Ages: 14 and 15 years old

SCIENTIFIC CASE:
Coronal mass ejections

Team members

Writer: ____

Equipment manager: _________________________________

Reader: ____

Spokesperson: ____

Maths: ____

Context

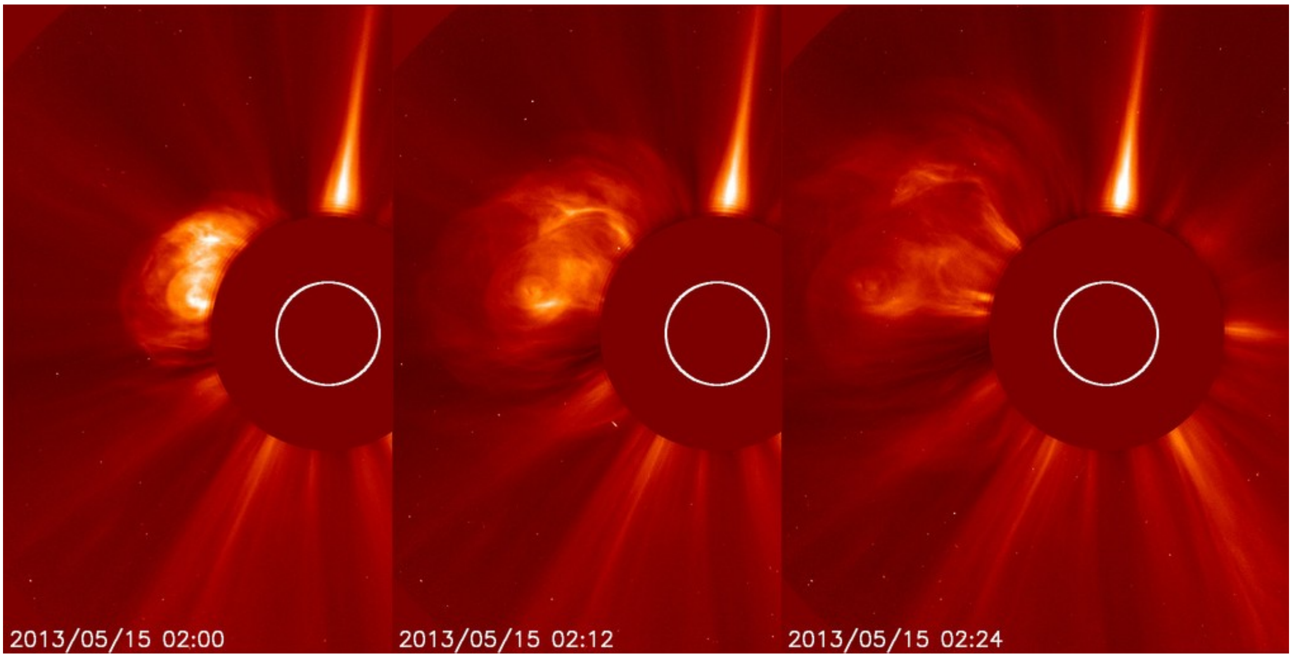
Fulgurations reaching furthest from the surface are called prominences, and they can even be ejected into space as solar wind. When that happens, they are called Coronal Mass Ejections (**CME**). CMEs can affect terrestrial communications, damage orbiting satellites, or interact with the Earth's magnetosphere forming aurorae. Unlike sunspots, fulgurations cannot be detected with regular telescopes, because they aren't significantly brighter than their surroundings.

If these ejections are bound to the south of the Earth, they can damage electrical circuits, power transformers, and communication systems. They could also temporarily diminish the Earth's magnetic field. We call this phenomenons solar storms.

More educational materials:

CESAR Solar Observation: http://www.cosmos.esa.int/web/cesar/solar-observation

SOHO classroom: http://soho.esac.esa.int/classroom/classroom.html



CME associated with the X1.2 flare captured by the SOHO/LASCO C2 camera.

Every space agency considers as a priority the presence of a satellite permanently watching the Sun. One of the most relevant missions has been the satellite SOHO, which is constantly sending us pictures of the Sun, so that we can study CMEs and know how they move. However, that mission is not the only one and every now and then, new plans are designed to continue with those tasks but with a technological upgrade.

A very useful piece of information to have is the time it would take for a CME to reach Earth, if it was coming towards us.

Taking data from two different positions, we can calculate the velocity using the formula

$$v = \frac{s}{t} = \frac{(s_2 - s_1)}{(t_2 - t_1)}$$

where s_2 is the position at time, t_2; s_1 the position at time, t_1 .

Similarly, if we know how far apart the Sun and the Earth are, we can also know how long it would take for a CME to reach us.

$$t = \frac{s_{Earth-Sun}}{v_{CME}}$$

Scientific case 1: CME velocity

How long do you think it would take for a CME to reach Earth if it was traveling in our direction?

Hypothesis

How long do you think it would take for a CME to reach Earth if it was traveling in our direction?

Research equipment

You have access to these:

- Pencil, rubber, and ruler (optional).
- Pictures of CME evolution.
- Useful data.

Procedure

It's time to estimate CME travel time!

1. Before doing the math, we remind you that you have to take your measurements with ruler to scale –see image and data–. You can do the following approximation if you like:
 1 cm » 1.000.000 km

2. Look closely at the formula and take the relevant measurements with your ruler. It'll be enough with picking two out of the four images to get an approximate result.

3. Do the maths. (REMEMBER NOT TO MIX UNITS!)

4. If you have any doubts, ask the educators or other teams. Don't hesitate to ask for help or to share your work with others.

Maths and results

Conclusions

Which forces act on the CME? Which error do you think there can be in your measurements and why? What observatins would you suggest to study what the fulguration velocity depends on? Does the fulguration size also vary with time?

Scientific case 2 (extra): CME acceleration

A more precise study would require us to look at the movement of the CME as uniformly accelerated linear motion.

The magnitude obtained is the mean velocity of the event, from the first to the second measurement taken. The smaller the interval we measure is, the closer we are to measuring the actual instant velocity – but it will be harder to do. It is the research team's job to find out the balance between precision and efficiency.

The acceleration equals the change in velocity over time,

$$a = \frac{v}{t} = \frac{(v_2 - v_1)}{(t_2 - t_1)}$$

Procedure

- Looking closely at the first two pictures, you can find the CME's acceleration.

- Plot the CME's movement in a graph representing traveled distance versus time. What kind of motion does the CME do? Why do you think that is?

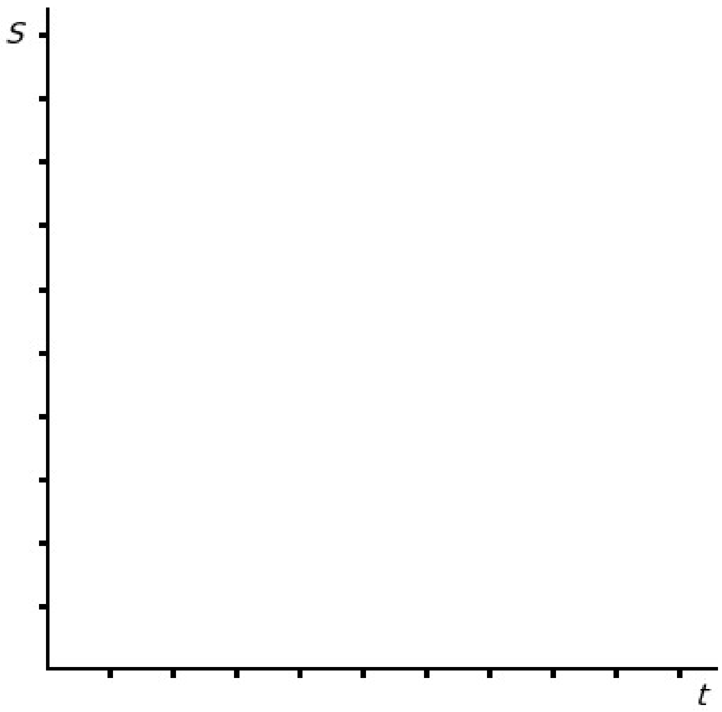
CME acceleration

a = ______________

You can register your data in a sheet like this:

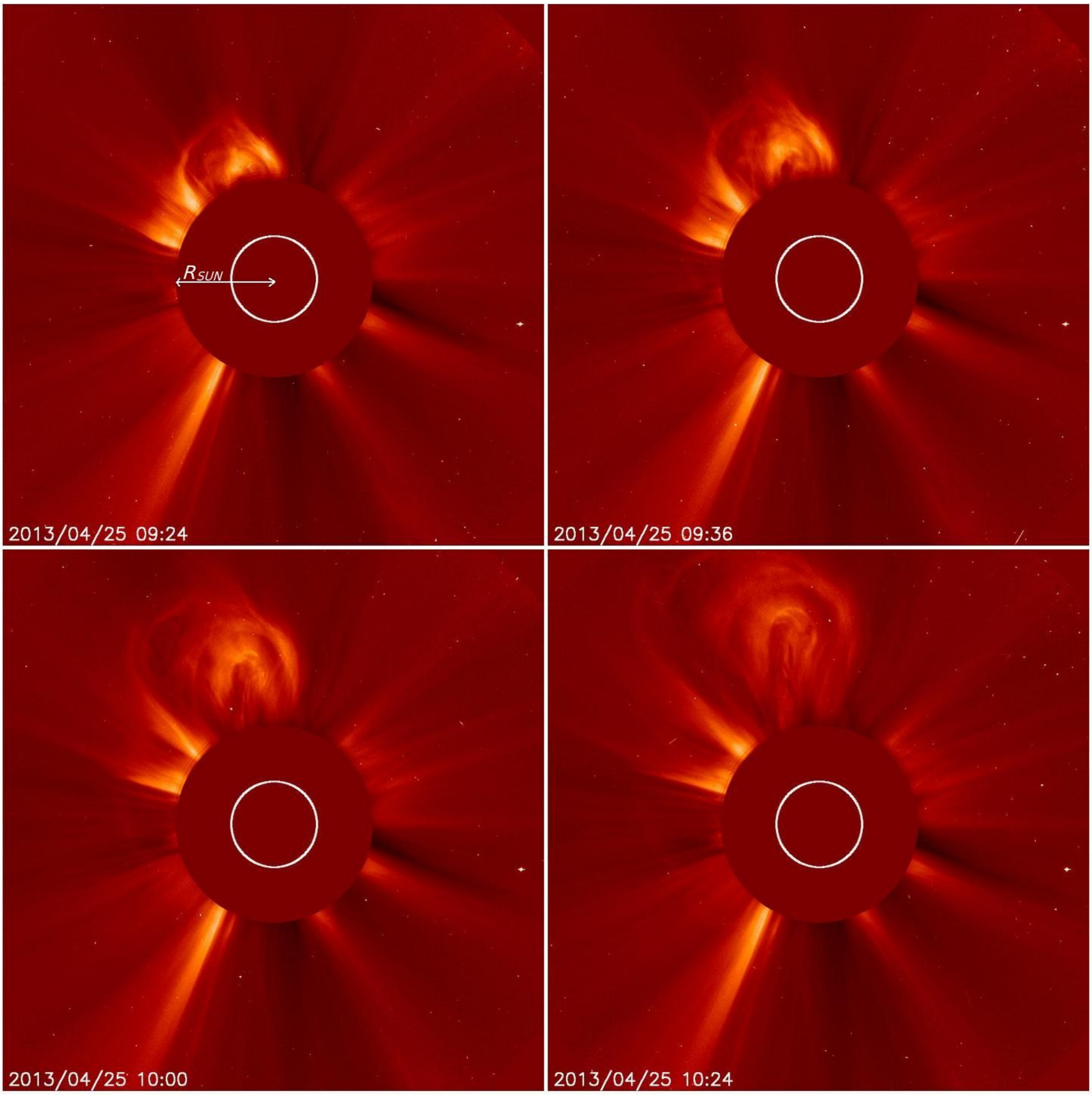
Medida nº	*t*	*s*	*v*
1			
2			
3			
4			
5			

Graph:



Research equipment

CME evolution



Useful data:

Radius of the Sun » 1.4 × 109 m = 1,400,000 km

Earth-Sun distance » 1.5 × 1011 m = 150,000,000 km