 **CME Activity Sheets: For High School**

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**Measuring the Motion of a Coronal Mass Ejection**

Here we calculate the velocity and acceleration of a coronal mass ejection (or *CME*) based on its position in a series of images from the LASCO (The Large Angle and Spectrometric Coronagraph) instrument on SOHO (Solar Heliosphere Observatory).

A coronal mass ejection occurs when a significant amount of relatively cool, dense, ionized gas escapes from the normally closed, confining, low-level magnetic fields of the Sun's atmosphere to streak out into the interplanetary medium, or heliosphere. In other words, a large quantity of mass is accelerated by the magnetic field of the corona and travels through space, sometimes towards the Earth. Eruptions of this sort can produce major disruptions in the near-Earth environment, affecting communications, navigation systems and even power grids. SOHO with its uninterrupted view of the Sun and allow a better understanding of how such violent events occur.

Materials:  
If you are doing this on paper you will need

* Images are attached below.
* Other SOHO images are attached to this document and require average velocity and acceleration are determined.
* Ruler, Pencil
* Tracing Paper
* Calculator

Instructions for the Student Level: High School-Grades 9 - 12

**For High School Students:**

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* Select a feature that you can see in the colored images, for instance the outermost extent of the bright structure or the inner edge of a loop shape. Measure Its position in each image using tracing paper to mark your information.
* Colored images taken from the coronagraphs on LASCO indicate CMEs erupting from the Sun.
* The white circle shows the size and location of the Sun. The solid red disk is the occulting disk blocking out the disk of the Sun and the inner corona.
* Measure position of the feature you have selected on the first image.
  + Lay tracing paper over the selected image
  + Using earliest image of the CME, on your tracing paper mark off the four corners of the image and the center of the white circle showing where the Sun is on the image: we will call this point, sun-center.
  + Is the mark you made for sun-center at the center of the white circle? If not, make sure that all the images are the same size.
  + Make a mark on the tracing paper over the feature you have chosen as your selected feature.
  + Remove the tracing paper and draw a straight line on the tracing paper from sun-center to the feature mark.
  + Record information in the table and continue to the next image, marking the time in the table.
* Measurements on the screen or page can also be converted to kilometers using the simple ratio:

dscreen/dactual= sscreen/sactual

where:

dscreen is the diameter of the Sun measured on the screen.

dactual is the actual diameter of the Sun.

sscreen is the position of the mass as measured on the screen.

sactual is the actual position of the mass.

*The diameter of the Sun = 1.4 × 106 (1.4 million) km.*

* Using the position and time, you can calculate the average velocity. Velocity is defined as the rate of change of position. Using the change in position and the change in time, the average velocity for the time period can be calculated using the following equation:

v = (s 2 - s 1) ÷ (t 2 - t1)

where: s 2 is the position at time, t 2.

s 1 is the position at time, t 1.

The acceleration is the change in time of the velocity:

a = (v 2 - v 1) ÷ (t 2 – t 1)

where:

v 2 is the velocity at time, t 2.

V 1 is the velocity at time, t 1.

In the table, **Average** Velocity and **Average** Acceleration are noted because the data is noting what is happening between two time points and is not a continuous measurement at every moment of the CME’s path. Therefore, it is the average velocity or acceleration that happened between the two time points.

* Record your results in the following table:

**Data Table for CME Information (choose your images):**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| [**Universal Time**](https://soho.nascom.nasa.gov/classroom/glossary.html#UNIVERSAL_TIME) **seen on image** | **Time Interval**  **Between subsequent images** | **Position (km)** | **Average**  **Velocity** | **Average Acceleration** |
|  | **None for first image** | **None for first image** | **None for first image** | **None for first image** |
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**Further Questions and Activities**

Select another feature, trace it, and calculate the velocity and acceleration. Are they different from those for the last feature you selected?   
Which one is "right"? Scientists often look at several points in different parts of the CME to get an overall idea of what is happening.   
Sometimes it can be tough to trace a particular feature. How much error do you think this introduces into your calculations?

How does the size of the CME change with time?

What kind of forces do you think might be acting on the CME? How would these account for your data? These are important questions in CME research!

**Exploring SOHO data**   
If you look at the data available from LASCO in the SOHO Gallery and elsewhere, you will see that the images usually have a circle in the center of the coronagraph disk representing the size and position of the Sun. Using this to find the scale of the image, you can make calculations similar to the one you just did for most sequences of LASCO images.

LASCO also observes comets. You can measure their velocities and accelerations too.

(This Activity was adapted from ESA and NASA)

**Images for Measuring the Motion of a Coronal Mass Ejecta: (High School)**

SOHO CME Images 2017/09/01

SOHO CME Images 2017/09/01:



















