

The Spinning Sun



To the best of our knowledge, our Sun is the only star proven to grow vegetables. Philip Scherrer

To discover various characteristics of the Sun, you'll need to observe it. Your 'eyes' will be the SOHO spacecraft, currently circling the Sun about 1,000,000 miles from Earth. With SOHO's 12 specialized scientific instruments, we can explore everything from the Sun's glorious halo or "corona", to the violent magnetic storms on its surface, to the sound waves which help us understand the mysteries of the Sun's deep interior.

Aim of the project:



Using daily pictures collected by the SOHO spacecraft, you are going to observe and record information about the currently visible sunspot groups. This data will be used later to discover many of the fascinating properties of the Sun. What do you think we can learn from watching sunspots? We will start in this project by trying to solve the Spinning Sun mystery. **Galileo Galilei, back in 1612, noticed something interesting about the Sun when he observed its sunspots. We will proceed as he did to see what he discovered.**

1st Part, Collecting Data:

- What You'll Need to Get Started:

Sunspot Recording Worksheet : You will find the worksheet attached to this document. Print it out and make enough copies for each day of your observations.

Latitude/longitude grids. : You can find the grid attached to this document. Print these out. If you can, copy the grids onto transparency paper.

An image of the Sun every day, for about 2 weeks. You will pick these up from the web (see below). Your images will look something like this, only bigger. (The sunspot groups show up as black blotches):

- What you are going to do:

You are going to observe and track the movement of sunspots (actually, magnetically "active regions") across the Sun's visible disk.

- Every day, using the web, print out a copy of the Internet solar image (we tell you how below). If you don't have a printer, sketch the image and sunspot groups you see. (If you have to sketch, try placing the latitude/longitude grid directly over the image on your screen to find exactly where to sketch your spots. Be careful to always have the image straight up and down.)
- For each of the major sunspots groups, record on your Sunspot Recording Worksheet:
 - The name of each spot group. Make up any name you want, but make sure to keep track of which group has which name.
 - Where (i.e. at what latitude and longitude) the spot groups lie
 - Note whether there were any observable changes in your sunspot groups (has the group changed size, shape, disappeared altogether?)
- Collect images every day for 10-14 days. After you've collected your data, go on to the other parts of the activity.

- Getting the Images:



The images you will be getting are called either **intensitygrams** or **magnetograms**. They are retrieved every 96 minutes by the **MDI instrument** on the **SOHO** spacecraft.

- **Before going any further, read [About the Images](#). This section is attached toward the end of this document. *Don't cheat and skip this part!***

- You can take the images from the SOHO Daily Images web site:

http://sohowww.nascom.nasa.gov/cgi-bin/get_soho_images?summary

- When you look at the image lists, use the images labeled: 'SOHO MDI, Magnetogram, longi. comp., Full Disk' or 'SOHO MDI, Intensitygram, Full Disk'. **What image is better for our purposes?**
- If there is more than one magnetogram or intensitygram available, pick the one done earliest in the day (there will be a time given with each).

- Exploring Other Images:

There are many interesting sites which provide solar images. We provide some in the internet link section of the 'fys120 bibliotek'. If you want to explore others Sun's images, visit them!

2nd Part, The Spinning Sun:

- Create your own animation:

Arrange your copies or drawings of the solar disk and sunspots in order from longest-ago to the present, and flip through them slowly as if they were an animated "flip-book". Are the sunspots permanent, or do they come and go? Do they stay in the same place, or seem to move? If they move, do they move in relatively straight lines or do they wander?

Galileo noticed that the spots seemed to move directly across the disk of the Sun. He thought that, if they were on the surface of the Sun, their movement might indicate that the Sun was rotating. What do you think?

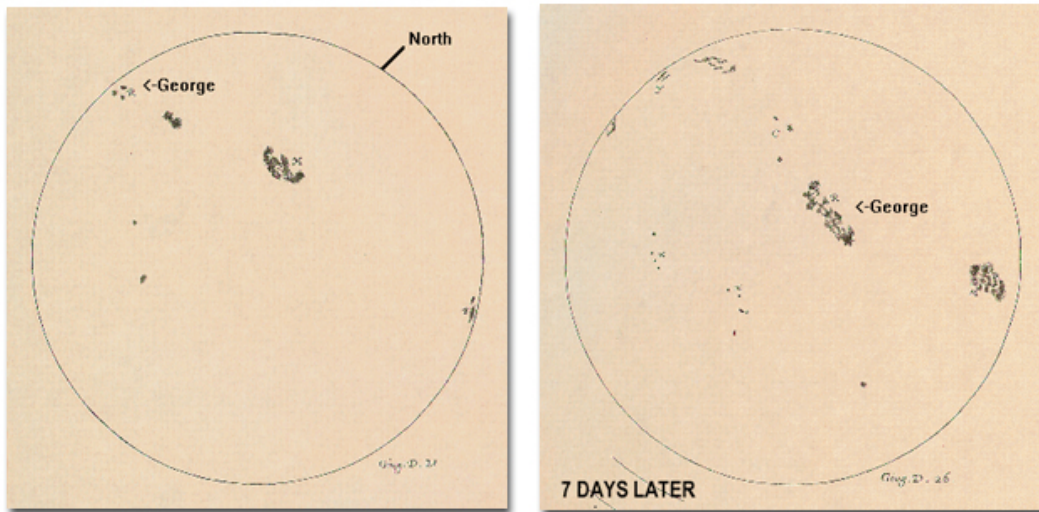
- Estimate the Sun's Rotation Rate

How can you use your sunspot data to figure out how long it takes for the Sun to spin around once? To estimate the Sun's rotation rate, let's assume that the Sun is a flat disk, just like it appears on your copies or sketches.

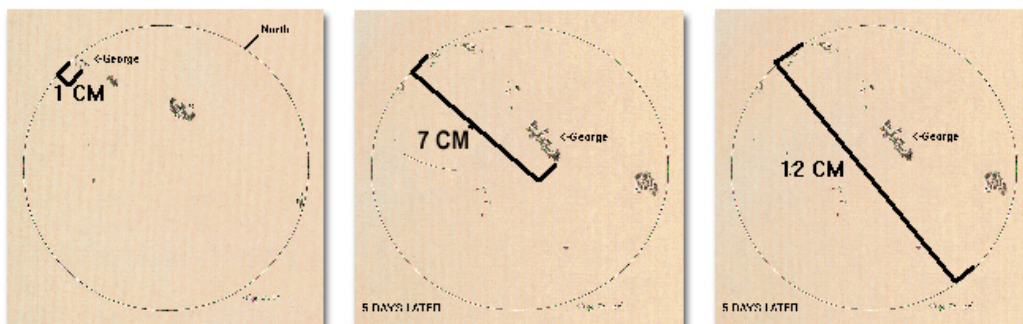
You can use a calculator for this part of the exercise.

- On your data sketches, pick a sunspot group which travels a long distance across the Sun's disk. A good choice would be a sunspot which starts out closest to the **left** limb (edge) of the Sun. Let's call this

spot "George". You are going to figure out how long it took George to move across the Sun.



- Find your picture with George closest to the **left** limb of the Sun. With a (metric) ruler, measure how far away from the left edge of the Sun's disk George is.
- Now, find the picture with George closest to the **right** limb of the Sun and measure it's distance. **Make sure you again measure the distance starting from the left limb.**
- Now, measure the distance across the entire disk of the Sun (ignoring George and any of his friends). You will need to multiply this by 2 to include the back side of the Sun.



- Look again at your data sheets and find out what time your first sketch of George was taken. Find the time for your last sketch of George. How long did it take for George to travel from the first place to the last? (Subtract the last time from the first. In our example, it was 7 days.
- Now, how far around the Sun did George go? In our example, George went 6 cm (7 cm - 1 cm) and the Sun was 24 cm around. So, in this example, it took George 7 days to get 1/4 of the way around the Sun,

which means that George would need $4 \times 7 = 28$ days to go all the way around (assuming he could last that long).

- If your numbers are more complicated than George's, then you can use your calculator to figure it out:

$$\begin{aligned} \text{Sun's rotation time} &= \text{George's-time} * (\text{Sun's-distance} / \text{George's-distance}) \\ 28 \text{ days} &= 7 \text{ days} * (24 \text{ cm} / 6 \text{ cm}) \end{aligned}$$

If you picked a different spot or group, do you think your answer for the Sun's rotation rate would be the same? Try to find out by doing the calculation for groups at higher or lower latitudes (that is, groups that are closer or farther from the Sun's poles).

- What did you discover?

Would you like to compare your sunspot sketches with those made by Galileo? If so, visit the collection of Galileo's drawings and animations in:

http://es.rice.edu/ES/humsoc/Galileo/Things/g_sunspots.html

Did Galileo's sunspots move horizontally across the solar disk? Do your sunspots move horizontally across the solar disk? If your pictures differ from Galileo's, **why do you think that is?**

Good luck with your collection of Sun images and calculations! Remember that you can use fys120 chat and discussions pages on the web if you need help or want to comment something.

ANNEX: About the Solar Images

- The SOHO images:

SOHO's instruments collect solar images in an assortment of formats. Some instruments look at the entire solar disk, others zero in on an interesting portion. Some block the Sun's brilliant glow with an eclipsing disk, allowing them to see the Sun's ethereal outer atmosphere, or corona. Some look at the Sun through wavelengths we cannot see with our eyes; these images are often strangely colored.

For this first activity, we are going to look at images collected by SOHO's MDI (Michelson-Doppler Imager) instrument. You can choose between 2 different types of images:

- Regular, "white light" images called **Intensitygrams**
- Images of the Sun's magnetic field strengths -- called **Magnetograms**

The **Intensitygrams** are nothing more than pictures of how bright the Sun is. Because sunspots are cooler than the surrounding regions, they will show up as black blotches.

The **magnetograms**, are pictorial representations of the Sun's magnetic field strengths and polarity. Active magnetic regions on the Sun will appear as white and black blotches. Quiet areas will be grey. Because sunspots are magnetic eruptions, they will be visible on magnetograms, appearing as large dark and light areas. (Not all the active regions are sunspots, but many of them are.) Each active region group will have a black portion and a white portion.

- How Do I Choose Between Intensitygrams or Magnetograms?

The Intensitygrams show primarily sunspots. And the sunspots last longer than the active regions shown by the magnetograms. Sunspots can live up to 30+ days, but active regions generally hang around for only 5 or so days. (Often the active regions turn into sunspots, but sometimes they don't.)

So, if you are doing the Sunspots Races activity, you should definitely use the Intensitygrams.

However, if you are doing the rotation activities, you could use either one. The magnetograms tend to have more "blotches" to track than the intensitygrams, and they are generally bigger. But the active regions are more short-lived than the sunspots on the intensitygrams. So, you can use either type.

Whatever type you choose, **make sure you stay with that type throughout the entire activity**. Do not use an intensitygram one day and a magnetogram the next!

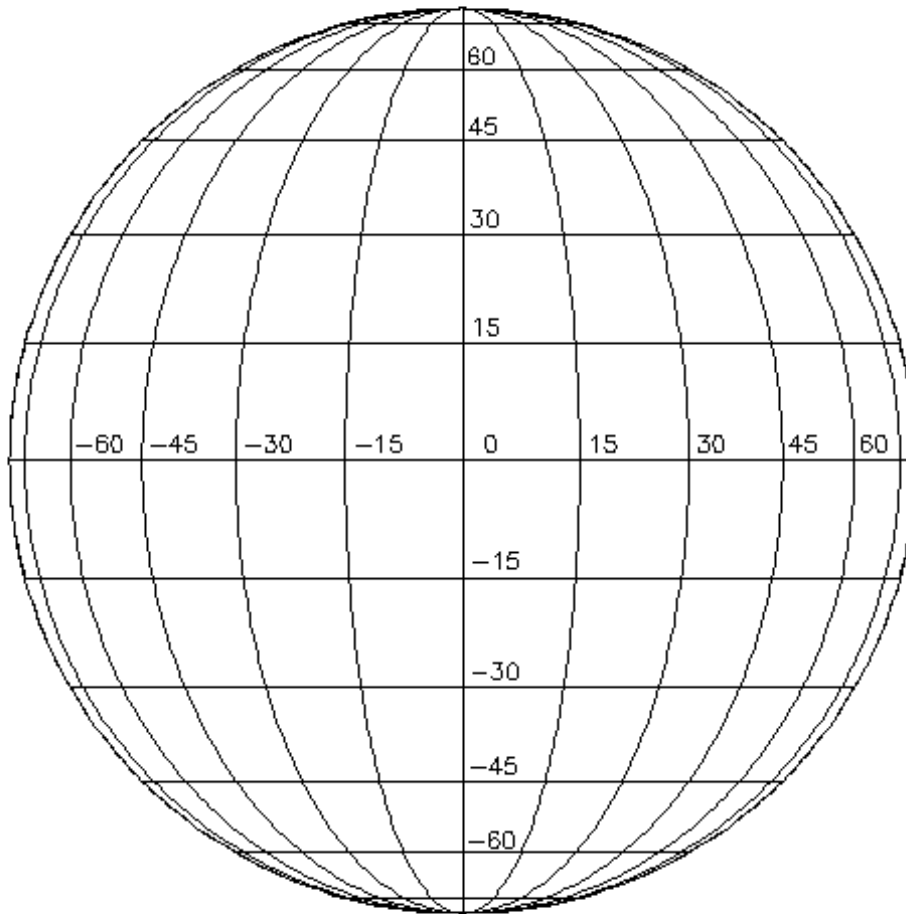
- Hints:

- To do the activities, you'll need to track the sunspots for about 2 weeks. Start with images for the current day. If these aren't complete, push the PREVIOUS DAY button and start with those. If you don't have 2 weeks to spare, we may help you providing some images.
- Each image indicates the time which it was taken (e.g. SOHO MDI, Magnetogram, longi. comp., Full Disk (at 01:42). The "01:42" is the time. Each day when you retrieve your images, try to get one from the same time as the day before.
- Measure only the large blotches, and don't worry about the smaller dots or the spread-out areas which look like lace.
- When you measure the latitude and longitude of your sunspots, measure to the center of the spot group. On the magnetograms, measure to the area right between the white and black portions:



Latitude/Longitude Grid

You may have to enlarge/shrink these with an enlarging copier to make them match your solar disk images. And it will be easiest if you can copy them onto transparency.



Solar Coordinates $B=+0$