Activity 8

Determining the Rotation Period of the Sun

Relevant Reading

Chapter 2, section 3

Purpose

Determine the rotation period of the Sun. Although numerous methods for accurate measurement are used in solar research, the method described here, using photographs taken over several days, will allow determination to within an Earth-day.

Materials

Photo set that shows at least one solar feature that can be followed over a several-day period. For real challenge, take the photos yourself, or make a simple projection sketch of sunspots over several days.

1 sheet of clear plastic used for overhead transparencies or viewgraphs, or something similar such as a clear plastic report folder

a mm ruler, compass and protractor

a fine-tipped marking pen suitable for plastic

graph paper with 1-mm squares

Procedures

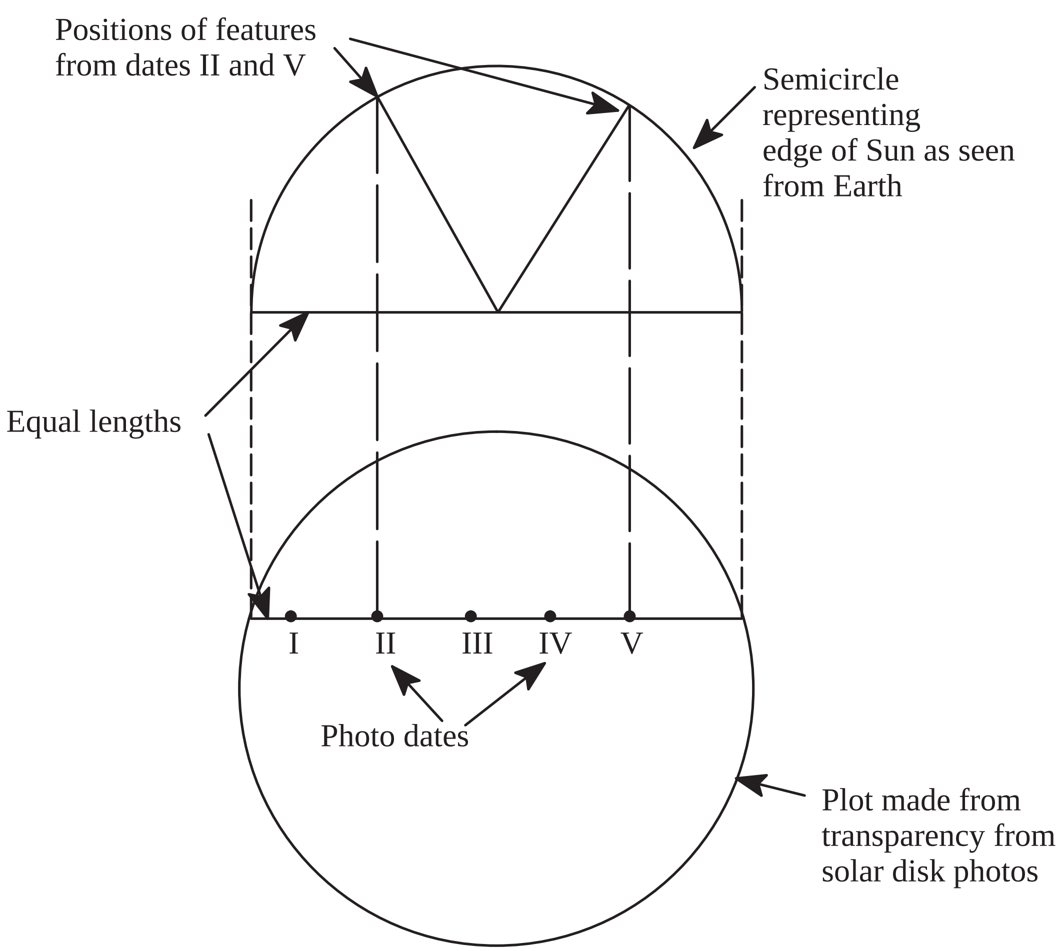
1. Measure, to the nearest millimeter, the diameter of the Sun on the photo taken near the middle of the data period.
2. Use a compass and draw a circle with the same diameter on the transparent sheet.
3. With the circle aligned over the photo on the date used for the diameter, trace the axis orientation marks onto the transparency.
4. Pick a solar feature that traverses the solar disk for as many days as possible. Align the circle on the transparency over each successive photo and carefully mark the position of the chosen solar feature along with its date.
5. Carefully draw the best fitting straight line through the marked positions and measure its length across the circle as accurately as possible. (Note that (a) unless the chosen feature follows right along the solar equator, the length of this position line will be less than the measured solar diameter, and (b) the line should be perpendicular to the solar axis.

6. Because the sun is a sphere, features near its edge (limb) will be foreshortened and motion there will not appear the same as motion near the center of the disk. To compensate for this, the positions on the transparency will be translated to a semicircle that represents the path of the solar feature viewed edge-on from Earth.

7. Using the measure of the line representing the solar feature's path as a diameter, draw a semicircle on a piece of graph paper. This semicircle represents the edge of the Earth-facing surface of the Sun along the feature's path.

8. Carefully transfer the positions marked on the transparency to the diameter line of the semicircle and again indicate the dates.

9. Chose two widely separated positions, avoiding those that are close to the limb (position accuracy will be less here) and mark their positions on the semicircle by drawing a perpendicular to the diameter through the position point to the semicircle. These markings indicate the actual position of the solar features on the Sun's surface.



10. Now connect these to points to the center of the diameter line so that a central angle is formed. Measure this angle with a protractor as accurately as possible (0.1 degrees can be estimated).
11. Calculate the number of degrees traveled per day for this solar feature.
12. If more than one feature is distinguishable in the photos, or another set of photos is available, repeat the process and then average the calculations of the degrees travelled per day.
13. One full solar rotation is 360° so instead of degrees per day, the number of days for a full rotation should also be calculated. Do this by dividing 360 by the value found for the degrees travelled per day.

Discussion

Because all the photos or observations of the Sun are made while our Earth is moving through space, the calculations performed here actually have this planetary motion "hidden" in them. The Sun rotates on its axis in almost the same direction as the Earth revolves around the Sun in space. Therefore, any features noted on the solar surface will have to travel more than 360° to get back to a place that appears the same as viewed from Earth. The name given to the time periods that include the Earth's motion is called **synodic**, while periods found related to the "fixed" background of stars is called **sidereal**. Because the Sun has had to rotate more than 360° to "catch up" with the moving Earth, the synodic period is longer than the sidereal period by about 2 days.

To calculate the sidereal period from the synodic value,

Let R = sidereal period
S=synodic period
Then $R = S \times 365.26\ (S + 365.26)$
The value of 365.26 is the number of days in an Earth Sidereal year.

Solar astronomers have found that the Sun exhibits a differential rotation. That is, it rotates at different rates at different latitudes, with the faster rates nearer the equator. An extension to this activity would be to analyze features from several latitudes and then determine the solar rotation rate as a function of latitude.