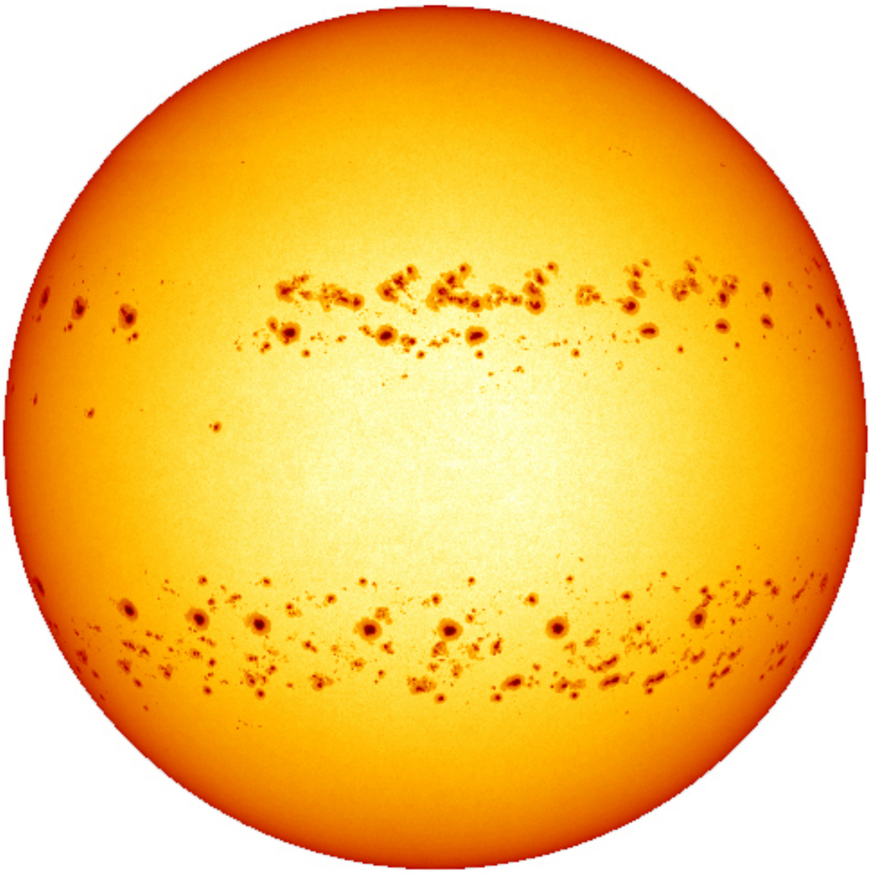
Sun's rotation period

Teacher's Guide - Intermediate Level

CESAR's Science Case



Introduction

This is the teacher's guide for "Sun's rotation period" CESAR's Science Case. Note that **this guide does not contain full instructions** to successfully develop the science case, those can be found at the student's guide. This guide includes information about the learning purposes of the activity as well as about the material and background needed for it, so that the teacher may decide **weather this laboratory is suitable** for his class or not. This guide is also meant to **help the teacher trough organising the activity**, providing tips and keys for each step, as well as the **solutions** to the case's calculations and the quiz.

In this science case the students are to **calculate the Sun's rotation period** using images from CESO (CESAR's ESAC Solar Observatory). By the end of this laboratory, students will be able to:

- Understand how fast the Sun moves.
- Calculate velocities by tracking targets in time-separated images.
- Explain what the rotation period is.
- Make predictions and prove them with experiments.

By completing this science case, students will find out how astronomical pictures can be used to obtain valuable data.

Material

What will they 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.

There are no needed chapters from the booklet, however "Sun" is recommended to get more knowledge about the topics treated in this laboratory, and the introduction in "Earth Coordinates" may came in handy if students don't have the basic knowledge about standard coordinate systems.

Background

To follow the intermediate level guide, student's must have a math basis. Knowledge about basic operations, degrees and unit conversions is recommended. Nothing harder than that will be done, but students should be conformable with those concepts.

Although all the Sun-related essential background is provided in the student's guide, it might be useful if those concepts among some others (like what sunspots or solar flares are) were explained in a lesson previous to the laboratory execution day. In that way they will learn more about our star, and they will have time to settle the knowledge before doing the exercise. In case you decide to do so, you'll find in the "Sun" booklet and in the "Sun's rotation period Student's Guide" all the information necessary for that lesson. Also, as said before, the introduction in "Earth Coordinates" may also be useful if the students don't have basic knowledge about standard coordinate systems.

If you want to consider a math free laboratory, check the basic level guide. On the other hand, note there's also an advanced level if you consider that the student's guide for the intermediate level is way to easy.

Laboratory Execution

All that students ought to do is read their guide and follow the steps. This task is suitable both for doing it alone or in small groups.

If they make no mistake, they should obtain about 26 days for the rotation period. Just in case they do commit some mistake, in the following paragraphs are every step's solutions along with common mistakes that may help you identify their error:

Step 1 - Making a prediction

Knowing that the Sun much bigger than Earth, and that it takes one day to the Earth to complete a rotation, they should had estimate a rotation period of 5-100 days for the Sun. Once they do the exercise, the result should be between 24 and 32 days for the rotation period.

Step 3 - Coordinates of a sunspot

The difference in longitude for a sunspot in two images separated by one day should be about 14º, and around 14º more for each extra day of difference.

Sunspots rarely move in latitude, if students note a change in latitude, they are most probably looking at a different sunspot.

Step 4 - Calculating speeds

If they make no mistake, they should obtain about 15 degrees/day for the rotation speed. If they don't, check that the distance and time values make sense and are expressed in degrees and days.

Step 5 - Rotation Period

You can explain this formula using the speed definition, using cross-multiplication, or as a unit change. If they make no mistake, they should obtain about 26 days for the rotation period.

Conclusions

Once they get the final result, they whole class could discuss how good the result matches their prediction. Even if they weren't able to predict the exact value, both the prediction and the final results should be bigger than the Earths rotation period. It is common in science to predict that some measurement should be bigger or smaller than some other, and to use an experiment to check that and obtain the exact value.

In the "Conclusions" part, they are also asked how long would it take to a solar flare located at the left-edge of the Sun to be pointed at Earth. If it takes 24 days to the Sun to complete a full rotation, then it would take 12 days to the flare to go from one edge to the other, and only 6 days to get to the centre of the Sun where it would point right to the Earth.

Even if the student's guide ends up here, the activity may continue with the quiz. Although this quiz can be used as a qualifiable exam, it is not only meant to be so. Even if the students have successfully obtained Sun's rotation period, if they don't fully understand the whole procedure, the quiz questions may make them doubt (some of them might be really tricky). Besides than examining them, it is a good idea to give them some time to do the test by their own, and then group them for discussing their answers. It is likely that they have different answers for some of the questions, and **by discussing them, they will achieve a much better comprehension of the whole process** they used. In the last pages of this guide, all the questions from the quiz are answered. For each question the correct answer is provided, and just in case it's not clear why, it's also indicated why the others are wrong. Finally, for each question there is a completely absurd possible answer, if one of this answers is given, you can be sure the student is randomly answering.

Once you finish the activity, please, do consider giving us some feedback at:

cesar.esa.int/index.php?Section=Contact

Quiz

The correct answers for the quiz are **a d b d c b b d a c**.

The absurd answers for each question are **c c d a b a c b d a**.

In case of doubt, the discussion of each question follows next:

1. The Sun rotates

- ☐ slower than Earth.
- ☐ faster than Earth.
- ☐ happier than Earth.
- ☐ once every 24h.

It takes more than two weeks to the Sun to complete a rotation and only one day to the Earth to do so.

2. The rotation period is

- ☐ how fast the Sun rotates.
- ☐ the time that takes to a sunspot to move from one edge of the Sun to the other.
- ☐ how fast the Sun rotates about an alien spacecraft.
- ☐ the time that an object needs to complete one full rotation.

No clarifications needed, answer **d** is the definition for rotation period.

3. If an object rotates very fast it

- ☐ must have a long rotation period.
- ☐ must have a short rotation period.
- ☐ must be very small.
- ☐ must be powered by a computer.

Objects that rotate fast are usually small, buy they do not necessarily have to. If an object is rotating very fast, it takes very little time to complete a rotation, hence it has a short rotation period.

4. We can calculate the rotation speed of the Sun by measuring the speed of sunspots because

- ☐ sunspots want to help us and they whisper the Sun's differential rotation.
- ☐ sunspots are located in the Sun's core, so we can measure their speeds with no disturbance.
- ☐ sunspots move through the surface.
- ☐ sunspots are located at the Sun's surface, whose speed we want to measure.

Sunspots don't move through the surface, they move with the surface, whose speed we want to measure.

5. Once we know the speed of a sunspot, calculating Sun's rotation period requires to know the

- ☐ distance between the initial and the final position of a sunspot moving through Sun's surface.
- ☐ help of astronauts that are on ongoing missions at the Sun.
- ☐ number of degrees in a complete rotation.
- ☐ time that takes to the sunspot o go from the initial to the final position

The distance between the initial and the final position of a sunspot moving through Sun's surface, and the time that takes to the sunspot o go from the initial to the final position, are both needed to obtain the speed of the sunspot. But once we know the speed of a sunspot, calculating Sun's rotation period requires only to know this speed and the number of degrees in a complete rotation.

6. Calculating the speed of a sunspot requires the

- ☐ cooperation of ESAC scientist, because their computers have to be used.
- ☐ distance between the initial and the final position of a sunspot moving through Sun's surface.
- ☐ exact coordinates of a sunspot located in Sun's surface.
- ☐ time that takes to a sunspot to move from one edge of the Sun to the other one.

If we know the coordinates of a sunspot we'll just know where the sunspot is, but nothing else. To obtain the speed of the sunspot we need both the distance between the initial and the final position of a sunspot moving through Sun's surface, and the time that takes to the sunspot o go from the initial to the final position (not from edge to edge).

7. Earth's rotation is the reason for day and night, Sun's rotation is the reason for

- ☐ Sun's day and night.
- ☐ the movement of Sun features.
- ☐ life in Earth's core.
- ☐ Sun's short rotation period.

Day and night are produced by Earth's rotation, because as the Earth is moving, the dark side and the side lighted by the Sun change over time. The Sun is always lighted because it is the light-source in the Solar System, so it does not have day and night. The Sun has a long rotation period, so only possible answer is b.

8. To calculate the speed of a sunspot you

- ☐ measured the distance between two sunspots.
- ☐ used a chronometer.
- ☐ looked at two different sunspots.
- ☐ tracked the sunspot in time-spaced images.

To calculated the speed of a sunspot we only looked at one single sunspot, that was seen twice as explained in question five.

9. In science its common to

- ☐ have predictions before measuring.
- ☐ ignore the predictions only when you finished the measurement.
- ☐ use the results of an experiment to predict the value that you measured.
- ☐ ignore other scientist, because scientist know nothing.

In science you should never ignore nor predictions nor scientist. It makes no sense to use the results of an experiment to predict the value that you measured, because if the values are already measured there's no need for a prediction. In science its common to have predictions before measuring.

10. The Sun rotates

- ☐ so fast that it is flat.
- ☐ clockwise, like the Earth does.
- ☐ counter-clockwise, like the Earth does.
- ☐ faster in the poles.

With the North orientated upwards, the Sun rotates counter-clockwise. Check the movement of the sunspots when you choose images of the same feature with a few days of difference, the sunspot moves to the right (counter clock-wise as seen from above).