japanese, and Greek literature refer to observations of spots on the Sun; however, the first recorded telescopic observations of sunspots were not made until 1610 by Galileo, an Italian astronomer. After many years of speculation, we are still not sure what causes sunspots, but we do know some interesting details about them.



Here, Christopher Scheiner, a contemporary of Galileo's, and a fellow Jesuit scientist trace sunspots in Italy, in about 1625.



A large sunspot can sometimes be 20 times larger than Earth (courtesy, Space Environment Center/NOAA)

Current theory says that sunspots are caused by horseshoe shaped magnetic fields, buried just below the Sun's surface, that prevent the flow of hot gases from below. Like a horseshoe magnet, sunspots have both a magnetic north and south pole. The spot where the magnetic field is located cools slightly compared to its surroundings. Because the spot is cooler, it looks darker.

Sunspots occur in 11 year cycles where the sunspot number increases from a minimum of almost zero to a maximum of over 100 spots. After one 11 year cycle, the poles of the horseshoe shaped magnetic fields switch and another cycle begins. Consequently, we have an overall 22 year magnetic cycle as well as an 11 year sunspot cycle.

At the beginning of an 11 year cycle, several spots appear at about $30\frac{1}{2}$ north and south latitudes. As the cycle progresses, you can track the sunspots' motion. Generally, individual sunspots or groups of sunspots do not shift significantly in latitude over time. However, they do seem to move across the face of the Sun. What do you think could be the reason for this? Could we use this apparent motion to determine the Sun's **period of rotation**?

ACTIVITY 4 STUDENT WORKSHEET

1. Locate the major group of sunspots on the photographs in Figure 5.
2. Place the plastic overlay (Figure 4) on the photographs so that you can determine the latitude and longitude for the major sunspot group. Each vertical and horizontal line equals 10° latitude and longitude, respectively.
3. Estimate how far the sunspot group moves between day one and day two by subtracting the smaller longitude from the larger. Record this longitude change in the Table below. Estimate this number to the nearest whole degree.
4. Repeat the same process for the next days up to day four and record your results.
5. The Earth revolves around the Sun at a rate of 360 degrees in one year (365 days) or an average motion of about 1° per day. Since Earth revolves around the Sun in the same direction as the Sun rotates, our motion seems to chase after the sunspots. Thus, the apparent movement of sunspots is less than the real rotation by about 1° per day. Therefore, you must compensate for the orbital motion of Earth by adding 1° to your computed apparent daily motion.
6. Let us assume that sunspots are features whose position on the Sun does not change very much over the course of a solar rotation. Use the following proportion to calculate the Sun's **period of rotation** (in days):

$$\frac{\text{corrected longitude change}}{1 \text{ day}} = \frac{360 \text{ degrees}}{X \text{ days}}$$

7. Find the average rotational period and record it in the Table below. Calculate to the nearest tenth of a day. Be prepared to share your result with the class.

Sunspot Motion Table - For Student Use

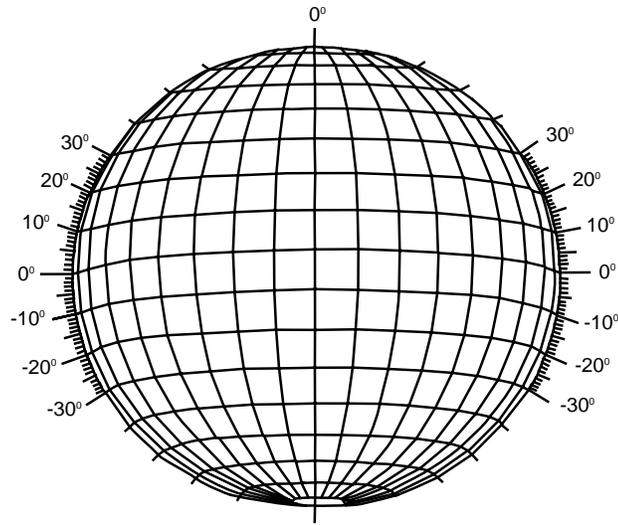
	Longitude of Sunspot Group	Change in Longitude (Ex: Day 2 - Day 1)	Corrected Longitude Change	Period of Rotation (Solve for "X")
Day 1				
Day 2				
Day 3				
Day 4				
Average Rotational Period =				



Questions:

1. Since the sunspot group appears to move across the Sun's surface, what kind of solar motion does this suggest?
2. Based on your calculations, what is the Sun's average **period of rotation**?
3. If the sunspot group had changed latitude would you have been able to calculate the number of degrees of change per day as easily? Why or why not?
4. Answer the problem question at the beginning of this activity. Include in this discussion what you learned about the Sun and what more you would like to learn about the Sun.

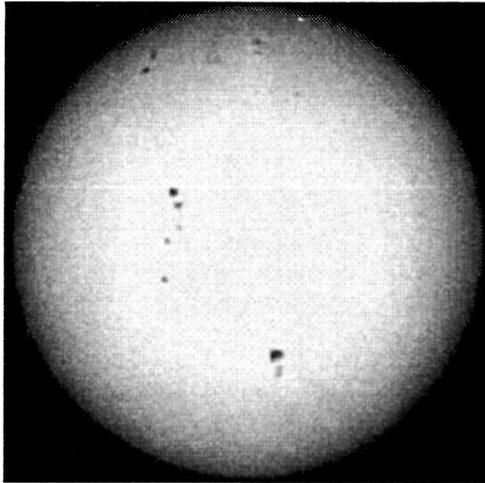
Figure 4. Solar Grid Overlay



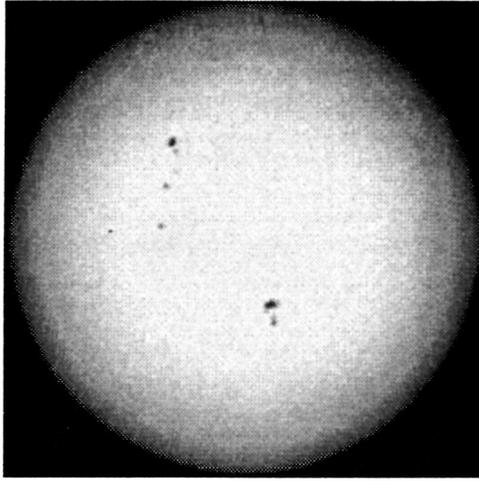
NOTE: Each horizontal or vertical line = 10° latitude or longitude, respectively.

Instructions: Copy this onto transparencies for use with Figure 5.

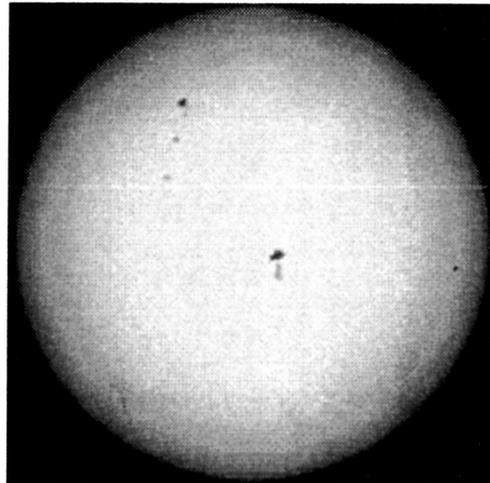
Figure 5. Sun Rotation Series



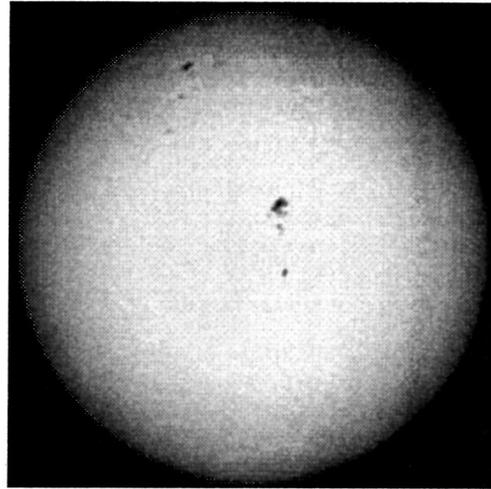
Day 1



Day 2



Day 3



Day 4

Sunspots can be used to determine how long it takes the Sun to rotate about its axis. These visible images were taken by the Japanese Yohkoh spacecraft, during February 12th through the 15th, 1996.