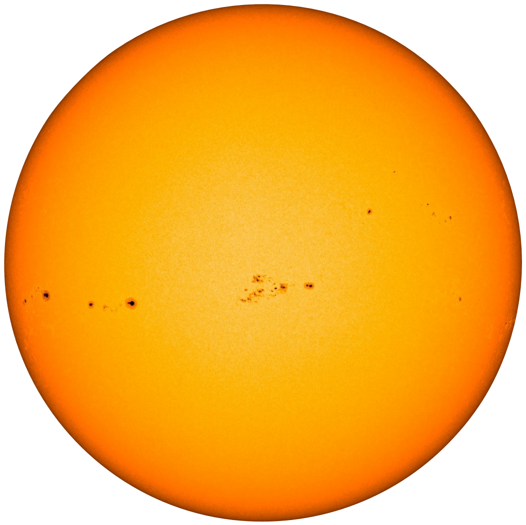
Solar Observing in Schools

The rotation of the Sun



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The rotation of the Sun

- In this exercise we will be using imaging from NASA's **Solar Dynamics Observatory** (SDO): http://sdo.gsfc.nasa.gov

- SDO was launched on February 11, 2010 on an Atlas V rocket from Cape Canaveral

- It has a variety of instruments onboard to perform sensitive measurements of the Sun.

- We will use data from the *Helioseismic and Magnetic Imager* (HMI) which is excellent for seeing sunspots

Obtaining SDO images

- SDO images are readily available from the following NASA website:

  http://sdo.gsfc.nasa.gov/data/aiahmi/

- Explore this site, and look at the different images of the Sun taken with the different instruments onboard SDO.

- You can also view movies taken with different instruments such as the Atmospheric Imaging Assembly (AIA). The AIA will show you all the prominences and magnetic loops on the surface. The HMI Intensitygrams are best for viewing sunspots.

- See what the Sun looks like now. How does it compare to what you saw through the solar telescope?

- Obtain the set of 7 SDO HMI Intensitygram images from your instructor for use in the next part.

Observing the rotation of the Sun

- Each image has the date and time that it was taken beneath.
- You will see that the sunspots and other features rotate across the disk of the Sun along lines of latitude.

The appearance and evolution of sunspots: Based on the images that you have printed, comment on the appearance of the sunspots visible (different kinds?) and how they change (if at all) over time, how long they last, etc.

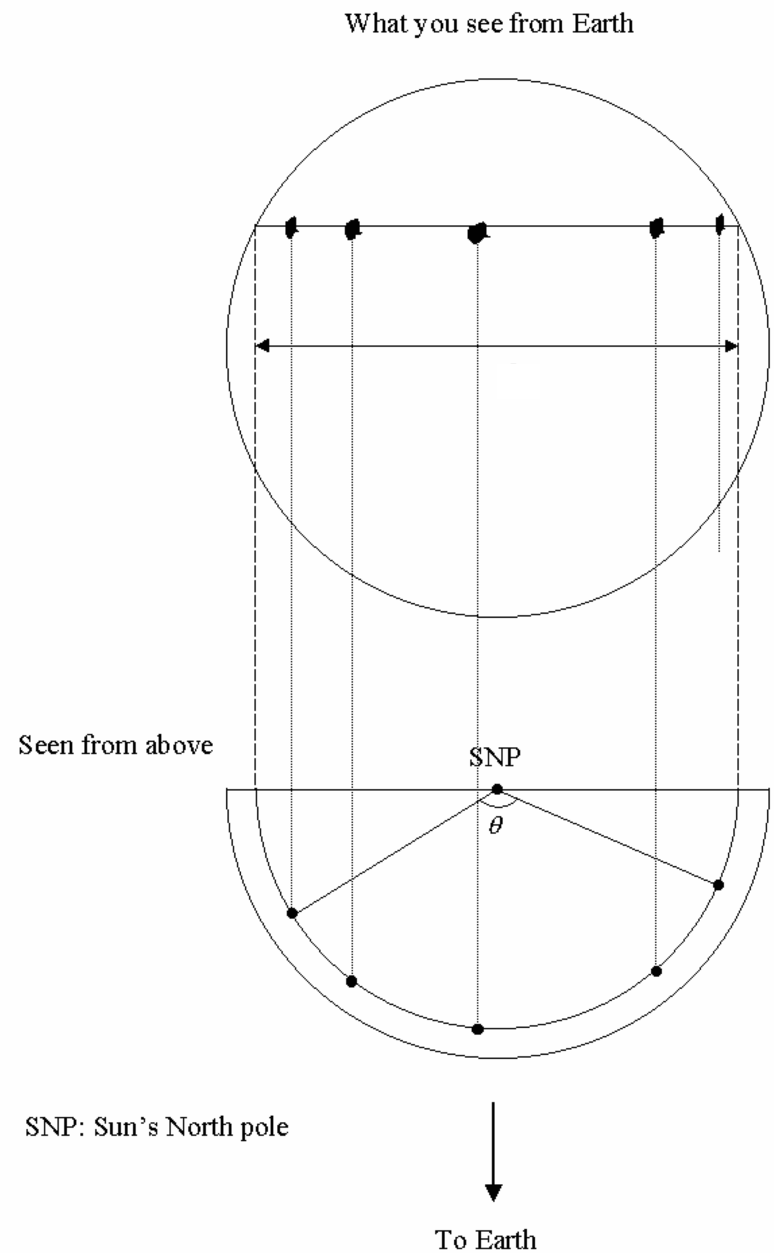
The apparent path of a sunspot: Choose a sunspot to track. Trace the position of your chosen sunspot on each image onto the earliest image showing the sunspot to show its apparent motion across the disk of the Sun. Label each position with the date. Be careful to properly register each image and to maintain the correct orientation.

Direction of rotation: In which direction does the Sun rotate (be careful about the definition of East and West!)? How does that compare with the Earth's direction of rotation? With the direction of the Earth's revolution around the Sun? *Note:* As seen from above the North pole, the Earth goes counterclockwise around the Sun.

The Sun’s period of rotation

It is quite obvious that the images you printed allow you to determine the **period of rotation** of the Sun. There are some subtleties, however, and we need to do a bit of geometry. The Sun is a sphere and the sunspot's motion from image to image is affected by the projection of the spherical surface of the Sun onto the plane of the sky (or equivalently, the flat surface of the sheet of paper). As a result, the sunspots appear to move **more slowly toward the edges** of the Sun than they do when near the center. *We need to account for that.*

The figure to the right shows the Sun seen from the Earth (i.e. the images you printed) and the Sun seen from above its North pole (SNP; only the half visible from the Earth is shown). The latter shows that the sunspot actually moves on a circle and that this circle is usually smaller than the diameter of the Sun, unless the sunspot happens to be exactly on the Sun's equator. For now, assume that it traveled in a straight line joining the points on the limb of the Sun where it appeared/disappeared.



The Sun's period of rotation

- Starting from the diagram you made tracing the track of a single sunspot (which corresponds to the top panel in the figure of the last page) and using a compass and a ruler, produce the lower part of the figure.
- Do this as accurately as possible, especially for the images where the sunspot is very near the edge of the disk. Because of foreshortening, a small error in position near the edge of the disk result in a large error on the angle of rotation.
- Note that the semi-circle has a diameter equal to the length of the long axis of the ellipse traced by the sunspot, NOT the diameter of the Sun's disk. Project the observed positions (top panel) onto the semi-circle (dotted lines).
- The angle θ is the amount of rotation that your sunspot incurred between the first and last image. Measure θ on your diagram, using a protractor. The rotation period of the Sun can be obtained simply from

  $$P\ (\text{days}) = (360^\circ/\theta) \times T(\text{days})$$

  where T is the time in days between the first and last image.
- What we have just measured is the *synodic* period of the Sun's rotation. How does your measurement compare with the real value, P_{syn} = 27.27 days?