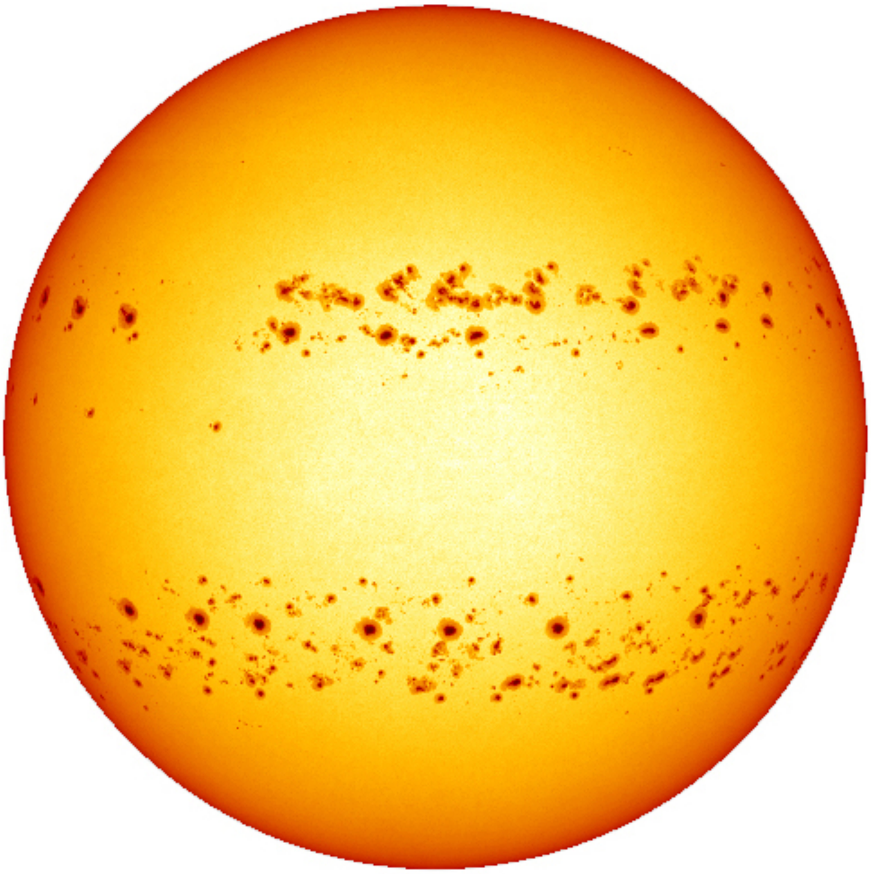
Sun's rotation period

Student's Guide – Intermediate Level

CESAR's Science Case



Introduction

Like the Earth, the Sun moves. Sun's main movement is a rotation over its axis. In this science case we will look at Sun images and try to determine how fast does it rotate and what is its rotation period. To do so we will track sunspots in time-spaced images.

Material

What will you need?

- The "Sun's rotation period" Student's Guide.
- CESAR's Booklet.
- Computer with Web Browser and Internet Connection.
- CESAR web tools.
- Calculator (physical or online such as wolframalpha.com) and paper and pen.
    - Or a spreadsheet program such as Open Office, Google Docs, Excel or Numbers.

Background

The Earth constantly rotates about it's axis, this rotation is the reason for day and night. Like the Earth, the Sun rotates too, and it's important to understand this movement. The features in Sun's surface rotate together with the Sun, so if we manage to measure how fast this features rotate, we will know how fast the Sun rotates.

The rotation period is the time that takes to complete one rotation, if you know how fast an object rotates its easy to obtain the rotation period.

Laboratory Execution

Step 1 - Making a prediction

In science, we usually have some predictions of what we expect to measure before we do the actual measurements. Let's try to get a prediction: We know that small objects such as peg-tops or spinners rotate really fast, tens of revolutions every second. Bigger objects like the Earth, need 24h to rotate only once. This does not necessarily mean that bigger objects rotate slower, for example, pulsars are neutron stars that can rotate as fast as a spinner. Still, in most of the cases, when the difference in size of two rotating objects is very big, the biggest object usually rotates slower. Knowing this, how fast do you think the sun rotates? How much does it take to the Sun to complete one complete rotation? Once you have a prediction, you are ready for the measurements.

Step 2 - Choosing data images

We are calculating the rotation speed of the Sun by measuring the speed of sunspots in Sun's surface. In the CESAR web tool, you must use the displayed calendar to look through different days until you find a picture that has a sunspot at the equator. The Sun is always moving, so once you locate a sunspot, you will realise that if you choose an image from the previous day, the sunspot will appear moved to the left. In the same way, if you choose an image from the next day, the sunspot will move to the right. What we actually want to do is **choose two images**, separated by two or more days, so that in one of them the sunspot is at the left, and in the other one in the right. **By measuring how much the sunspot moved in those days, we will know how fast it is moving.**

Step 3 - Coordinates of a sunspot

To measure the speed of the sunspot, we first have to know how much it moved. For that we will take the difference between the final position and the starting position, the difference in position is just the distance it moved. To get the initial and the final positions, we will use coordinates for measuring, and degrees as units. You have to align your image to a grid with Sun's parallels and meridians and then merge them together. This process is automatically done by CESAR's web tool. The image should look like the Image 1. Looking at the picture it should be easy to get the position, take the vertical line marked in a different colour as 0°. Each adjacent line is 10° away, knowing this you can easily get the position of sunspots. For example, in our picture there are big sunspots at 13° and 21°. Its only important to measure the longitude as the sunspots rarely move in latitude. You must get the position of your sunspot in the two images.

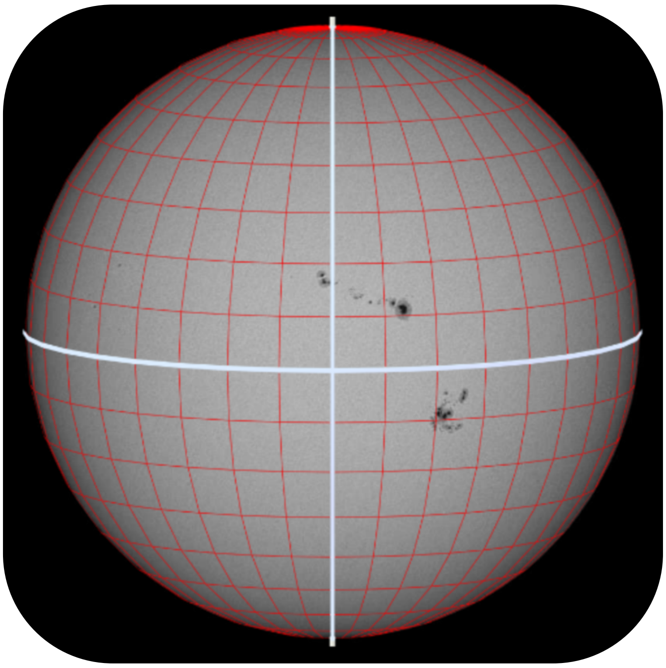


Image 1: Sun picture aligned to a grid

Step 4 - Calculating speeds

Now that we've got the positions in degrees, just make the difference between the final position and the starting position, the result is the distance (in degrees) that the sunspot travelled. Now, we are ready to get the speed, the formula it's easy:

$$speed = {}^{distance}/_{time}$$

The distance, measured in degrees, is just the difference in longitude between two days. Then we need the time interval, that is just the difference in time between the two dates of the images expressed in days. To express the date / time difference in days you can use this formula

$$days\ difference + \frac{hours\ difference}{24\ h/day} + \frac{minutes\ difference}{24\ h/day\ \cdot\ 60\ min/h}$$

Once you have the time difference in days and the distance in degrees use the speed formula and you will obtain the speed of that sunspot in degrees/day.

Step 5 - Rotation Period

We now know how fast the sunspot moves, but our goal is to obtain the rotation period, for doing so we can make use of this simple formula.

$$\frac{360^{\circ}}{\text{rotation period (days)}} = \text{speed (degrees/day)}$$

Using the formula, you should finally obtain Sun's rotation period.

Conclusions

In this laboratory you have studied Sun's rotation. You've calculated Sun's rotation period. For doing so you tracked the movement of a sunspot in time-spaced images and calculated its speed by measuring how much it moved between the images.

Do your results make sense? Do your results agree with what you expected? When the results agree with the prediction, both are usually correct.

If you do have obtain a consistent value, lets go one step further and try to use the results. Let's say we locate a big solar flare at the left-edge of the Sun, this solar flare may cause solar wind which could produce a geomagnetic storm if it reaches Earth. Using your calculations of Sun's rotation period, estimate how long would it take to the solar flare to be pointed at Earth.