Name___________________________________

ASTR 106 Using Sunpots to Measure Solar Rotation due: 30 Sep

This year is the 400th anniversary of the study of sunspots. In 1609, Galileo built a telescope and used it to observe that the Sun was covered with dark spots. Furthermore, he noted that these spots moved across the surface of the sun, indicating that the sun was rotating! At the time these were truly startling ideas. We now know that sunspots are regions of the sun's photosphere that are cooler than their surroundings, and thus look dark. The cooling is the result of the sun's magnetic field lines "popping" through the surface of the sun at the point where we see the sunspots. Since the spots are physically located on the sun's photosphere, the sun's rotation carries them around the sun. In this lab exercise, you will use sunspots to determine the rotation period of the sun, as seen from earth.

DATA COLLECTION PROCEDURE:

Nine optical images of the Sun will be obtained from the image archive at the National Solar Observatory's GONG website: http://gong.nso.edu/Daily_Images. The number of sunspots in the current solar cycle recently reached its minimum; so most days for the past two years have not had any sunspots visible. However, in 2008 there were a few sunspots visible from March 25th through the 2nd of April. You will use images from these days as data for your lab. In the Big Bear section of the GONG image gallery click on "*Archives*: Browse" then click on the Archive Year: 2008 link to view the menu of dates when data is available for last year, with Dec 31 data at the top of the list and Jan 01 data at the bottom of the list. Scroll down the page and click on the thumbnail image labeled bb 080325 to view thumbnail images acquired March 25, 2008. Click on the Scroll down the page of images until you get to the image named "bbiqa080325t1454.jpg"; where *bbiqa* identifies it as a Big Bear Solar Observatory visible light image, 08 is the year, 03 the month, 25 the day, and t1454 represents the time of day when the image was acquired. Click on the thumbnail to see the full size image. Do **not** use magnetogram images from the right hand column!

(8 points) For each of the nine days from **080325** through **080402**, select the image acquired at **14:54**. Print the image for each day so they show the Sun at the same size. Be sure the date and time of the image is on each hardcopy when your browser prints the page.

DATA ANALYSIS PROCEDURE:

On each of the full-disk white light solar images, identify a sunspot that you can clearly identify on at each images. Identify an individual sunspot to follow, not a group.

1. **(3 points)** On each of the nine images identify the two darkest sunspots, noting how they progress across the Sun from day to day. Be sure you follow an individual sunspot, not a group. On each of the images mark the two sunspots you have chosen, using arrows above and below : ˇ•ˆ .

2. **(1 point)** On the GONG images, north is at the top of each image and east is to the left. Which direction do the sunspots move from one day to the next? ___________

3. **(2 point)** Use a ruler to draw a **horizontal** line through the sunspot in each successive picture. Start the line at the left edge of the Sun's image and end the line at the right edge. Avoid choosing spots near either edge of the Sun.

4. **(3 points)** For each day a given sunspot is visible, measure the distance in millimeters from the Sun's eastern edge to the center of that sunspot. Record your values in the table below. The difference between the first distance entered in the table and the last distance entered in the

table is the distance the spot has traveled. For example, if a sunspot on the image from the earliest date was 111.5 mm from the left edge of the Sun, and the same sunspot was 347.0 mm from the left edge of the Sun on the final date, then the spot moved 235.5 mm between those dates.

	Image name for each solar image	distance (in millimeters) to sunspot from left edge of Sun	
		lefthand sunspot	righthand sunspot
1			
2			
3			
4			
5			
6			
7			
8			
9			

5. **(2 points)** Distance your spots traveled: lefthand sunspot: _______________ mm

righthand sunspot: _______________ mm

6. **(1 point)** Look up the Sun's <u>actual</u> diameter as measured in kilometers: ______________ km

On your images, measure the diameter, the greatest distance across the disk, in millimeters.

7. **(1 point)** Diameter of the Sun on your printed images: ______________ mm

The scale factor of the images is the diameter in kilometers divided by the diameter in millimeters.

8. **(1 point)** Scale factor: ______________ km/mm

9. **(2 points)** Convert your measurement of the Sun's diameter from millimeters to kilometers using this scale factor to calculate the actual distance the sunspot traveled.

The lefthand sunspot traveled: _____________km The righthand sunspot traveled: _____________km

10. **(1 point)** Calculate the <u>average</u> distance traveled by the two sunspots: _____________ km.

11. **(1 point)** The time it took the sunspots to travel that distance was __________ days.

Determine how fast the sunspots are moving across the surface of the Sun. The distance the spot traveled was calculated above. We know how long it took the spot to move this far, since we know the date of each photograph. The time it takes for a given spot to go the calculated distance is the difference between the dates in the first and last photograph you used. The speed is the distance calculated in #9 divided by the time it took the spots to go that distance.

12. **(2 points)** The average speed of the Sun's rotation was measured to be _____________km/day

Each sunspot must travel a distance equal to the Sun's circumference in order to make a full rotation around the Sun. As observed from Earth, the synodic rotation period, the time it takes a spot to go around the sun once, is given by the Sun's circumference / rotation speed.

13. **(1 point)** Synodic rotation period = 4.37×10^6 km / (measured rotation speed) = _________ days.

14. **(1 point)** Calculate the percent difference between your value and the accepted value of 27.3 days for the synodic rotation period of mid-latitude sunspots:

[(measured synodic rotation period – 27.3) / 27.3] x 100 = ____________