CESAR Scientific Challenge

Following Sunspots

(Calculate the Sun rotation with the HELIOS Telescope)

Student Guide

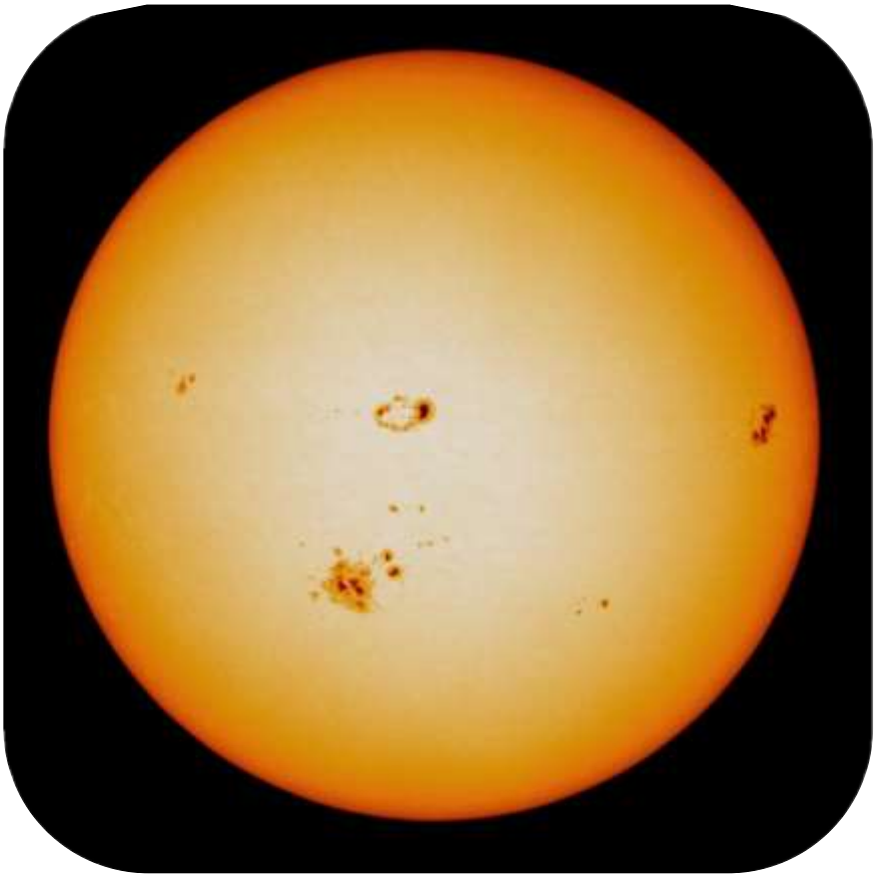


Table of Contents

Your Scientific Challenge

Following Sunspots

We have received a message:

"¡ Solar storm to Earth detected! Take cover!"

Figure 1: *Coronal Mass Ejection (CME) (Credits: https://www.libertaddigital.)*

In addition, the Solar Observatory HELIOS at ESAC, which was observing the Sun, has detected spots on the surface of the Sun where the SOHO satellite detected the coronal mass ejection.

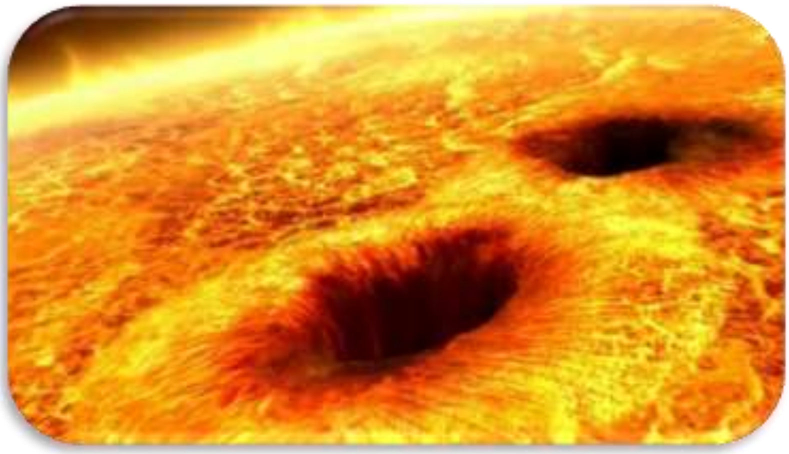


Figure 2: *Sunspots (Credits: http://newsmobile.in/)*

We need your help to protect Humanity. ***Can we count on you?***

In this scientific challenge, we will follow the trail of the sunspots, in order to answer the following questions: Do the sunspots move? Does the sun break? And if so, does it do the same on its entire surface?

Phase 0

To put us in context we recommend looking at these **videos**:

- This is ESA (5 min)
- ESAC: ESA's A window on the Universe (3 min)
- Presentation to ESA/ESAC/CESAR by Dr. Javier Ventura (15 min)
- Other videos about Space.

You will work in Teams of (4-6) people, each of you having an specific key role, unique and needed for the Team. Fill in Table 0 with the Identification for the Challenge, Number of the Team and Name of the Team members.

Challenge ID			**Team Number (1-6):**	
Members				
Professions	**Mathematics Software Engineer**	**Astrophysicists**	**Engineers**	**Biologists/ physicist**
Roles	She/he leads the correct execution of the calculations	She/he controls the solar telescope	He/She is in charge of finding agreements and leading the team.	He/She addresses the need for further research.
References **(female)**	Katherine Johnson 	Vera Rubin 	Samantha Cristoforetti 	Marie Curie 
(male)	Steve Wozniak 	Matt Taylor 	Pedro Duque 	Albert Einstein 

Table 0: *Write down the Identification of your Challenge (an unique number), the Number of your Team (1-6) and the name of the team members, one of them with a clear role (and assigned tasks), all needed.*

Note: The documentation makes use of the International System of Units.

Phase 1

Activity 1 Refresh concepts

You can refresh concepts needed for the Scientific Challenge by clicking on the links in Table 2. These correspond to the contents of the school curriculum.

10 curiosities of the solar system	**The states of matter (TED-Ed)**	**Latitude and longitude**
Speed rotation and period	**Discovering electromagnetism**	**How do nuclear reactions work?**

Table 2: *Concepts that need to be refreshed before facing this scientific challenge.*

In this activity we are going to study the surface of the Sun. In the same way that we can know the time it takes for a ball to go around on itself by looking at some of the details (colors, lettering, stains) on its surface, we are going to do with the Sun. In this case we will look at what we call its **sunspots**, which we will explain later.

It is important to keep the concepts of **latitude and longitude** in mind when identifying the positions of the spots, just as you use **coordinates** to express what position on Earth you are in. Latitude is positive for the northern hemisphere and negative in the south. Longitude takes a meridian (Greenwich) as a reference and is positive for the east and negative for the west.
For example, if you are in Madrid, you will find yourself in some coordinates **(Latitude: 40° 25′ 0″, Longitude: 3° 42′ 12″),** however, someone who is in Santiago de Chile, will be in some coordinates close to (**Latitude: -33° 26′ 14″, Longitude: - 70° 39′** 2**″)**

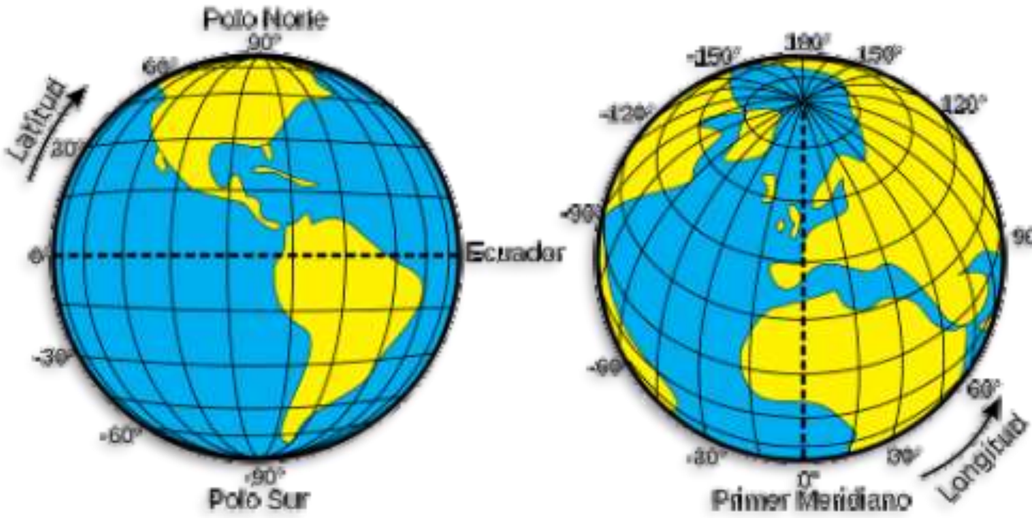


Figure 3: *Concepts of latitude and longitude (Credits: Wikipedia)*

Activity 2: Compare the Sun with Earth

Fill in Table 3 comparing the Sun and the Earth:

Property	Sun Value	Value on Earth	Sun/Earth comparison
Type of object	Star		
State of most of the matter		Solid	
Radio (km)		6 400	
Mass (kg)	~ 2 x 10^{30}		~ 33 333
Density (kg/m^3)		5 500	
Surface temperature (°C)	~ 5 500		~ 20
Most abundant elements	H_2, He, O_2		
Age (years)	4 650 000 000		~ 1

Table 3: *Comparison of some of the characteristics of the Sun and the Earth.*

- *How many Earths fit in the Sun? (Hint: volume of a sphere, V, is 4/3 πR^3)*

Activity 3: The Sun

The Sun is our closest star. It is a star of hot ionized gas or "plasma". It generates energy through nuclear reactions inside it, consuming about four million tons of hydrogen fuel every second. Figure 4 shows some of the Sun's properties.

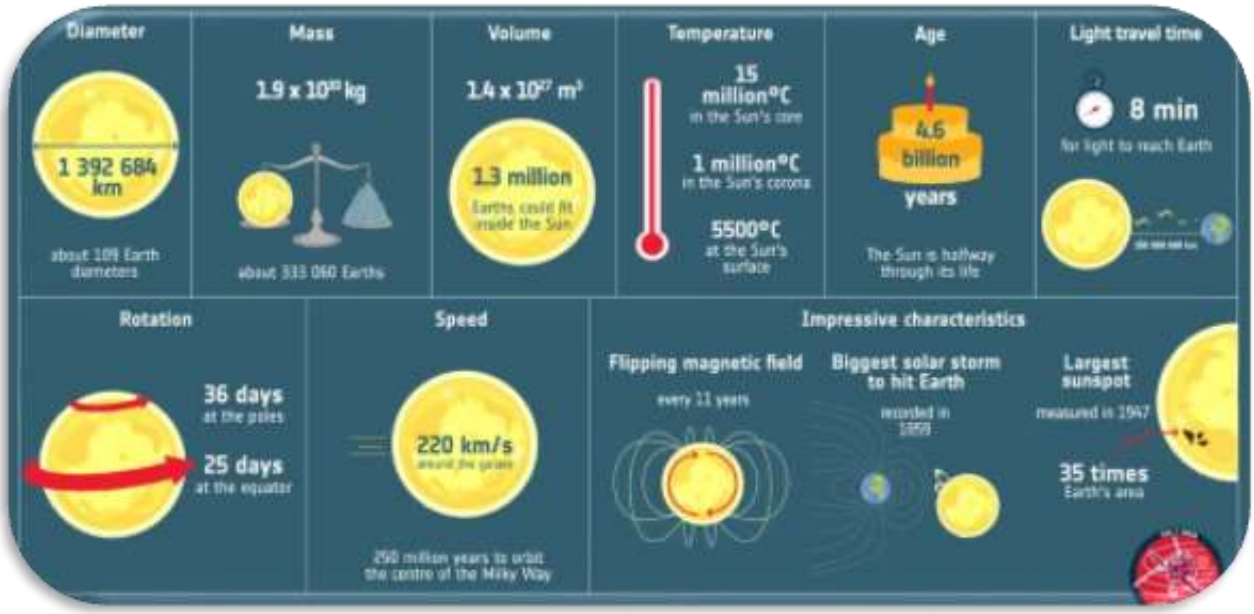


Figure 4: *Meet the Sun (Credits: ESA)*

Despite its age, it is expected to shine for another five billion years. By then, though, it will have become a red giant. In Figure 5 we can see the different phases that the Sun will go through during its life. For more information about the Sun and how stars evolve, access the [CESAR booklet on the Sun and CESAR booklet on stellar evolution].

Figure 5*: Life Cycle of the Sun (Credits: Wikipedia)*

1. Watch this video of The Sun and tell us what you have learned from the Sun.

Activity 3.1The Sun Structure

1. Draw what you think the structure of the Sun looks like.

2. Check what you have learned in this game. To do this:
   a. Click on this **Link**
   b. Press "play" or the upper right button "Again" if it is not the first time you play
   c. At the top you will be shown the name of a zone of the Sun, your mission will be to click on the number you think corresponds to that zone. The results appear in the upper left corner

      - If you hit the number it will turn green. If you fail the number will turn red.

Think carefully about what the area is and take into account the time shown on the top right.

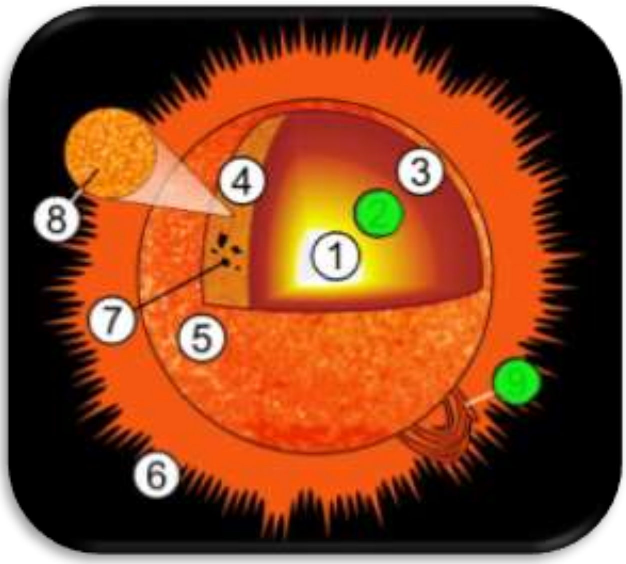


Figure 6: *Simulation layers dollars. (Credits: https*://www.purposegames.com)

3. Write here the layers you remember in order from the inside to the outside of the Sun .

4. What layer(s) of the Sun do we see from the Earth?

WARNING-Never look directly at the sun, it can cause serious damage to your eyes.

Activity 3.2: The Chemistry of the Sun

The nuclear reactions that take place in the Sun generate the energy that makes life possible on our Planet. During the most stable phase of the stars, chemical reactions take place in their nucleus that transform 4 atoms of hydrogen into one of helium, as shown in Figure 7.

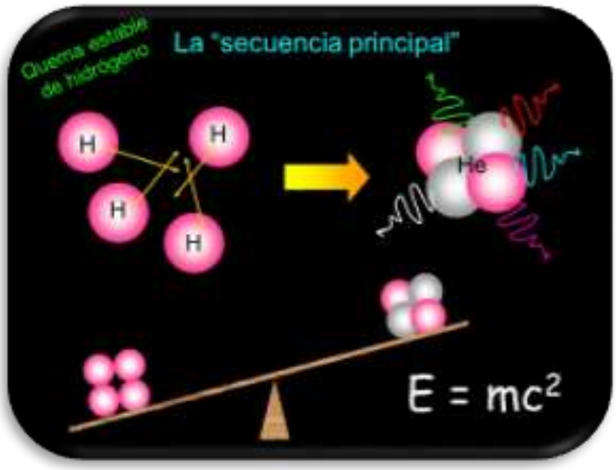


Figure 7: *Nuclear reaction of stars in their most stable phase (Credits: Talk by Dr. Benjamín Montesinos Comino in course of professors CESAR and June 2018).*

Note 1: Specifically 92 sextillions (92 000 000 000 000 000 000 000 000 000 000 000 000) of nuclear reactions occur every second in the Sun

Note 2: Every second 4 260 000 tons of matter are converted into energy, which is capable of providing a (standard) home with electricity for 9 500 billion years.

As shown in Figure 8, the Sun is composed mainly of hydrogen (H ~91%) and helium (He ~8.8%), plus other chemical elements in a much smaller percentage.

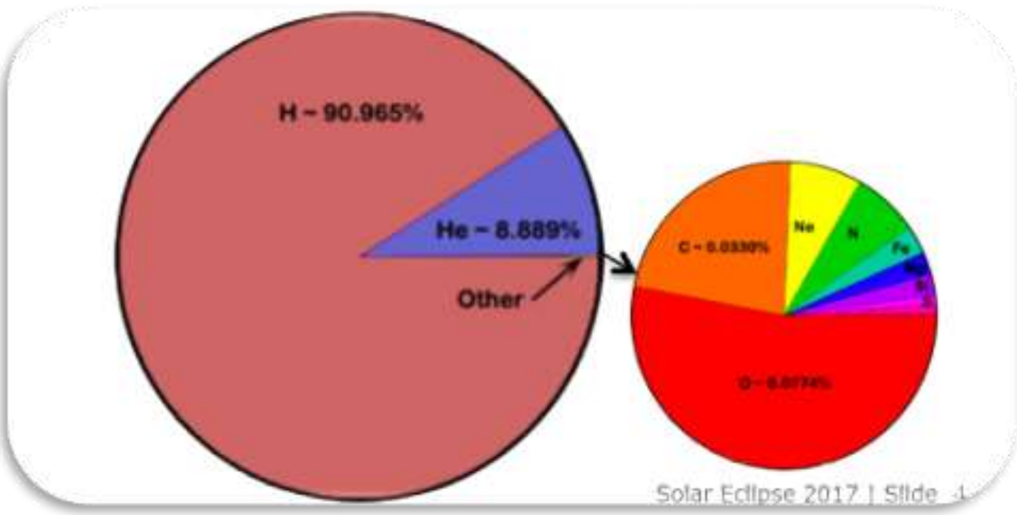


***Figure 8: Elements of the Sun (Credits: Presentation of Dr. Anik De Groof, in course of professors** CESARr).*

1. Identify which group each of these chemicals belongs to by checking the [Dynamic Periodic Table] (figure 9) and fill in Table 4.

Figura 9: *Tabla Periódica Dinámica (Créditos: PTable).*

Proportion of that element (%)	Nomenclature	Chemical element	Group in the Periodic Table	Atomic number
90.96	H	Hydrogen	No metal	1
8.89	He			
0.07	O			
0.03	C			
< 0.1	Ne			
< 0.1	N			
< 0.1	Fe			
< 0.1	Mg			
< 0.1	Si			
< 0.1	S			

Table 4: hemical composition of the Sun.

2. Repeat the previous activity for the case of the Earth. by checking the [Dynamic Periodic Table] and see Figure 10 for this.

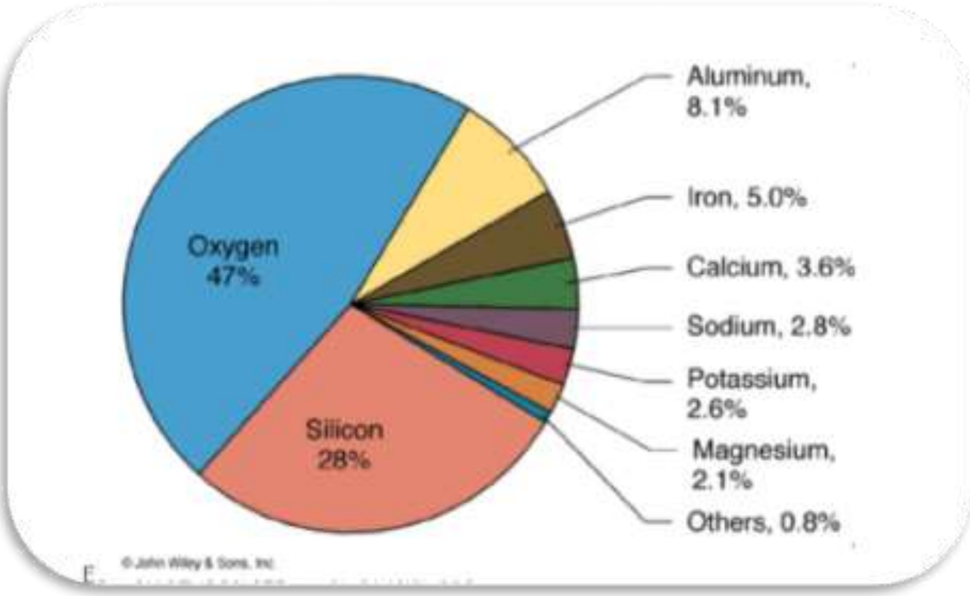


Figure 10: Elements of the Earth (Credits: Presentation by Dr. Anik De Groof, in course of professors CESARr).

Proportion of that element (%)	Nomenclature	Chemical element	Group in the Periodic Table	Atomic number
47	O	Oxigen	No metal	8
28	Si			
8.1	Al			
5.0	Fe			
3.6	Ca			
2.8	Na			
2.6	K			
2.1	Mg			
0.8				

Table 5: Chemical composition of the Earth

3. Compare the composition of the Sun and the Earth

Figure 11 shows the positions in the electromagnetic spectrum occupied by the transitions of the different elements found in the Sun.

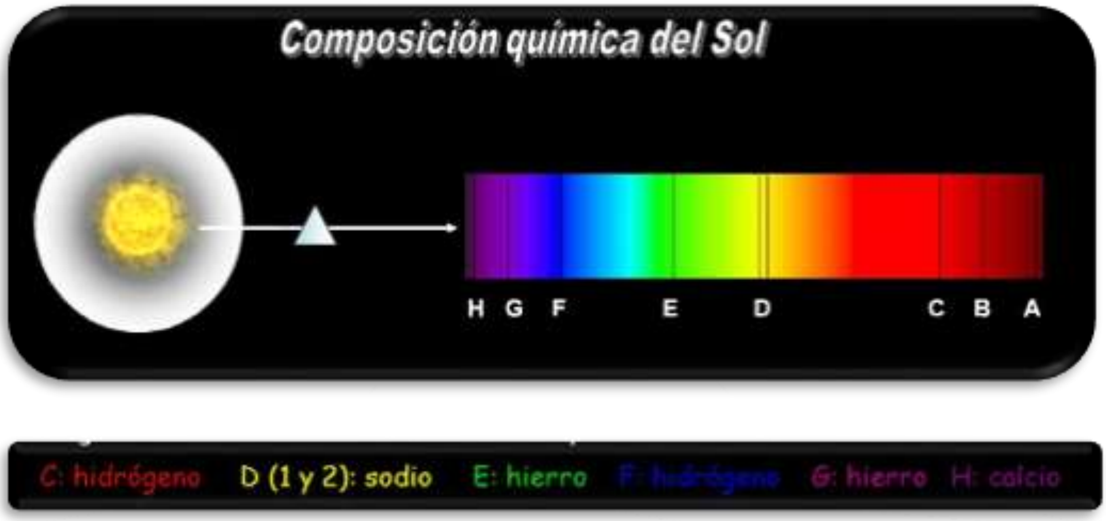


Figure 11: *Chemical Composition of the Sun (Credits.* https://slideplayer.es)

Perform the activity CESAR " What are the stars made of? using the application https://spectralworkbench.org/

Activity 4: The Magnetic Activity of the Sun

As we commented in Activity 3, the sun is a large ball of gas at very high temperatures that is in a plasma state, as seen in Figure 12

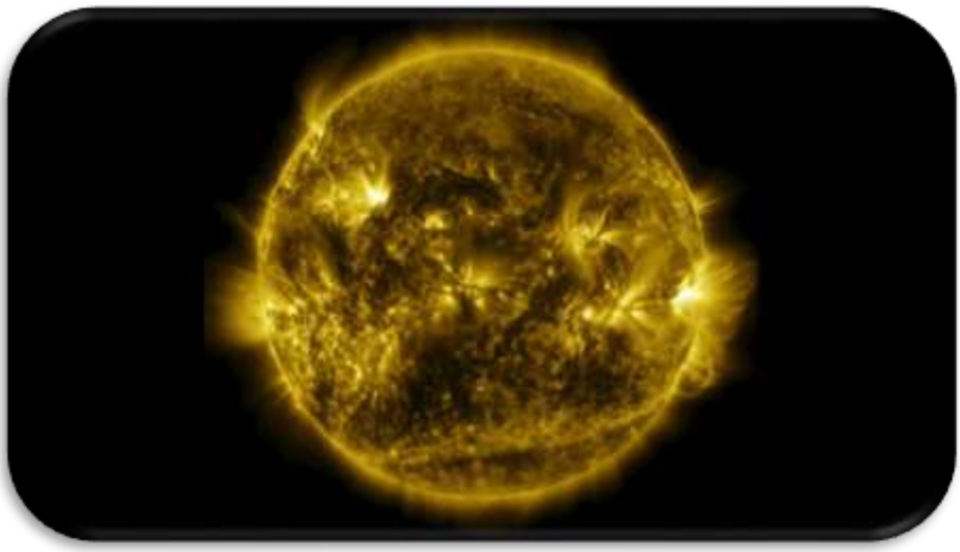


Figure12: *Image of the Sun (Credits: Presentation by Dr. Benjamín Montesinos Comino for the CESAR teachers' course, June 2018)*

Due to this state, as the Sun rotates on itself, the equatorial and polar areas rotate at different speeds, twisting its magnetic fields and causing variations in its magnetic field, as shown in Figure 13.

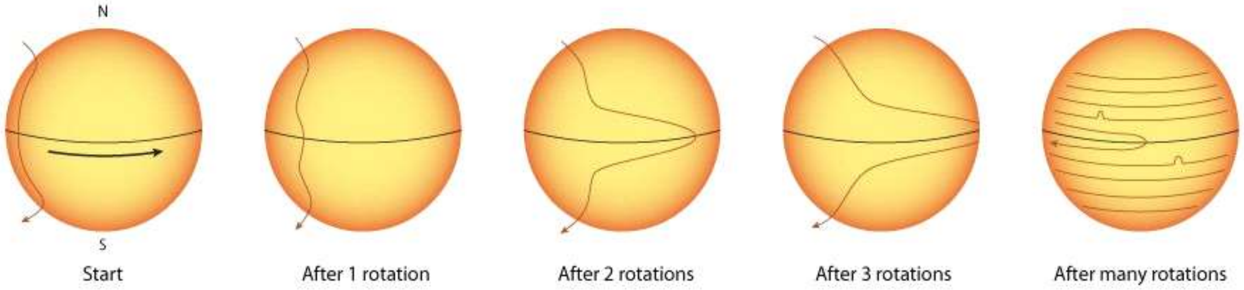


Figure 13: *Explanation of how the differential rotation of the Sun is generated over several days (Credits: NASA / IBEX)*

Our star is very active magnetically, because it has a very intense and variable magnetic field, which changes year by year. The orientation of its magnetic poles changes every time it reaches its maximum activity, which occurs once per cycle (every 11 years approximately), as shown in the data recorded in Figure 14.

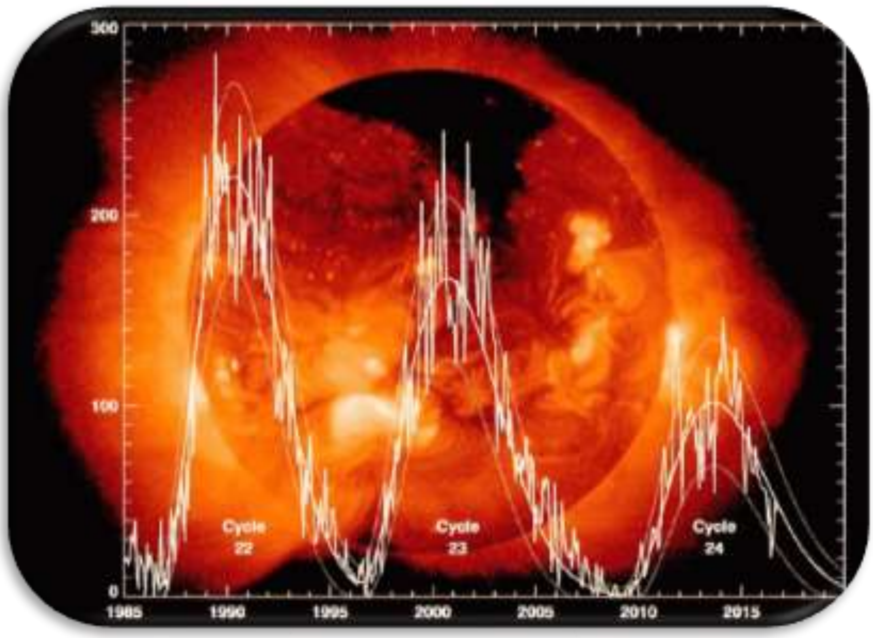


Figure 14: *Cycles of activity of the Sun (Credits https://ciencia.)*

The magnetic activity of the Sun produces numerous effects, which together are known as solar activity. Figure 15 shows some of them as solar flares, erupting prominences, sunspots and coronal mass ejections of various types sent to the solar wind, among others.

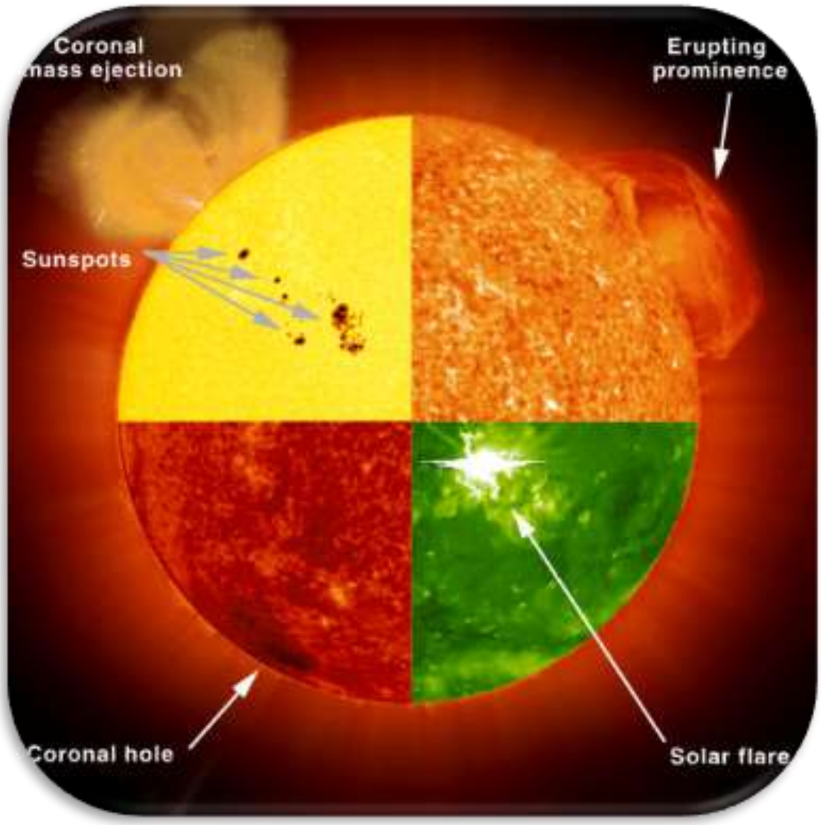


Figure 15: Connection between the different effects of solar activity (Credits: geomag)

For more information about the different effects caused by the magnetic field, we invite you to visit CESAR's booklet on the Sun..

Activity 4.1: Sunspots

1. What do you think sunspots are and what causes them?

2. In what layers of the Sun are sunspots visible? Draw an outline.

3. ¿ Do you think sunspots are related to the sun's magnetic field?

Sunspots are a result of the Sun's magnetic activity, being regions where the Sun's magnetic fields exit (or enter) through the surface of the Sun (photosphere). They often appear in pairs, with one of the spots being created by the magnetic field line coming out of the photosphere and the other by the magnetic field line coming in. Therefore they often have magnetic poles (or polarity), resembling the north and south poles of a magnet.

They appear as dark patches on the surface of the Sun (known as the photosphere) because they are about 1000 K cooler than their surroundings and can vary in size, becoming as large as the Earth or Jupiter (see left image of Figure 16)

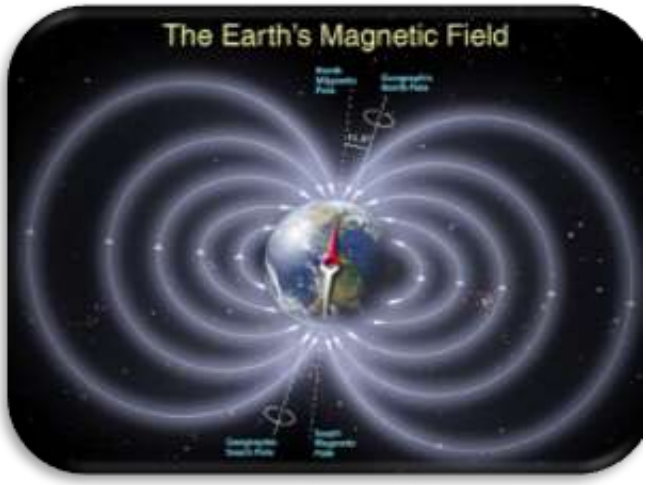
Figure 16*: (Left image) Sunspot size comparison. (Right image) Comparison of sunspots with a magnet (Credits: ESA Solar Orbiter)*

Activity 4.2: The influence of the Sun on the Earth

The Sun is the star that allows the existence of life (zone of habitability), as we know it on Earth, and the variations in its activity impact on Earth at many levels.

Most of the planets in the Solar System are surrounded by large magnetic envelopes. They are known as magnetospheres and are produced by activity inside the planet. These magnetospheres form the largest structures in the Solar System, being between 10 and 100 times larger than the planet itself.

The solar wind interacts with these "magnetic bubbles" and can move and deform them. They can therefore be induced by this interaction with the solar wind with its ionosphere (Venus and comets) or by a magnetic dynamo process (as occurs on Mercury, Earth or giant planets).



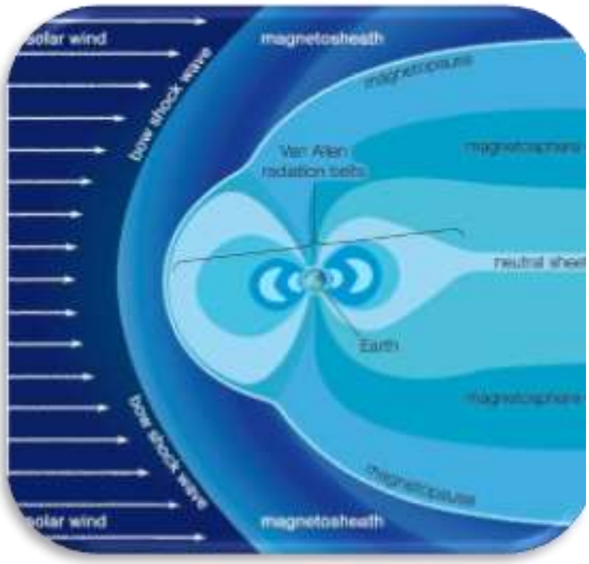


Figure 17: *Earth's magnetic field and the influence of the solar wind on it (Credits NASA, ESA)*

The Earth's magnetic field is very stable and does not change much over time, unlike the solar magnetic field. However, some of the ultraviolet radiation manages to pass through the atmosphere and so we must protect ourselves. Watch this TED-ED video to see the effect of the sun on people and the need to use sunscreen.

1. Draw how you think it might affect the Sun's magnetic activity on Earth

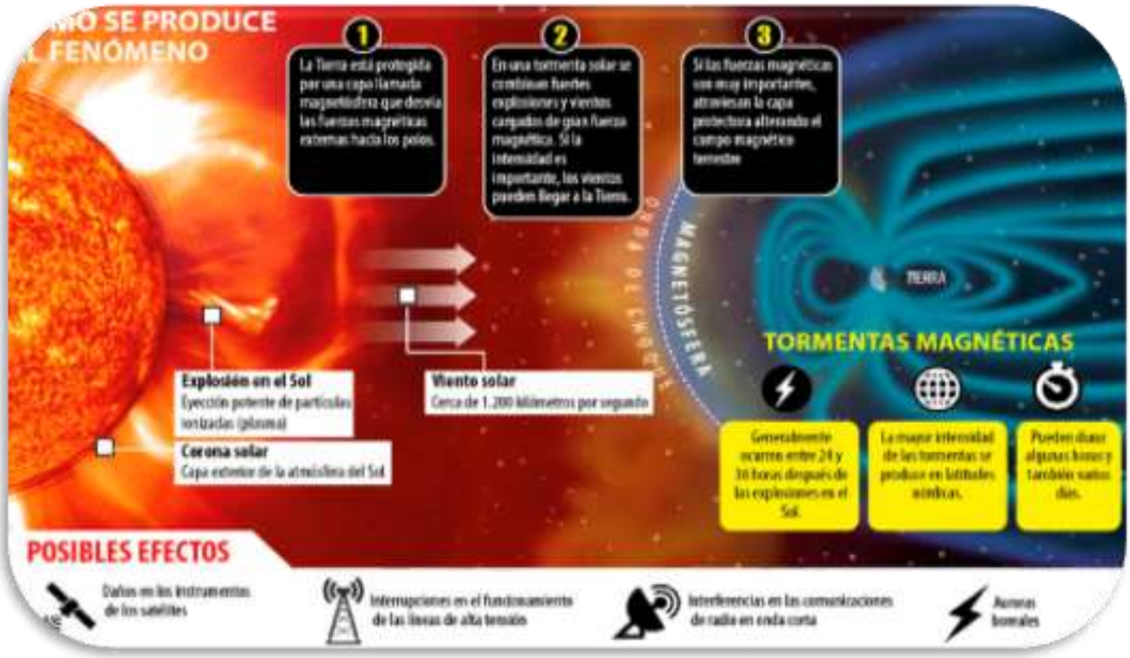
Figure 18: *Earth's magnetic field and its effect on the Sun and satellites (Credits : ESA)*

2. Do you think there is any relationship between the Sun and the Northern Lights?

Figure 19: *Auroras Boreales Training (Credits :* www.meteorologiaenred.com)

- **The following [video](#) explains the appearance of the Northern Lights as a cause of the Sun's influence on the Earth's magnetic field**

3. What other influence can solar activity have on the Earth?



Activity 5: The Space Exploration of the Sun by the European Space Agency (ESA).

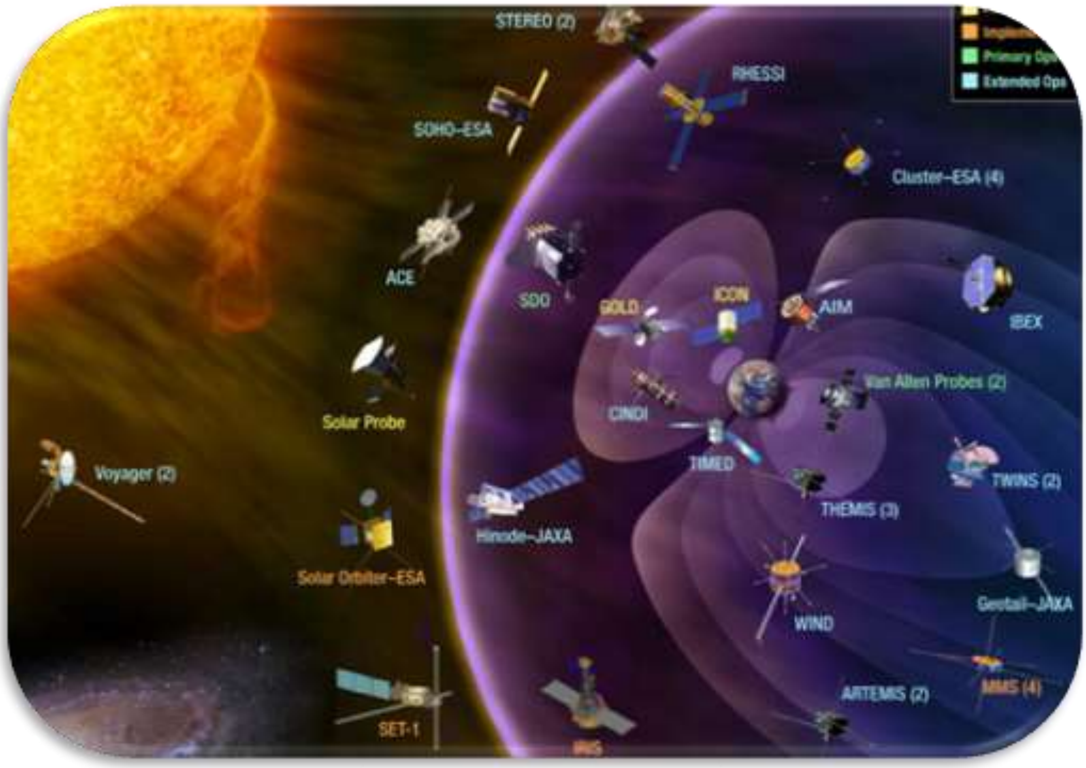


Figure 20: *European Space Agency mission fleet. (Credits: www.fidefundacion.es)*

For more than two decades, the European Space Agency, together with the US Space Agency, has been studying the Sun, as its variations can significantly affect the Earth. Figure 20 shows all of them and Figure 21 those with a high European contribution (PROBA-2 , SOHO y Solar Orbiter). The field of physics that studies the Sun is called **Heliophysics.**

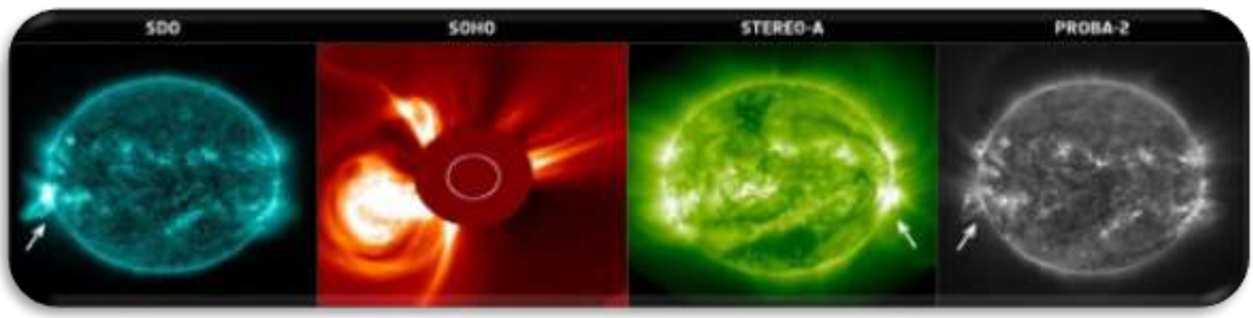


Figure 21: *The Sun observed in different filters (credits: kiri2ll.livejournal.com)*

Actividad 5.1. Solar Orbiter. SOLO

Figure 22: *Simulation SOLO, ESA. (credits www.esa.int)*

ESA's Solar Orbiter mission was launched in 2020, with the main objective of closely studying the Sun, its poles and in particular to analyze the behavior of its magnetic fields, in order to predict the behavior of the star on which our lives depend.

Figure 23: *SOLO launch, ESA. (Créditos: ESA–S. Corvaja)*

Discover the travel blog and educational activities created by SOLO mission scientist Dr. Anik de Groof to chronicle her journey to see the mission launch in February 2020. Here is a video of the launch of the SOLO mission.

The following links are extra resources to know the missions in charge of the study of the Sun:

- ESA mission to the Sun
- 3D Simulators of the European Space Agency mission spacecrafts fleet
- The ESA SWARM mission studies the variations of the Earth's magnetic fields.
- The mission ESA SWARM studies the variations of the Earth's magnetic fields.

Activity 5.2: Solar telescope CESAR (HELIOS)

The HELIOS telescope, as shown in Figure 24, is a solar telescope belonging to the CESAR Team and has been installed at ESAC since 2012. Its main objective is to observe the Sun's disk every day (in the visible and H-alpha range) as shown in the calendar created with the images of the Sun taken in 2017 in Figure 25.

Figure 24: Solar *Observatory HELIOS (Credits: CESAR*

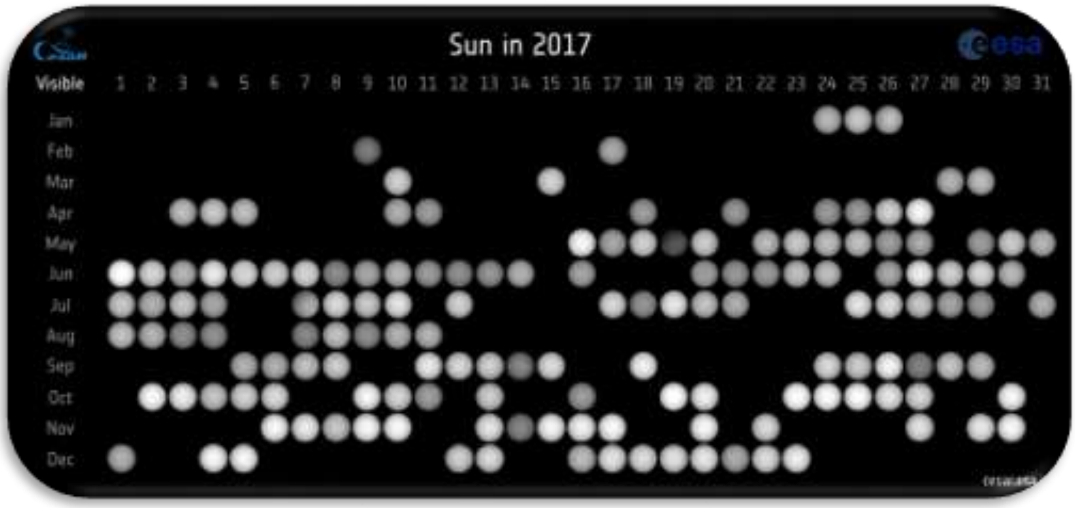


Figure 25: *ESA solar observatory (Credits www.esa.int)*

From this scientific data the CESAR Team creates educational material such as "The Study of the Rotation of the Sun.

If you want to see the last image taken by this telescope Access to "The Sun live"”

- For more information about this ground-based telescope access the ESAC SOLAR OBSERVATORY, in the following link.

Activity 6: Evaluate what you have learnt so far

Check what you have learnt so far with this questionnaire

Phase 2

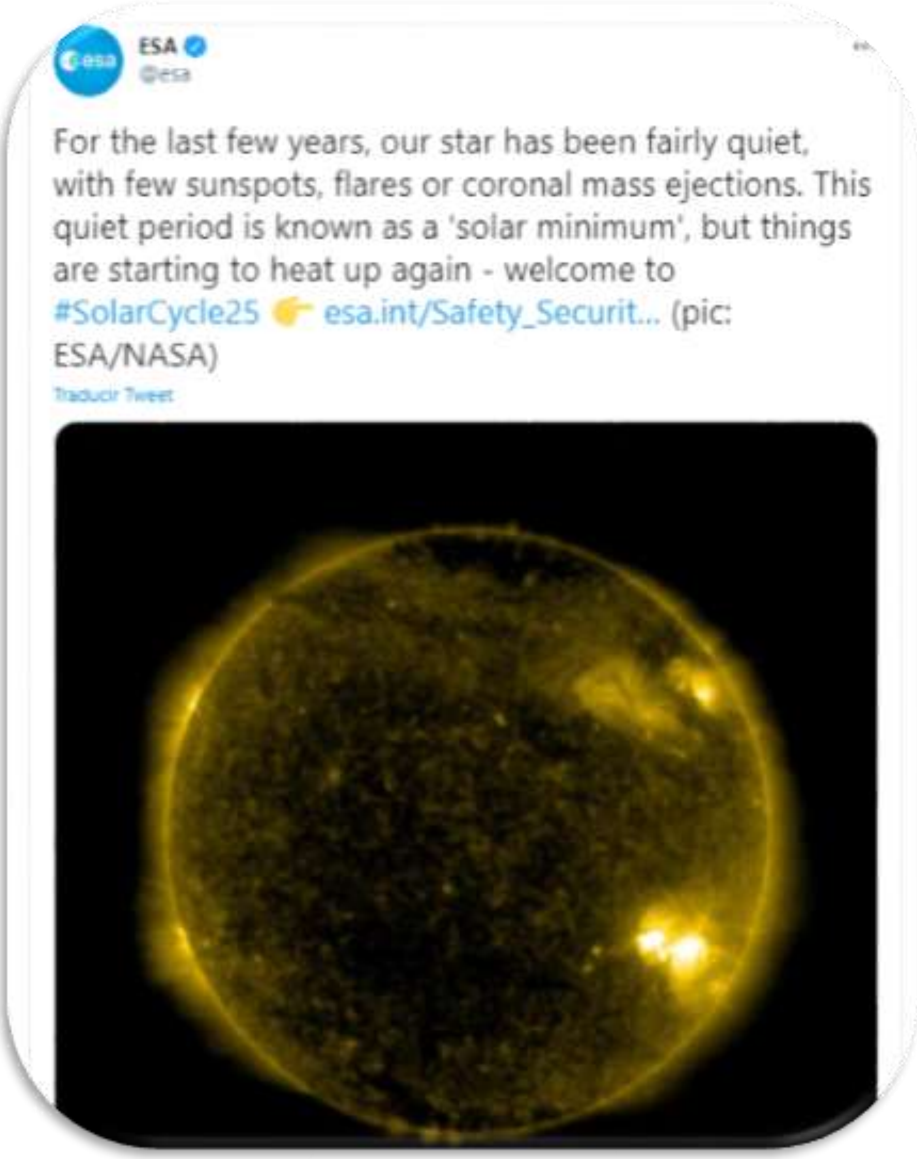


Figure 26: *Image of the Sun taken by ESA mission (Credits: https://twitter.com/esa/status/1322117428806123520)*

Phase 3

This activity is structured according to the scientific method. First you will make a **hypothesis**, then an **experiment** (procedure) and finally you will come to your own **conclusions**.

Are you prepared to think like a scientist?

Hypothesis

1. How long do you think it takes the Sun to go around itself?

2. Do you remember what a sunspot was? (Hint: Check Activity 4.1 to remember)

3. In what direction do you think a sunspot moves on the surface of the Sun? Draw a diagram that illustrates your answer. (Hint: Check Activity 4.1 to remember)

4. Do you think sunspots only move in one direction?

Activity 8: Calculation of the rotation of the Sun

In this activity, students will use images of the Sun taken by the Solar Observatory HELIOS, belonging to the CESAR Team and installed in ESAC. From these images, they will measure the movement of a sunspot over several days to calculate the rotation of the Sun.

Actividad 8.1: Versión on-line

- **Data:** Images taken by the HELIOS solar telescope of the Sun's photosphere.
- **Tools:**
    - Web tool designed by the CESAR Team of "Study of the Differential Rotation of the Sun
    - Calculator
- **Video tutorial** https://youtu.be/6C5wirg9IQU
- **Recommendations:** It is convenient that different groups carry out the exercise with different sets of images and finally put their results in common so that the differential rotation of the Sun is more evident.

Procedure

- Watch the video tutorial and repeat the exercise for the set of images chosen in Option 3
- **Access the CESAR web tool for** the "Study of the Differential Rotation of the Sun".
- **Step 1/4:** Choose a set of images (for example, Option 3). These are consecutive images which allow us to study the evolution of sunspots.

***Figure 27:** Step 1 of the web tool for calculating the rotation period of the Sun (Credits: CESAR)*

- **Step 2/4 (I):** Calculate the radius of the Sun to know the scale of the image.
  Click with the mouse in the center of the Sun (black cross) and then on the end of the disk. This will allow the tool to know internally how many kilometers from the Sun fit in a pixel of the image.

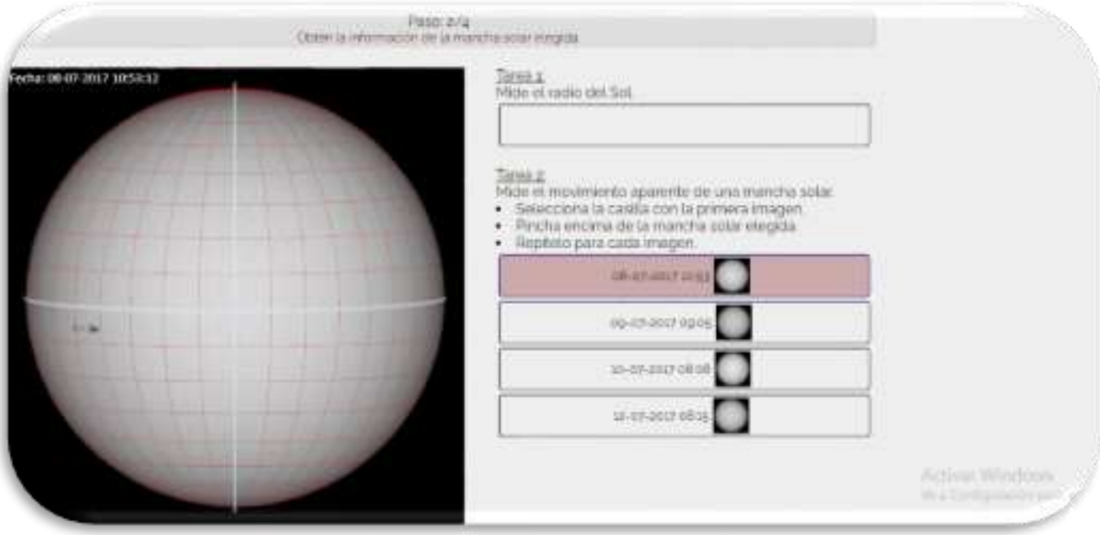


Figure 28: Step 2 of the web tool for the calculation of the rotation period of the Sun (Credits: CESAR)

- **Step 2/4 (II):** For each image select the position where the stain is.

- **Step 3/4 (I): Calcule the rotation period of the Sun:**

  - Fill in the time difference between the image(N) and the image(N-1), in days (e.g. XY days) in the numerator.
  - Fills in the denominator the difference in length between the image(N) and the image(N-1), in degrees.

__Note__: Calculations should be performed using external means which may be calculator, paper or mental calculations

Figure 29: Step 3 of the web tool for the calculation of the rotation period of the Sun (Credits: : CESAR)

- **Step 3/4 (II): Calculate the average value of the rotation period:**
  - Use the values of the three instantaneous rotation periods (calculated between pairs of images) and calculate the average value. (Note: This value should be calculated using external means which can be calculator, paper or mental calculation).

- **Step 3/4 (III): Calculate the average value of the stain latitude:**
  - Enter the average latitude of the spot from the latitude of the four images.

- **Step 4/4: Compare your result of the rotation period with that of the solar system planets**

Figure 30: *Step 4 of the web tool for the calculation of the rotation period of the Sun (Credits: CESAR)*

Figure 30 shows a result for Option 3. Note that when choosing the center of the image by hand there is an error in the measurement. (Note: We give the periods of rotation of the planets of the solar system, taking into account that for the gas giants the value is average (link)).

1. Based on your observations, how long does it take for the Sun to turn on itself?

2. Do you give the same value to your colleagues? If this is not the case, analyze the reasons

Activity 8.2: PDF Version

- **Data**: Images taken by the HELIOS solar telescope of the Sun's photosphere, with dates and distribution of parallels and meridians on it. We see the surface of the Sun (or disk) and sometimes dark spots on it (sunspots).
- **Tools:** The images bring superimposed the meridians and parallels of the Sun for that date.
- Calculator

Follow the **Procedure:**

- Download and print the sun disk images taken by the HELIOS telescope. There are two groups of images taken on two different dates, with spots at different latitudes:
  - **Option 1: Three images taken between 29/03/2001 and 02/04/2001** (link)
  - **Option 2: Three images taken between 31/12/2010 and 11/01/2011** (link)
- **Step 1 /4:** Inspect the images and choose the sunspot you will use for your measurements (Note: It is important that the same spot is visible in all 3-4 consecutive images)
- **Step 2/4 (I):** Measure how much your favorite sunspot has shifted in length

Image	Date (DD-MM-YYYY hh:mm)	Latitude	Longitude
1			
2			
3			

Table 5: *Table for the identification of sunspots in the study images (Credits: CESAR)*

  - Fill in Table 5 with the date, latitude and longitude information of your patch.
  - Repeat the exercise for the same spot in the other images.

- **Step 3 of 4 (I):** Calculate the rotation period of the Sun:
  - Fill in Table 6 with the time difference between the image(N) and the image(N-1), in days (e.g. X.Y days). (Note: The time the images were taken is given as YYYY/MM/DD hh:mm, with DD being the day, from month MM to year YYYY at hour hh and minutes mm.)
  - Fill in Table 6 with the difference in length between the image(N) and the image(N-1), in degrees. (Note: Depending on whether the spot is in one area or another, it will have a positive or negative value, check Activity 1. What the tool needs is the angle in absolute value).

- **Step 3/4 (II):** Calculate the average value of the rotation period:
  - Uses the values of the two instantaneous rotation periods (calculated between pairs of images) calculates the average value. (Calculations should be performed using external means which may be calculator, paper or mental calculations).

- **Step 3/4 (III):** Calculate the average value of the latitude of the spot:

o Enter the average latitude of the spot from the latitude of the three images.

Pair of images	Variation in time (days)	Variation in longitude (degrees)	Rotation period (days)
1 and 2			
2 and 3			
Average value of the rotation period (days)			
Average latitude (degrees)			

Table 6: Table of sunspot movement variation (Credits: CESAR)

- Step 4/4: Compare your result of the rotation period

Table 7: Rotation periods of the planets of the Solar System.

Objeto	Periodo de rotación
Mercurio	58.64 días
Venus	243.02 días
Tierra	1 día
Marte	1.03 días
Jupiter	0.41 días
Saturno	0.44 días
Urano	-0.71 días
Neptuno	0.67 días

Conclusions

1. Is the value of the rotation period of the Sun what you expected? Compare your results with those of other colleagues, are they similar? If not, what do you think is the reason for these differences?

2. Did you expect the Sun to rotate more or less fast than the Moon? And more or less fast than the Earth?

3. The following factors affect how the sunspot (and therefore the Sun rotates:):
   a) the hemisphere we are looking at?
   b) date?
   c) the latitud value?

   Explain the reasoning behind your answers.

4. Given the latitudes of the sunspots, at what latitude does the Sun rotate fastest? In other words, at what latitude is the Sun's rotation period shorter?

Phase 4

Congratulations!
You have completed your Scientific Challenge!
Tell us your story!

Recall you Adventure and do these last Activities

Activity 9: Evaluation

- **Teams:** Fill in this questionnaire so that you can check what you have learned in the Challenge.
- **With your teacher:** Give us your feedback

Activity 10: Tell us about your Adventure

Create a final product (A0 poster) showing what have they learnt in the different Phases of their Scientific Challenge and present it to their classmates/school.

This poster is your ticket to participate in the *worldwide contest for the CESAR Adventures*.

Links

PHASE 0:

VIDEOS:

- This is ESA: https://www.youtube.com/watch?v=9wdbNU7Pu8U&feature=youtu.be
- http://www.esa.int/ESA_Multimedia/Videos/2015/01/ESAC_ESA_s_Window_on_the_Universe
- Presentation to ESA/ESAC/CESAR by Dr. Javier Ventura: http://cesar.esa.int/index.php?Section=Multimedia&Id=63
- http://cesar.esa.int/index.php?Section=SSE_Videos_NEW&ChangeLang=es

APP:

- https://www.edumedia-sciences.com/es/media/112-cinematica

WEBS:

- Katherine Johnson: https://kids.britannica.com/kids/article/Katherine-Johnson/628677
- Vera Rubin: https://www.nytimes.com/2016/12/27/science/vera-rubin-astronomist-who-made-the-case-for-dark-matter-dies-at-88.html
- Samantha Cristoforetti: https://www.nytimes.com/2016/12/27/science/vera-rubin-astronomist-who-made-the-case-for-dark-matter-dies-at-88.html
- Marie Curie: https://es.wikipedia.org/wiki/Marie_Curie
- Steve Wozniak: https://es.wikipedia.org/wiki/Steve_Wozniak
- Matt Taylor: https://www.famousbirthdays.com/people/matt-taylor-scientist.html
- Albert Einstein: https://es.wikipedia.org/wiki/Albert_Einstein

PHASE 1:

VIDEOS:

- http://www.esa.int/ESA_Multimedia/Videos/2013/07/Science_ESA_Episode_8_The_Sun_our_local_star/(lang)/es
- https://www.youtube.com/watch?v=ZSJlTdsTze0
- https://www.youtube.com/watch?v=1DXHE4kt3Fw
- Solar Orbiter https://www.esa.int/ESA_Multimedia/Missions/Solar_Orbiter/(result_type)/videos
- SOLO: https://www.esa.int/ESA_Multimedia/Videos/2020/02/Solar_Orbiter_launch_highlights
- https://www.esa.int/ESA_Multimedia/Missions/Solar_Orbiter/(result_type)/videos
- https://www.esa.int/Applications/Observing_the_Earth/Swarm/Highlights/Earth_s_magnetic_field
- https://dlmultimedia.esa.int/download/public/videos/2013/07/020/1307_020_AR_ES.mp4
- COSMOGRAPHIA: https://www.youtube.com/watch?v=VBO9MDt8Gvs

APP:

- https://www.purposegames.com/game/layers-of-the-sun-game
- https://www.ptable.com/?lang=es
- http://cesar.esa.int/index.php?Section=SSE_Composicion_de_las_estrellas_portada
- https://spectralworkbench.org/

- http://scifleet.esa.int/#/.
- http://scifleet.esa.int/#/model/sun
- SOHO: http://scifleet.esa.int/#/model/soho
- SOLO: http://scifleet.esa.int/#/model/solar_orbiter
- https://www.solarorbiterforkids.com/
- http://cesar.esa.int/form.php?Id=11&k=9gPSn9hqRN&ChangeLang=en

WEBS:

- http://cesar.esa.int/upload/201905/jupiter_moons_booklet_pdf.pdf
- https://www.esa.int/Space_in_Member_States/Spain/Explorando_el_Sol
- https://www.esa.int/Space_in_Member_States/Spain/El_Sol_en_2018
- http://cesar.esa.int/index.php?Section=News&Id=183

- http://cesar.esa.int/index.php?Section=Live_Sun
- http://cesar.esa.int/index.php?Section=Observatories_ESAC_Sun
- https://www.esa.int/kids/es/Aprende/Nuestro_Universo/El_Sol/Eclipses_solares

- http://www.esa.int/Our_Activities/Space_Engineering_Technology/Proba_Missions/About_Proba-2
- SOHO: http://www.esa.int/Our_Activities/Space_Science/SOHO_overview2
- Solar Orbiter: http://sci.esa.int/solar-orbiter/

PHASE 2:

PHASE 3:

VIDEOS:

- LASCO
  - https://www.esa.int/ESA_Multimedia/Keywords/System/SOHO_LASCO_coronograph/(result_type)/videos

- http://cesar.esa.int/tools/15.coronal_mass_ejections/index.php?ChangeLang=es
- https://es.wikipedia.org/wiki/Coron%C3%B3grafo

PHASE 4:

- http://cesar.esa.int/form.php?Id=11&k=9gPSn9hqRN&ChangeLang=en
- http://cesar.esa.int/upload/202001/bases_concurso_sse_final.pdf

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- Previous guide: http://cesar.esa.int/index.php?Section=Differential_Rotation_of_the_Sun