

Explosions From the Sun

Objective:	To measure the motion (speed and acceleration) of coronal mass ejections from the sun.
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Grade Level: 9-12
Subject(s): Algebra, Physical Science, Physics
Prep Time: < 10 minutes
Duration: 40 minutes
Materials Category: Classroom

National Education Standards	
Science	1b, 1c, 3d, 3e, 7f
Mathematics	2a, 4b, 4d, 7, 12, 13a, 13d
Technology (ISTE)	
Technology (ITEA)	
Geography	

Materials:

- Student Sheets
- Rulers
- Calculators

Related Links:

Images and activity adapted from
SOHO: Sun Fun Activities (Measuring a Coronal Mass Ejection)
<http://soho.nascom.nasa.gov/>

Supporting NASAexplores Article(s):

Staring at the Sun
http://nasaexplores.nasa.gov/show2_article.php?id=05-102



Explosions From the Sun

Teacher Sheet(s)

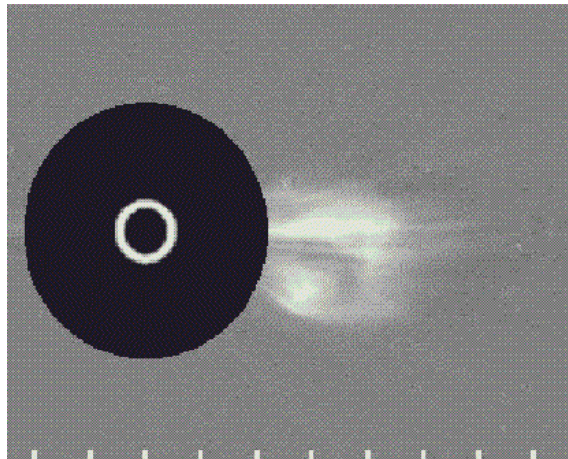
Pre-lesson Instructions

- Duplicate the Student Sheets (one per student).
- Provide each student with a ruler. Based on your class, you may not need a calculator. This activity can be done with pencil and paper calculations.
- The images on the Student Sheets are in black and white, so printing or copying this in color will not benefit the accuracy.

Background Information

The Solar Heliospheric Observatory spends its day looking at the sun. SOHO can see many amazing things. Sometimes the sun's magnetic field becomes unstable and erupts in huge magnetic bubbles of plasma known as coronal mass ejections. CMEs blow out (explode) from the sun's corona and travel through space at high speed.

This is a sample image taken by SOHO. The white circle shows the size and location of the sun. The black disk is the occulting disk, which blocks out the brightest parts of the sun. This allows us to see what is happening near to the sun. The tick marks along the bottom of the image mark off units of the sun's diameter. It is easier to calculate distances using this as our unit. To the right of the occulting disk, we can see a CME erupting from the sun.



Guidelines

1. Read orally the 9-12 NASAexplores article, "Staring at the Sun."
2. Distribute the Student Sheets.
3. Review the equations provided to ensure your students understand.
4. Instruct students fill in the chart with the missing data.
5. Have students answer the questions at the end.



Discussion / Wrap-up

- Discuss the benefit of having a satellite that is always watching the sun.
- Ask the students, "By studying the sun, how will this help life on Earth?"
Answers will vary. Some may include: predicting solar storms, learning more about other stars (life cycle, thermonuclear fusion, etc.), finding details about its beginning (cosmology), and increasing our knowledge of science (astronomy or astrophysics) and the universe.
- Possible answers (these are only approximate due to inaccuracies of measurement) to the table:

Time	Measured Position (diameters)	Actual Position (km)	Velocity (km/s)	Acceleration (km/s/s)
8:05	2.00	2.8×10^6		
8:36	2.44	3.416×10^6	331.2	-0.008
9:27	3.11	4.354×10^6	306.5	+0.028
10:25	4.11	5.754×10^6	402.3	-0.038
11:23	4.78	6.692×10^6	269.5	

- Answers to the questions:
 - This prevents the brightest parts of the sun from shining through. This allows scientists to study areas that are unable to be seen due to the brightness.*
 - Some factors are: quality of the picture, measuring the position, and calculations.*
 - Some improvements are: better pictures, having a better way to measure the position, and having a spot that was easy to see how it moves.*
 - No, they do not travel at the speed of light. No, they are very, very slow compared to the speed of light.*
 - It begins to expand, spreads out.*
 - Forces could be from gravitational fields from planets and other particle interactions around the sun.*
 - For the sample results, the third velocity is not right. The velocity should get smaller as the time elapses. The acceleration should not be positive either.*

Extensions

- Go to the SOHO Web site for other pictures of coronal mass ejections. Can you determine their speed?
- Go to the Classroom section of the SOHO Web site for more lessons and activities.



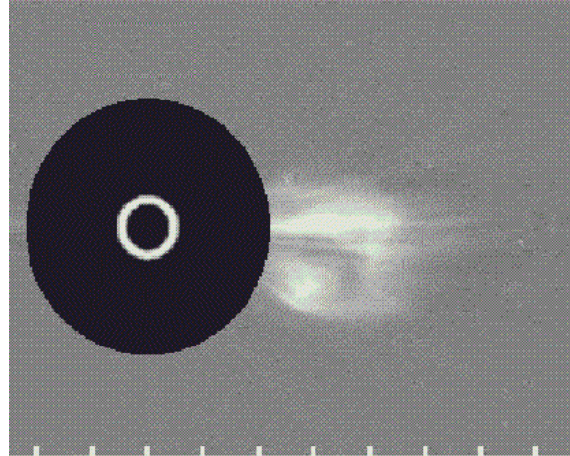
Explosions From the Sun

Student Sheet(s)

Background Information

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The motion of a CME can be done with the proper images and a ruler. To do this, we need to be able to use three different equations. To convert the measurements on the picture to real lengths, we use

$$d_{\text{picture}} / d_{\text{actual}} = s_{\text{picture}} / s_{\text{actual}}, \text{ where}$$

- d_{picture} is the diameter of the sun measured on the screen,
- d_{actual} is the actual diameter of the sun (1.4×10^6 kilometers [km]),
- s_{picture} is the position of the mass as measured on the screen and
- s_{actual} is the actual position of the mass.

To find the speed or velocity (v) of the CME, we use

$$v = (s_2 - s_1) / (t_2 - t_1), \text{ where}$$

- s_2 is the position at time t_2 and
- s_1 is the position at time t_1 .

To find the acceleration (a) of the CME, we use

$$a = (v_2 - v_1) / (t_2 - t_1), \text{ where}$$

- v_2 is the velocity at time t_2 and
- v_1 is the velocity at time t_1 .



Materials

- Rulers
- Calculators

Procedure

1. Look at the five pictures of the time elapsed CME. Select a feature that you can see in all five images.
2. Using the ruler, measure the diameter of the sun on the picture. Record this value here: _____.
3. Using the ruler, measure this feature's position in each image. Record this in the chart. Hint: use the units of diameters of the sun, as labeled in the coronagraphs (this will make the calculations easier).
4. Convert this measured position to the actual position (in km).

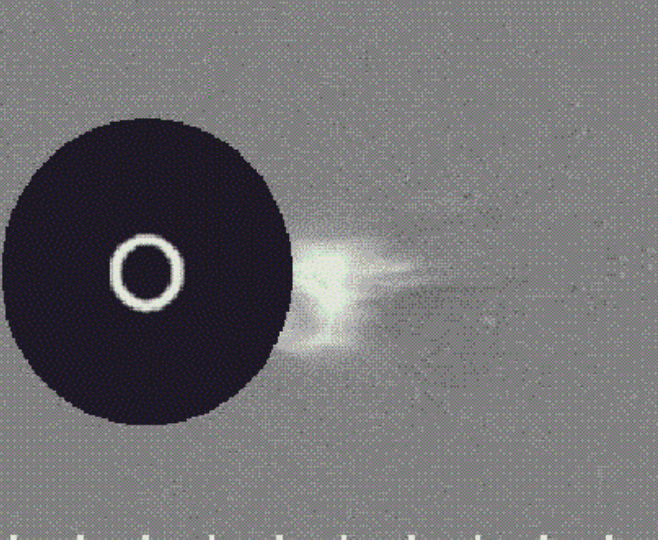
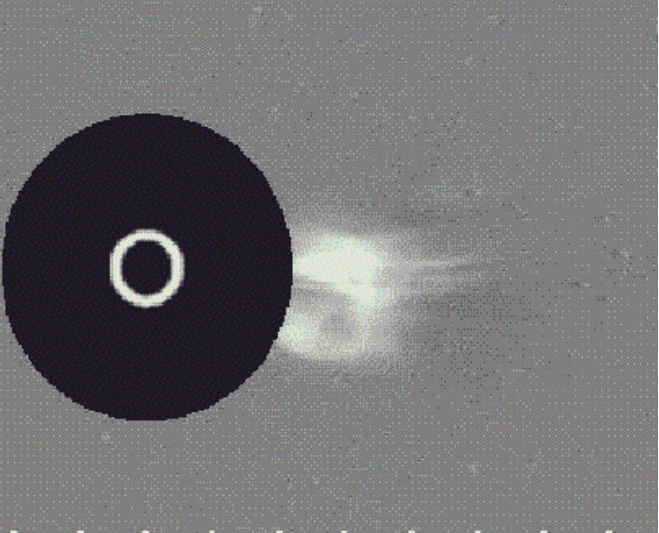
Time	Measured Position (diameters)	Actual Position (km)	Velocity (km/s)	Acceleration (km/s/s)
8:05				
8:36				
9:27				
10:25				
11:23				

5. Find the speed (velocity) for each possible interval in kilometer per second (km/s). Record the values in the chart.
6. Find the acceleration for each possible interval in kilometers per second squared or kilometers per second per second (km/s/s). Record the values in the chart.



7. Answer the following questions:
- a. If SOHO is studying the sun, why does SOHO block the sun with an occulting disk?
 - b. In your calculations and measurements, what error factors may limit your accuracy?
 - c. What could improve your results?
 - d. Do CMEs travel at the speed of light? Is it close to the speed of light?
 - e. How does the shape of the CME change over time?
 - f. Once the CME leaves the sun, what forces or interactions will affect its motion?
 - g. Did your results make sense? In other words, did you have any "strange" values? What pattern do you see in your results?



Time picture was taken	Coronagraph
8:05	
8:36	



9:27	
10:25	
11:23	

