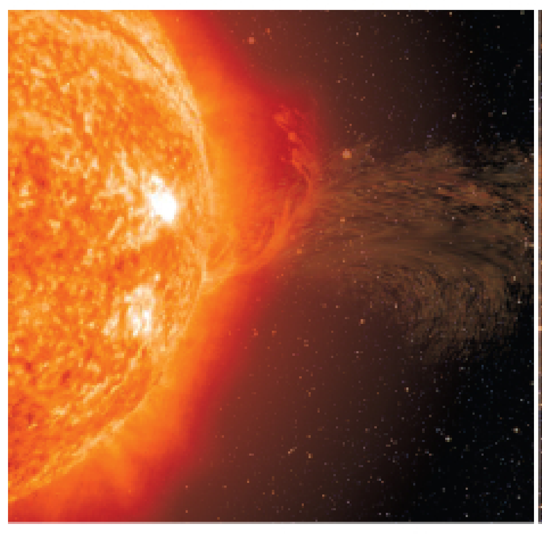
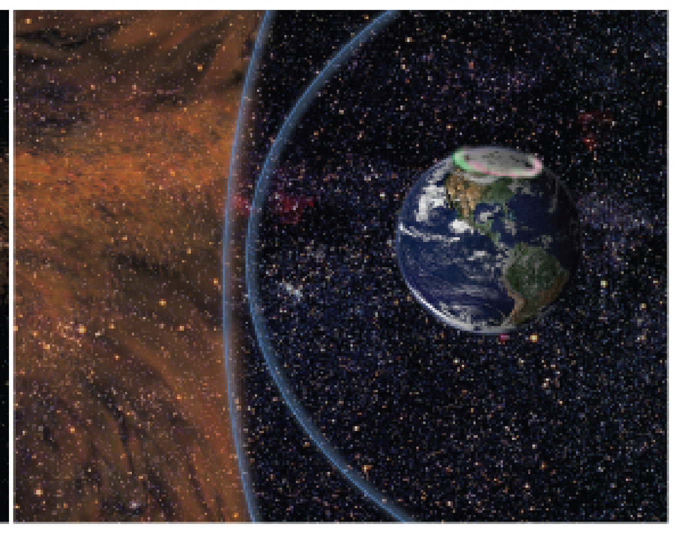
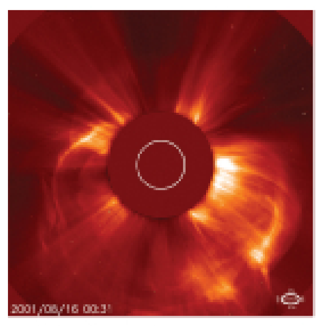
STEREO and the Sun

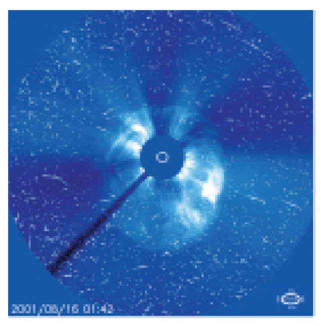
NASA's two STEREO (Solar TErrestrial RElations Observatory) observatories will give a unique, never before seen 3D view of our star, the Sun, and the solar wind.





As the closest star to Earth, the Sun produces the light that heats our planet making life possible. However, the Sun is not a simple, unchanging glowing ball. Its complex magnetic field drives a hot atmosphere, the corona, filled with dynamic loops and other structures at temperatures from tens of thousands to millions of degrees. The super-hot gases from the corona flow out into the solar system to form the solar wind. This wind carries with it magnetic fields from the Sun, which in turn, interact with the magnetic field of Earth.

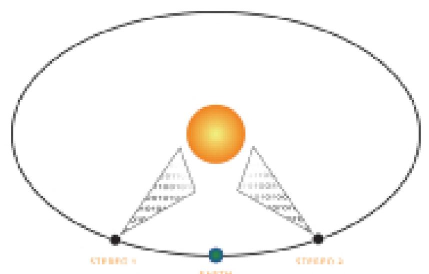




The solar atmosphere also releases huge magnetically shaped eruptions of material known as coronal mass ejections (CMEs). These structures, expanding to many times larger than the Sun itself, explode off the Sun and move out into the solar system at velocities that can be as high as 4.5 million miles/hour (7.2 million km/hour).

The disturbances caused by these ejections produce high-energy particles that can be dangerous to humans and our technology in space. When a CME hits Earth's magnetic field it can create disturbances that cause problems for spacecraft, power, and communications systems as well as causing the beautiful atmospheric displays know as the northern and southern lights, or the aurora.

We have many basic questions about CMEs. What causes them and determines their size, shape, speed, and direction? What is their general structure? How can we predict them and determine which ones will affect us the most?

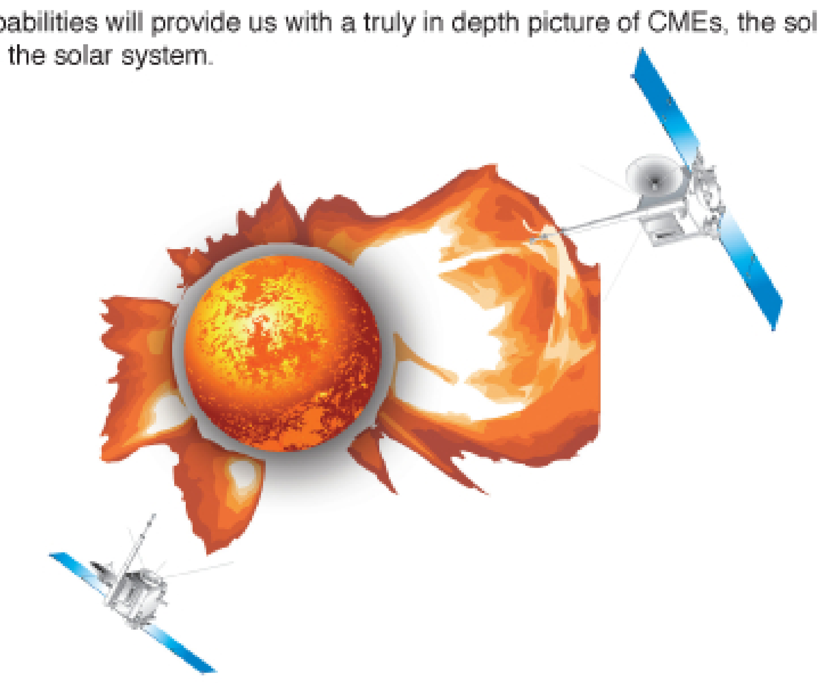


In order to resolve these questions, we need a full 3D picture of CMEs and their environment from the Sun's atmosphere out to the orbit of Earth and beyond. The STEREO observatories can provide us with this critical information.

The mission consists of two nearly identical observatories which will be sent on orbits around the Sun close to that of Earth, but one pulling ahead of Earth at about 22.5 degrees per year and the other falling behind at the same rate.

STEREO's imaging instruments will show us the Sun's corona and CMEs from two points of view. This will give us a much better idea of their shape and direction of motion. Other instruments will measure the radio waves produced by the shockwave running ahead of a CME and the properties of the particles and magnetic field in the CMEs and solar wind flowing by the spacecraft. Using two observatories will allow us to simultaneously image a CME from outside with one observing and measure conditions inside the CME with the other.

These new capabilities will provide us with a truly in depth picture of CMEs, the solar wind and our environment in the solar system.



HOW DOES 3D WORK?

Most human beings use what is known as binocular vision to perceive depth and see the world in 3D. The binocular vision system relies on the fact that we have two eyes, which are approximately 2 in (5 cm) apart. This separation causes each eye to see the world from a slightly different perspective. The brain fuses these two views together. It understands the differences and uses them to calculate distance creating our sense of depth and ability to gauge distance.

Hold you thumb up at arms length and close one eye. Then try closing the other eye. As you switch between open eyes you should see your thumb "jumping" back and forth against the background. To see how much of a difference the binocular vision system makes, have a friend throw you a ball and try to catch it while keeping one eye closed!

CREATE YOUR OWN 3D IMAGES

Prepared by Ethan Hurdus and Jacob Noel-Storr
Science Camp Watonka (http://www.watonka.com/)
CAPER Team (http://caperteam.as.arizona.edu/)

You can create your own red/blue 3D images to print, or look at on a computer screen, using a normal digital camera and some image processing software. For this activity we explain how to use Adobe® Photoshop®, but you should be able to get the same results using similar programs by playing around with the tools and settings.

To recreate this 3D effect in print or on a computer screen, we need to simulate binocular vision. In short, we need to take two photos of our subject, separated by a short distance (the distance between your eyes, about 2 in (5 cm), then make it so your left eye only sees the left image and your right eye only sees the right. To do this we will use red/blue 3D glasses and our image processing software to tint one image red, tint the other one blue, and superimpose them. When viewed through the glasses, our photo will appear three-dimensional!

MATERIALS

- Digital Camera
- Photo editing software
- Red/Blue 3D glasses

ACTIVITY PROCEDURES

STEP 1
Start out by picking a subject. It is easier to take photos of objects or landscapes because we need to take two photos that are as identical as possible. Shots of people can work provided they stay very still and do not move in the time it takes you to snap two photos. Take your first photo, then try to slide the camera over 2 or 3 inches and take the same photo. One easy trick is to take one photo looking through your left eye and the second while looking through your right. A common mistake is to take the pictures too far apart.

Left Photo

Right Photo

STEP 2
Download the photos to your computer and open them up in a photo-editing software such as Adobe Photoshop®. Any program will work as long it allows for the red, blue, and green color channels to be manipulated independently.

STEP 3
Once both pictures are open, convert them both to grayscale by clicking on IMAGE in the menu bar and selecting MODE then GRAYSCALE.

[Image > Mode > Grayscale]

STEP 4
Convert the right photo back to red, green, and blue (RGB) by clicking IMAGE on the menu bar and selecting MODE then RGB (the image will still appear gray).

[Image > Mode > RGB Color]

In the Channels tab (in the layers palette between the LAYERS and PATHS tabs), select the red channel by clicking on the word RED and NOT the little eye next to it (eyes indicate which channels are displayed, not selected). Only that channel should appear highlighted.

STEP 5
Go back to the left photo and select the entire photo [Ctrl-A] for PC or [Command-A] for MAC then copy the image [Ctrl-C] for PC or [Command-C] for MAC, and finally return to the right photo and paste the image [Ctrl-V] for PC or [Command-V] for MAC.

STEP 6
Now you are ready to complete the merging of the left and right images. Go back to the channels palette. Click on the little box next to RGB. An eye should appear in all four channels but still only the red channel should be highlighted. You should now have a mostly black-and-white image with red and blue halos.

STEP 7
You are nearly done. The left and right eye images need to be better aligned to remove as many of the halos as possible. This is achieved by centering the two images on the subject of your photo (typically what is in front and center - this will be the easiest part of the 3D photo for people to focus on). Select the move tool [press V] then use the arrow keys to move the red image until you see the best alignment. We are trying to remove the halos from around our subject, though objects towards the edges will still be quite haloed.

STEP 8
The final step is to crop the image down to the size you want using the crop tool located in the tool bar (left hand column, third tool down). Try to remove areas of excess red or blue around the edges. Once you have selected the area of the image you want to keep hit ENTER to crop the image. Now that you are done, don't forget to save!

Now when you look at your image using red/blue 3D glasses you should see the scene appear in 3D, depending on which way you shifted the images you might need to switch which way you are looking through the glasses. You should try experimenting for a while with taking photos and creating the images to get the best results.

HINTS

- Don't save the changes to the original photos, always work with a copy.
- Try making other versions and centering on something else in your photo (something more in the foreground or background) than what you originally planned.
- It may be helpful to adjust the alignment while watching through 3D glasses.
- This method works especially well with close up photos of detailed and textured things (use your camera's macro mode, usually indicated with an icon of a flower, which will make it autofocus even when very close to your subject).

MAPPING MAGNETIC FIELDS

An Activity for: Grades 4–8

NATIONAL SCIENCE CONTENT

- Unifying Concepts and Process: Evidence, models, and explanation; Change, constancy, and measurement.
- Science as Inquiry: Abilities necessary to do scientific inquiry; Understandings about scientific inquiry.
- Physical Science: Properties and changes of properties in matter; Motions and Forces.

STUDENT OBJECTIVES

1. Students will know that bar magnets have two poles and that similar poles repel each other and differing poles attract each other.
2. Students will be able to detect and draw a magnetic field using compasses.
3. Students will know that magnets have an invisible force field known as a magnetic field and a bar magnet has a dipole field.

MATERIALS (per group of two students)

- 1 compass per student
- 2 Alnico bar magnets
- 4 sheets of 8" x 11" paper
- paper clips; pencils
- ruler
- tape

ACTIVITY PROCEDURES

Prepared by the STEREO/IMPACT E/PO Team
(http://cse.ssl.berkeley.edu/impact/)

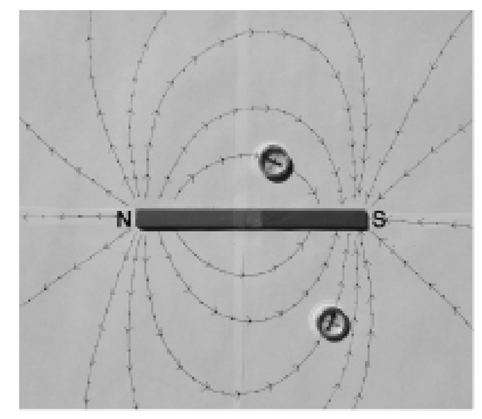
Using bar magnets, classroom materials, and a compass, students will explore how bar magnets interact with one another and with other materials. Students will learn how to use a compass to find which direction is North. Students will use a compass, a bar magnet, paper, and a pencil to make visible the lines of magnetic force (magnetic field lines) around a bar magnet. Magnetic field lines are an important concept that STEREO scientists use to understand CMEs.

STEP 1
Ask your students about their experiences with magnetism and their knowledge and ideas about what it is and what causes it. Ask questions about whether or not Earth is magnetic, how they know if it is or not, and if there are any other astronomical bodies that are magnetic (like the Sun). You might also ask if they know what a magnetic compass is and what it does.

STEP 2
Allow students some time to freely experiment with the magnets and materials around them, such as paper clips, rulers, and pencils. You may make some suggestions about trying to get the magnets to attract or repel each other and attract or repel the other objects.

STEP 3
Discuss with the students what they know about compasses. Teach the students how a compass works by having each student hold the compass so the disc of the compass is horizontal and the N-S (North-South) markings are facing up. Next have the students align the line marked "N" (for North) on the glass/plastic top with the arrow inside the compass. Talk about how compasses are used in the wilderness.

STEP 4
Have the students tape some white paper together and place the bar magnets on top and in the middle of the taped paper. Tell the students that they will now trace the magnetic force field shape around the bar magnet. Ask them to hypothesize what they think the magnetic force field will look like and to draw it.



To make the tracings, have the students do the following:

a. Draw a dot somewhere near the magnet and place the center of a compass over the dot.
b. Draw a dot at the location of the arrowhead (or tail) of the compass needle.
c. Move the compass center to this new dot, and again draw a dot at the location of the compass needle head (or tail).
d. Remove the compass from the paper and draw lines connecting the dots with arrows indicating the direction that the compass points.
e. Repeat steps c-d until the line meets the magnet or paper's edge.
f. Pick another spot near the magnet and repeat the process (steps a-e).

Have the students continue until they have lines surrounding the magnet as shown in the picture: a dipole (two-pole) pattern of force field. Introduce the word dipole magnetic field and that these lines are called magnetic field lines.

STEP 5
If time permits, have the students place two magnets side by side and do the same magnetic field tracing procedure again. Be sure to ask the students to hypothesize what the field of force will look like before they create their map.

HINTS

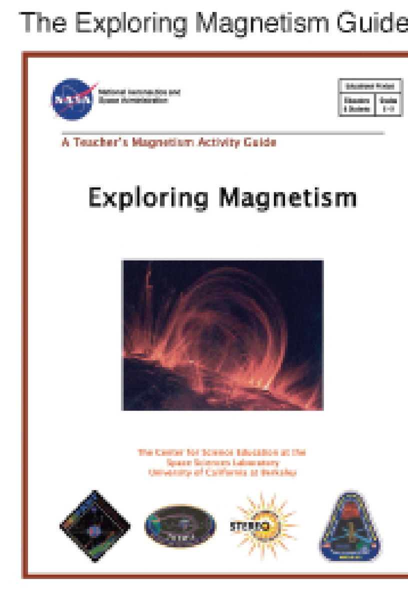
- We recommend using Alnico or cow magnets rather than Chrome-Steele magnets since they hold the magnetism longer.
- Compasses with transparent (glass or plastic) faces can be used on an overhead to demonstrate the mapping procedure.
- Compasses can easily change polarity when a bar magnet is dragged across the compass needle without allowing the needle to move.

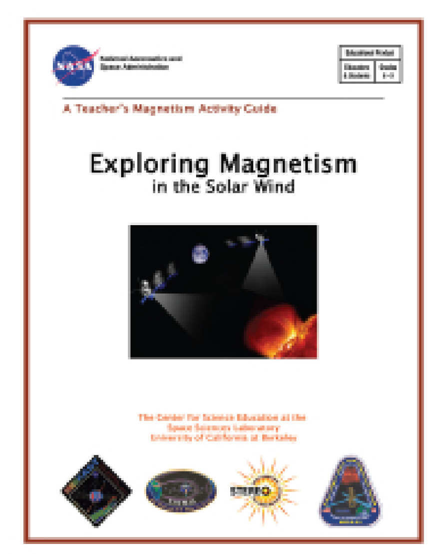
ASSESSMENT QUESTION

1. What do you notice about the interaction of the bar magnets you were given?
2. What materials interact with the magnets and how do they interact?
3. What do all the materials that interact with magnets have in common?
4. What happens when you bring a compass near a magnet? How does it depend on where you place the compass?

The Complete Teachers' Guide is available for download at:
http://cse.ssl.berkeley.edu/impact/magnetism/MagGuide.htm

The Exploring Magnetism Guide Covers:





- Magnetism
- Mapping Magnetic Field Lines
- Iron Filings and (2-3D) Magnetic Field Lines
- Exploring Magnetic Field Lines in Your Environment
- Compass Needles around a Simple Circuit
- Jumping Coils
- Electric Current Generated with a Moving Magnet
- The Interplanetary Magnetic Field (IMF)
- Learning About Space Weather
- Measuring the IMF
- Science and Engineering Conference
- Background Material
- Electromagnetism
- Glossary
- Resources

NASA RESOURCES FOR EDUCATORS

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Educator Resource Center Network (ERCN)

To make additional information available to the education community, NASA has created the NASA Educator Resource Center (ERC) Network. Educators may preview, copy, or receive NASA materials at these sites. For a list of ERCs by region visit the NASA Spacelink web site: (http://spacelink.nasa.gov/ercn)

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http://ehb2.gsfc.nasa.gov/edcats/educational_wallsheet

STEREO MISSION RELATED SITES:

http://stereo.gsfc.nasa.gov/

http://stereo.jhuapl.edu/

http://stp.gsfc.nasa.gov/

http://www.nasa.gov/stereo/

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