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Astronomy 104 Observing Laboratory Spring 2009

Using Sunspots to Measure Solar Rotation

This is a required exercise worth 40 points toward your final grade. Carefully read the lab and complete the exercise as instructed. If something is not clear, do not hesitate to ask the instructor. This lab is due **April 16**.

When Galileo Galilei and a few of his contemporaries turned their new telescopes to the Sun in 1611, they were astonished to find that its supposedly pure ethereal substance was blemished by a variety of dark spots. Furthermore, 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 were we see the sunspots. Since the spots are physically located on the Sun's photosphere, the Sun's rotation carries them around the Sun. Thus, we can use sunspots to determine the rotational period of the Sun, as seen from Earth.

For this lab, we will use images obtained from the image gallery at the National Solar Observatory's GONG website: http://gong.nso.edu/Daily_Images. The Global Oscillation Network Group (GONG) uses a number of telescopes around the world to conduct a detailed study of solar internal structure and dynamics. The current solar cycle is near its minimum, resulting in many days each month without visible sunspots. However, during March 2008 there were a few sunspots on the Sun from the 25th through the 30th. The images of the Sun from these days are attached in the following pages. Each image was acquired at the same time each day. You will use these images as data for this lab.

Data Analysis Procedure:

1. On the solar image of March 25th, the two largest, darkest sunspots have already been identified and marked with arrows about and below. Indentify and mark the same two sunspots on the solar images of March 26th to 30th. Be sure you follow an individual sunspot, not a group. We will use these two sunspots to find out the rotation of the Sun.

2. For each of the images, north is at the top and east is to the left. Which direction do the sunspots move from one day to the next (for example, from north to south)? ______________________

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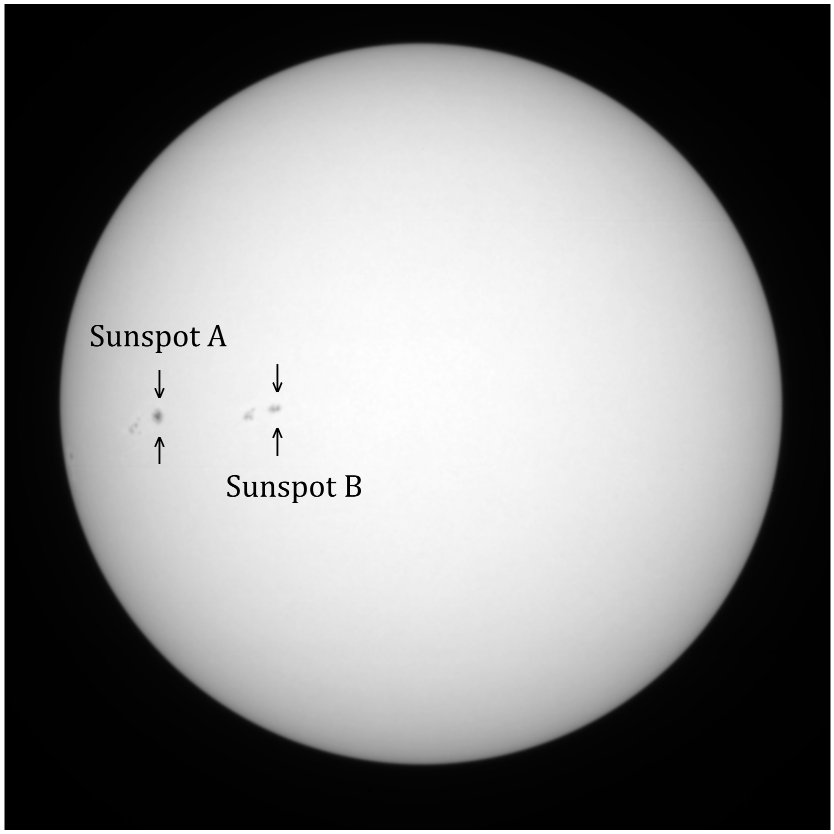
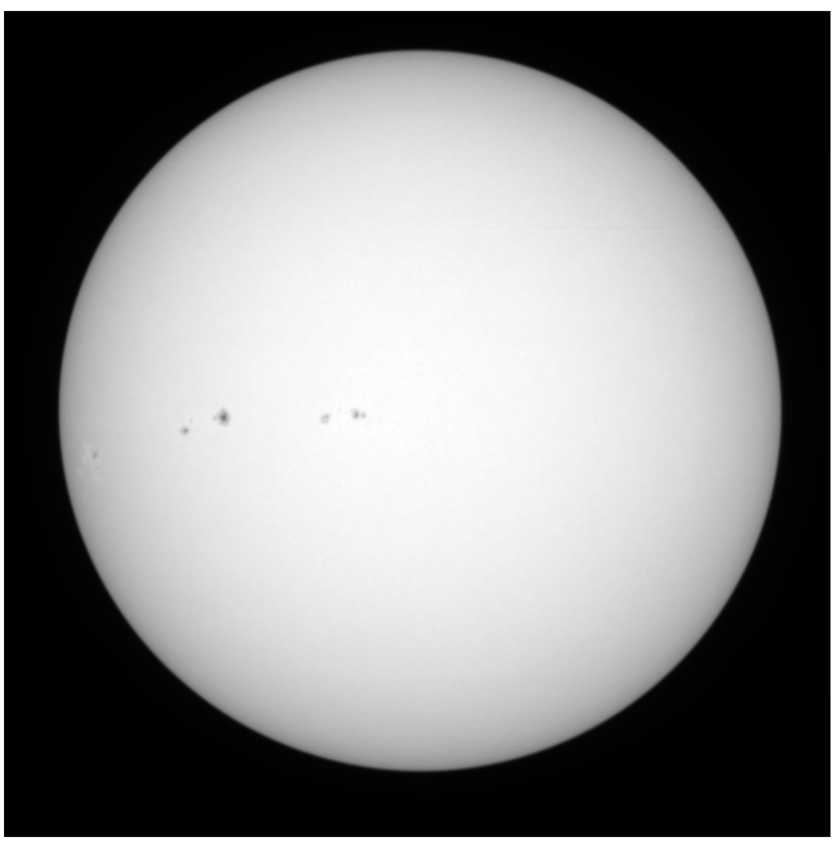
March 25th 2008



Mar 26th 2008



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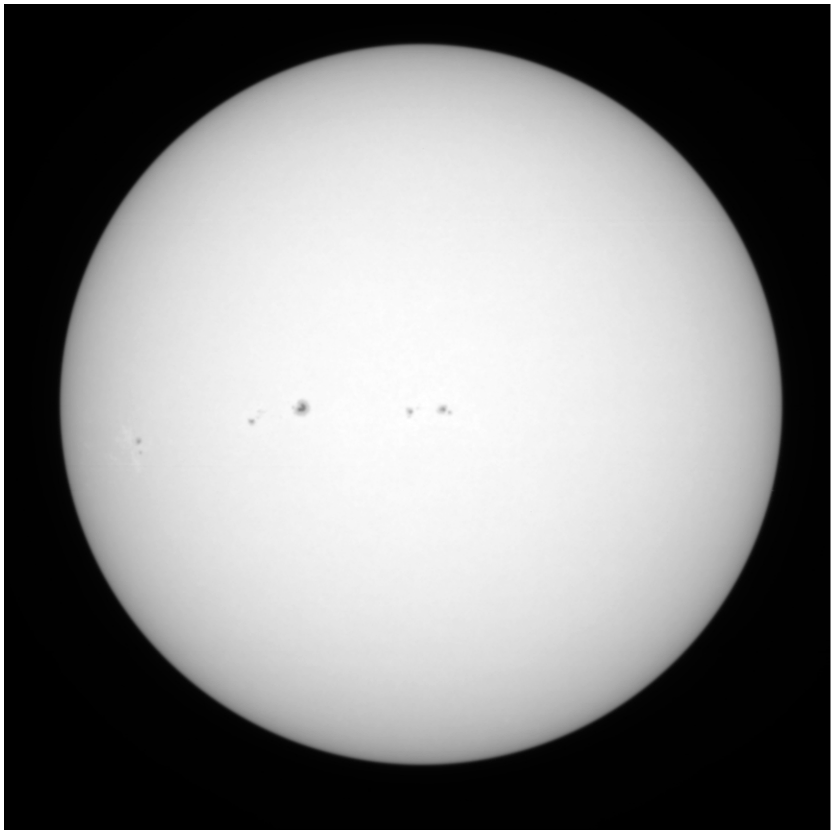
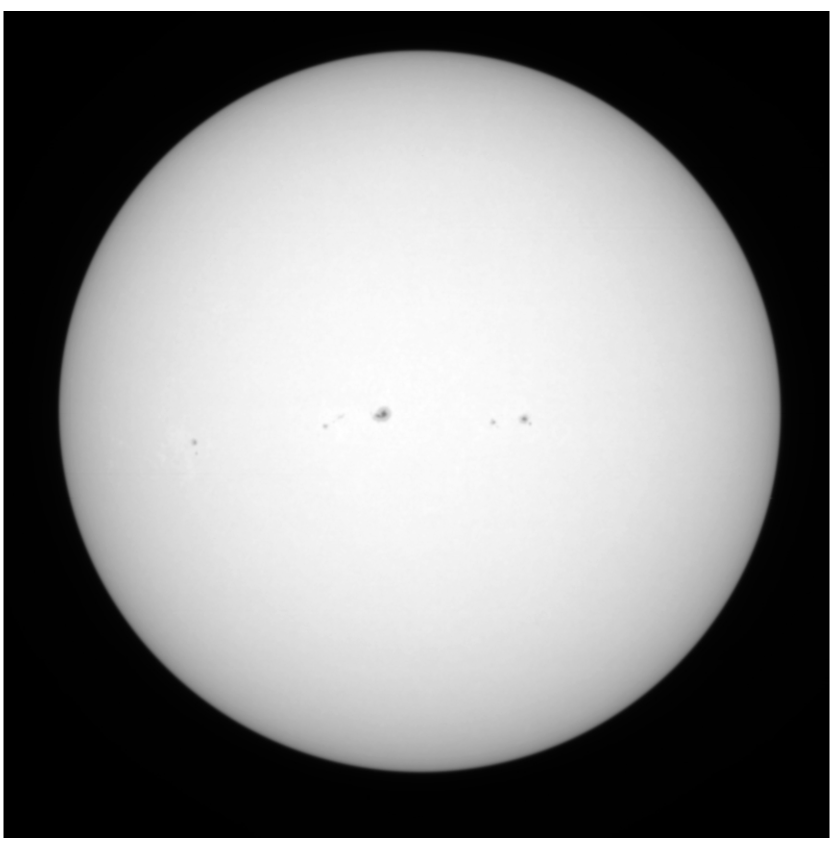
March 27th 2008



March 28th 2008



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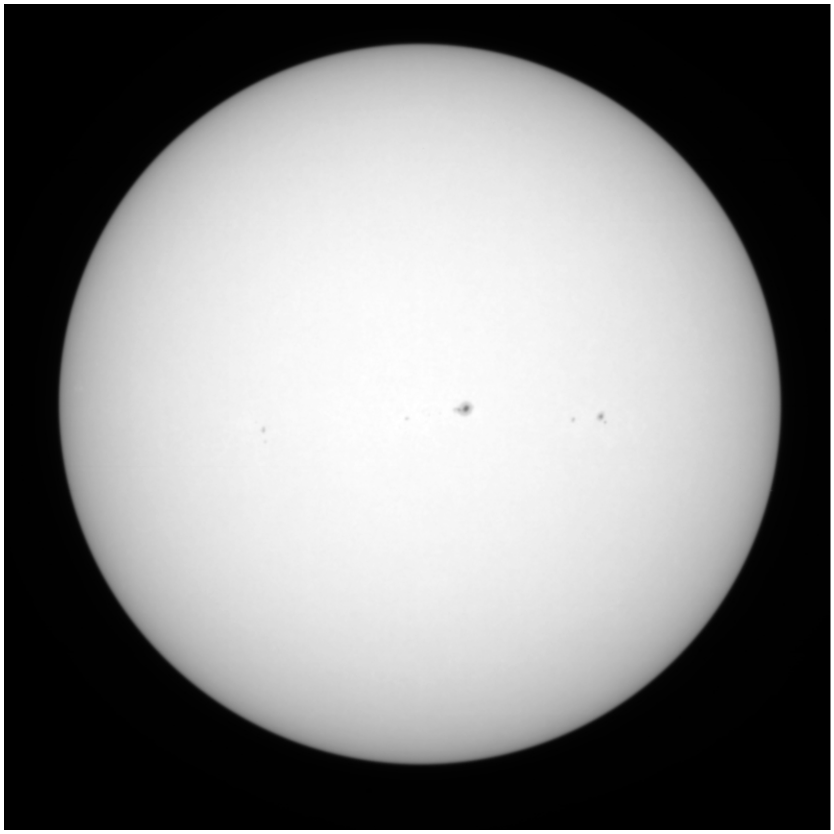
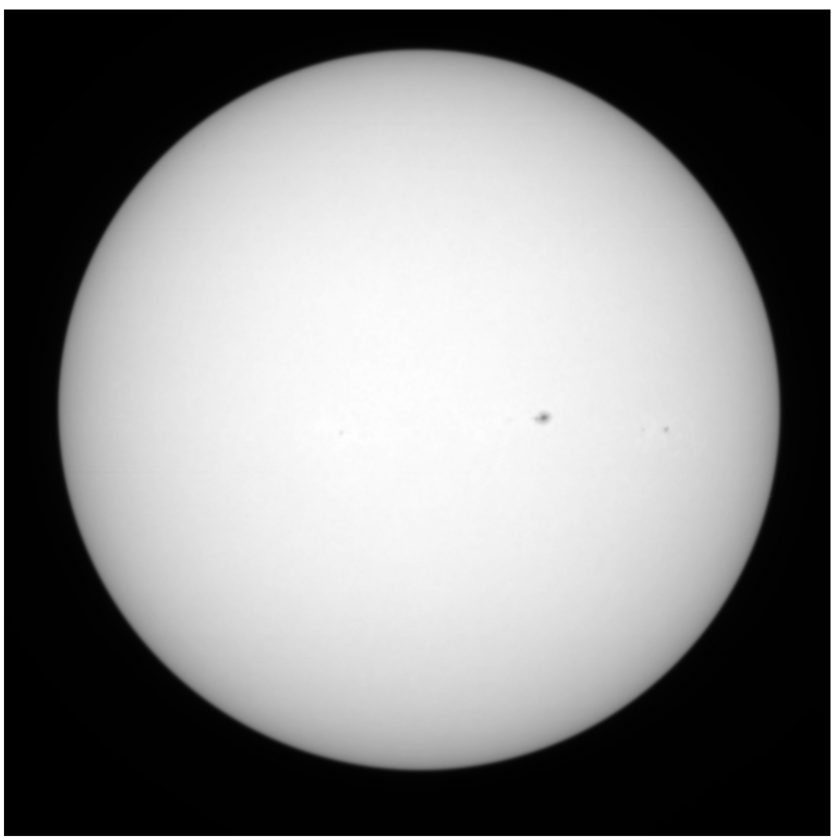
March 29th 2008



March 30th 2008



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3. For **each** sunspot, 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.

4. For each day, measure the distance of the sunspot in millimeters from the Sun's left edge to the center of that sunspot. Record your values in the table below.

	Date of the solar image	Distance (in millimeters) to sunspot from left edge of the Sun	
		Sunspot A	Sunspot B
1			
2			
3			
4			
5			
6			

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 the sunspot on the images from the earliest date was 65.4 mm from the left edge of the Sun, and the same sunspot was 125.6 mm from the left edge of the Sun on the image from the final date, then the spot moved 60.2 mm between those dates.

5. Distance traveled: Sunspot A ___________________ mm

   Sunspot B ___________________ mm

6. Look up the Sun's actual diameter in kilometers: _________________ km

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

7. Diameter of the Sun on the printed images: __________________ mm.

The Scale factor for the images is simply the ratio of the diameter in kilometers (from step 6) divided by the diameter in millimeters (step 7).

8. Scale factor: ________________km/mm

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Use this scale factor to calculate the actual distance the sunspot traveled. The actual distance = the distance the sunspots traveled in millimeters (step 5) × the scale factor (step 8).

9. The Sunspot A traveled: ___________ km .

   The Sunspot B traveled: ___________ km.

10. Calculate the average distance traveled by the two sunspots: ____________ km.

11. The time it took the sunspots to travel that distance was ________ days (subtract the first date from the last).

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 velocity is the distance the spots traveled divided by the time it took the spots to go that distance.

12. 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 rotation period, or the time it takes a sunspot to go around the Sun once, is give by the Sun's circumference divided by the rotation speed.

13. Sun's circumference = 2 π × radius of the Sun = _________________ km.

14. Rotational period = circumference / rotational speed = ________________ days.

To know if your analysis makes sense, we should compare the measured value with the known value. The sunspots we have chosen for analysis are very close to the Sun's equator.

15. Look up the following in your textbook: the rotational period of the Sun at its equator is ________ days.

16. Calculate the percent difference between your measured value and the known value of rotation period of equator:

[(measured value – known value) / known value] × 100% = ___________