Astronomy 101 Lab - Solar Observing

For this lab, you will be using real images of the Sun taken at the Big Bear Solar Observatory and data from other observatories. You will determine the rotation period of the Sun using sunspot positions, similar to what was done by Galileo and you will study some of the solar features.

When the Sun is unusually active, the aurora borealis, or northern lights, can be visible in more of the continental U.S., including here in Champaign. You will be using data from that time period, when there were many sunspots and large number of solar flares.

In the lab room, you will find several images of the Sun. You will find three images taken in white (visible) light on October 26, 27, and 28. These images will be labeled with the date on which they were taken. You will also find a fourth image labeled "GONG", showing a map of the magnetic field strength on the Sun on October 27. Put this last image aside for now.

You will now use sunspot positions to track the rotation of the Sun. On the white light images, the sunspots are the dark splotches. Look at the three white light images and find three sunspot groups that appear on each image (each dot will be a group rather than a single spot). You will track the progress of these spots as the Sun rotates.

Call the first sunspot group object "1"; the second and third groups will be object "2" and object "3", respectively. Now, you must be careful here. We know that the image we see of the Sun is a circle. You know that if you measure horizontally across a circle, you will get the largest value at the equator and a value that approaches zero as you approach the poles. For each object, measure the distance across the image of a horizontal line that passes through your object. Record the length of this line in the appropriate space below.

1. Total horizontal distance across the image for:
   a. Object #1 (cm): _______________________
   b. Object #2 (cm): _______________________
   c. Object #3 (cm): _______________________

Locate each object on the 26th and measure the distance (in cm) from the object to the left edge of the image. Fill in the appropriate spaces in the table below. Repeat the procedure for the 27th and 28th.

2. Distance from Object to Left Edge of Sun

<table>
<thead>
<tr>
<th>Date</th>
<th>Object 1 Distance (cm)</th>
<th>Object 2 Distance (cm)</th>
<th>Object 3 Distance (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You will now use your data to determine the rotation rate of the Sun. Calculate the distance travelled by each spot (in cm) between the image taken on the 26th and the image taken on the 27th. Do this by taking the object distance on the 27th and subtracting the object distance on the 26th.
3a. Distance travelled (cm) by spot 1 (10/26-10/27): ____________________
3b. Distance travelled (cm) by spot 2 (10/26-10/27): ____________________
3c. Distance travelled (cm) by spot 3 (10/26-10/27): ____________________

Calculate the distance travelled by each spot between the image taken on the 27th and the image taken on the 28th.

4a. Distance travelled (cm) by spot 1 (10/27-10/28): ____________________
4b. Distance travelled (cm) by spot 2 (10/27-10/28): ____________________
4c. Distance travelled (cm) by spot 3 (10/27-10/28): ____________________

Calculate the average distance travelled by each spot in 1 day of time. As an example:

\[
\frac{\text{Distance travelled by spot 1 (10/26-10/27)} + \text{Distance travelled by spot 1 (10/27-10/28)}}{2} = \text{Average distance travelled by spot 1 in 1 day of time.}
\]

5a. Average distance travelled by spot 1 in 1 day of time: __________________
5b. Average distance travelled by spot 2 in 1 day of time: __________________
5c. Average distance travelled by spot 3 in 1 day of time: __________________

To get the time for each spot to cross the front of the sun, take the total horizontal distance across the Sun for each spot and divide it by the average distance travelled by the spot in 1 day of time. For example:

\[
\frac{\text{Total Distance across Sun for spot 1 is 18 cm. Average distance travelled by spot 1 in 1 day of time is 1.2 cm.}}{1.2} = 15 \text{ days to cross the front of the Sun.}
\]

6a. Time for spot 1 to cross the front of the Sun: ______________________
6b. Time for spot 2 to cross the front of the Sun: ______________________
6c. Time for spot 3 to cross the front of the Sun: ______________________

You have now calculated the time to cross the front of the Sun. To go completely around the Sun would require twice the time you calculated. Multiply each of your above answers by 2 and find the average. This is the rotation period of the Sun.

7. Rotation period of the Sun: ______________________

The rotation period of the Sun near the equator is 25 days. Calculate a percent error for the rotation period you calculated.

8. Percent error: ______________________

9. What do you think is your greatest source of error? ______________________________________

Now, turn your attention to the GONG image. Compare the white light image on October 27th with the GONG magnetogram image. Note specifically the locations of the sunspot groups.

10. Is there a correlation between sunspots in the white light image and structures on the magnetic field image? What does this tell you about the relationship between sunspots and the magnetic field?
On the lab table, you'll find a print-out of a page from spaceweather.com. Look at the data in the left margin to see the most recent sunspot number. How many sunspots were detected? (Include both the date and the number of spots.)

11. Date and number of sunspots: ______________________________

On the lab table, you should also find two graphs. The first is labeled "Sunspot Number" and the second is labeled "Butterfly Diagram". From the "Sunspot Number" graph, estimate the length of the sunspot cycle. Since no cycle is exactly the same, calculate the average over several cycles. Find the average by determining the time between several sunspot maxima and dividing by the number of cycles completed.

12. Length of sunspot cycle: ________________

13. Are we closer to a sunspot minimum or a sunspot maximum? Explain your answer.

14. What was the maximum number of spots ever recorded? _____________

15. How did the number of sunspots in the most recent solar cycle compare with the cycle in which the maximum number of spots was recorded? Was the most recent cycle very active or relatively quiet?

Turn your attention to the next diagram which shows the average latitude of sunspots. Note that the graph shows the sunspot number at the same time on the plot below.

16. What is the latitude of the sunspots at a period of sunspot maximum? ______________

17. Describe how the latitude of sunspots changes when you start at a minimum and go to the next minimum.

The layer of the Sun that we see in visible light is the photosphere, hence this is the layer of the Sun that has been pictured in the images you used above. In the pre-lab, you defined some terms for structures that can be seen on the photosphere.

18. On the back of the page, sketch one of the white light images of the Sun that you used in lab today. On your sketch, label the following features: sunspots, plages, limb darkening, and granules.