

The Magnetic Sun

Unit: Sun-Earth Lesson: 3

Materials & Preparation

Time:

- Preparation: 30 min
- Teaching: one or two class periods

Materials for the Teacher:

- Overhead projector
- Transparency of p.5

Materials for the Class:

- 16 File folders
- Approx. 30 Ceramic donut magnets (or “rare earth” magnets)
- Masking tape
- Two copies of each image on pages 6-12
- Scissors
- Approx. 10 donut or bar magnets for magnetizing pins
- Internet access (optional)

Materials for Individual Students:

- 10 cm (4-inch) long piece of plastic straw
- 2 steel straight pins
- Masking tape (2 inch-long pieces)
- Sewing thread (approx. 7 inch piece)
- Student Pages (p. 13-15)

National Science Standards

- Science as Inquiry: Content Standard A
- Physical Science: Content Standard B
- Earth and Space Science: Content Standard D

Colorado Science Standards

- Science: 1, 2, 4

Learning Goals

Students will

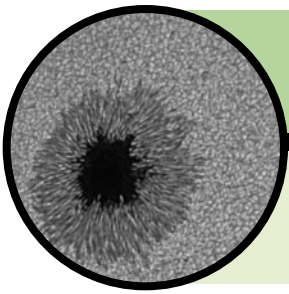
- Students will build an instrument that can detect the direction of a magnetic field.
- Students will observe magnetic fields using a magnetometer.
- Students will identify positions of strong magnetic fields on models of the Sun.
- Students will describe the features associated with strong magnetic fields on the Sun.

What Students Do in this Lesson

Students follow steps to build a simple version of a magnetometer, an instrument capable of detecting areas of strong magnetic field. Students will discover the types of areas of the Sun that have very strong magnetic fields by using their magnetometer instrument to investigate models of the Sun. Students will describe what the types of features associated with the Sun's strongest magnetic fields look like. Finally, the class will examine images of the Sun and learn more about the features they have identified either through student research or teacher presentation.

Key Concepts

- There are areas of the Sun that have very strong magnetic fields.
- These features may have various different outward appearances.
- Sunspots are areas of very strong, localized magnetic fields on the Sun that appear dark in color through their shape and size can vary.



The Magnetic Sun

Advanced Preparation

- Construct the Sun Image Models:
 - These models can be used for multiple class periods and will last for many years. Consider covering them with clear contact paper to increase longevity.
 - Print pages 6-12 of this lesson in color, cut the key off along the dotted line. (For large classes, print two copies of each.) If you do not have a color copier available, visit a local copy store to have copies made. Alternatively, many of the images can be printed effectively from a high-quality black and white printer (omit images that appear gray).
 - Glue or tape each image to the outside cover of a file folder (or a padded mailing envelope or a pizza box).
 - Arrange magnets within the folder (envelope or box) as indicated in the associated key. The magnets represent the locations of features on the Sun that have intense magnetic fields, so take care to locate them with the appropriate features.
 - Secure the magnets in place with tape and then tape the folder or envelope closed. In certain cases, the polar orientation of the magnets matters. Make sure that students do not disturb the locations of the magnets.
 - Arrange the Sun Image Models at numbered stations around the classroom.
- Magnets: Ceramic donut magnets can be found at Radio Shack stores (www.radioshack.com). One face of these magnets is positive and the opposite face is negative polarity. "Rare Earth Super Magnets" also can be used and are advised for some of the models. They are somewhat more expensive, but are small and strong.
- Print page 5 of this lesson (Making a Magnetometer) onto transparency for use on an overhead projector.
- Copy double sided Student Page (p.13-14) for each student.
- Copy Student Page (p.15) summary questions for each student.
- Prepare student supplies. Cut drinking straws and thread into pieces for younger students.

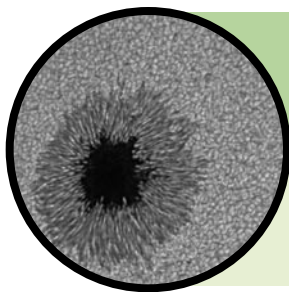
Introducing the Lesson

- Tell students that there are features on the Sun that have very strong magnetic fields and that the objectives of this lesson is to identify what those features are like.
- To do this, students will need to make a tool to detect the presence of magnetic fields.

Facilitating the Lesson

Making the magnetometer tool:

- Project transparency (p.5) on the overhead projector while guiding students through the directions to construct their magnetometers. Once students have constructed their magnetometers, have them stroke the pins (lengthwise along the pins) from left to right several times with one pole of a permanent magnet. This will magnetize the pins.
- Have students test their magnetometers with a magnet to make sure the pins are properly magnetized to indicate the presence of a strong magnetic field. (The pins should orient themselves with the field.) If students are unfamiliar with magnets, consider allowing them to explore the fields of various magnets using their magnetometer.



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Using the tool to detect strong magnetic fields on the Sun:

- Hand out the Student Page and review directions and the objective. The students should test each of the Sun images for strong magnetic fields. Once they have tested all images, they should draw conclusions about what sorts of features on the Sun are associated with strong magnetic fields.
- Allow students to circulate around the room, visit each station, and test each image. Once they have found the magnetic fields in an image they should sketch their location and describe the appearance of the magnetic feature on their Student Page.

Summarizing and Reflecting

- Ask students to come to the black/whiteboard and draw the features that had strong magnetic fields.
- If time permits, have students research the types of features for themselves using the Space Weather section of Windows to the Universe (www.windows.ucar.edu) and report their findings to the class.
- If time is limited, show images of sunspots, prominences, and coronal mass ejections, and explain each. (A presentation for classroom use is available at: www.eo.ucar.edu/educators/ClimateDiscovery/sun.ppt.) Ask students to identify what types of features were present on each Sun image.
- Have students answer the summary questions on the final *Student Page* to assess understanding.

Extension

Have students sprinkle iron filings on a sheet of paper and place a button magnet or donut magnet beneath. Ask students to describe the pattern that the filings made when they were affected by the magnetic field. The filings will radiate from the magnet, aligned with their opposite pole pointing towards the magnet. This will look somewhat like the spines within a sunspot's penumbra. The spines are similar in that they reflect the shape of a sunspot's magnetic field. If a variety of magnet types are available, ask students to experiment with the shape of the iron filings around different magnets or combinations of magnets.

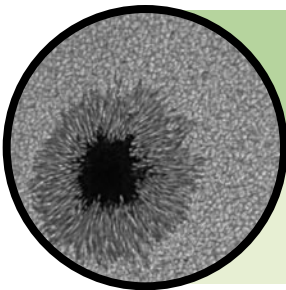
Background Information

The force of magnetism

The force of magnetism causes magnetized material to point along the direction the magnetic force points. Magnetic fields are invisible; we can only see the effects of the magnetic force. Magnetometers are devices used to detect and measure the strength of magnetic fields. Compasses are basically magnetometers with directions marked on them. A magnetometer will dip or point toward a source of magnetism. The magnetometers used in this activity can also be used for other activities. For example, have students use their magnetometer to find things in your room or at home that are magnetic, or try Windows to the Universe activities (see *Additional Resources* below.)

Sunspots

Sunspots are caused by extremely strong, localized magnetic fields on the Sun. Loops of magnetism, or magnetic "ropes," are generated within the Sun by flowing ionized gas called plasma. The plasma can flow freely along magnetic field lines. These loops thread through the visible surface (photosphere) of the Sun, they produce sunspots. Sunspots generally appear in pairs with opposite magnetic polarities; one where the bundle of "ropes" emerges from the solar surface, and the other where the bundle plunges back down through the photosphere. Magnetic field strengths within sunspots are thousands of times more intense than the Sun's global average field (which is approximately 1 Gauss). Larger sunspots may have higher field strengths.



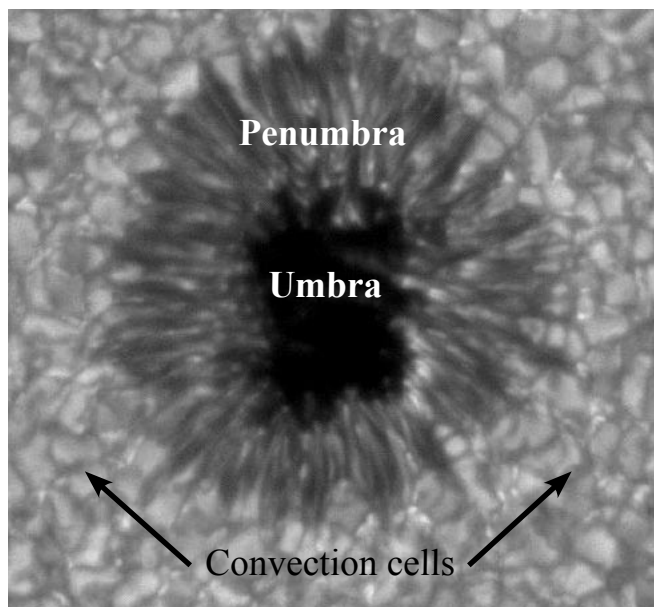
The Magnetic Sun

Anatomy of a Sunspot

Sunspots can be a variety of sizes but they are often as large as planets. Sunspots are darker than the rest of the sun because their very strong magnetic fields inhibit convection and are thus cooler than the surrounding areas. The penumbra is the lighter outer region of a sunspot. It has radiating lines called spines which indicate the magnetic field. The dark central portion is called the umbra. Small sunspots may not have a well-defined umbra.

Solar Flares and Coronal Mass Ejections (CME)

Solar flares are a sudden brightening of light in a region of the Sun. All wavelengths of light may be brightened but especially those at the x-ray end of the electromagnetic spectrum. Solar flares are formed in areas of intense magnetic fields in the vicinity of active regions on the Sun. Coronal Mass Ejections are explosions in the Sun's corona adding a great number of charged particles to the solar wind. Sudden changes in magnetic fields generate energetic solar flares and vast Coronal Mass Ejections (CMEs). See the space weather link below for more information.

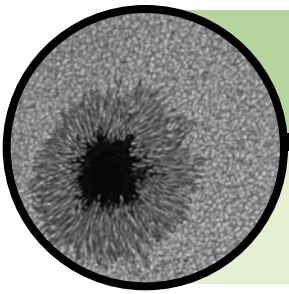


About Models

This activity uses models of the Sun and its magnetic fields to help students understand the connections between visual features on the Sun and magnetic fields. To accomplish this educational goal, these models somewhat simplify the complex nature of the sun's magnetic fields. When using this type of activity with more advanced students, it is useful to engage the class in a discussion of how these models do and do not reflect reality.

Additional Resources

- Space Weather: Useful information with pictures of the Sun, space missions, and magnetism information related to solar events (www.windows.ucar.edu/tour/link=/space_weather/space_weather.html)
- More activities that use magnetometers:
 - Terrabagga (www.windows.ucar.edu/tour/link=/teacher_resources/magnetism/teach_terrabagga.html)
 - Extensions (www.windows.ucar.edu/tour/link=/teacher_resources/magnetism/teach_extension.html)



The Magnetic Sun

Make your own magnetometer, a tool to detect magnetic fields!

Step 1: Lay a pin across the sticky side of a piece of tape.

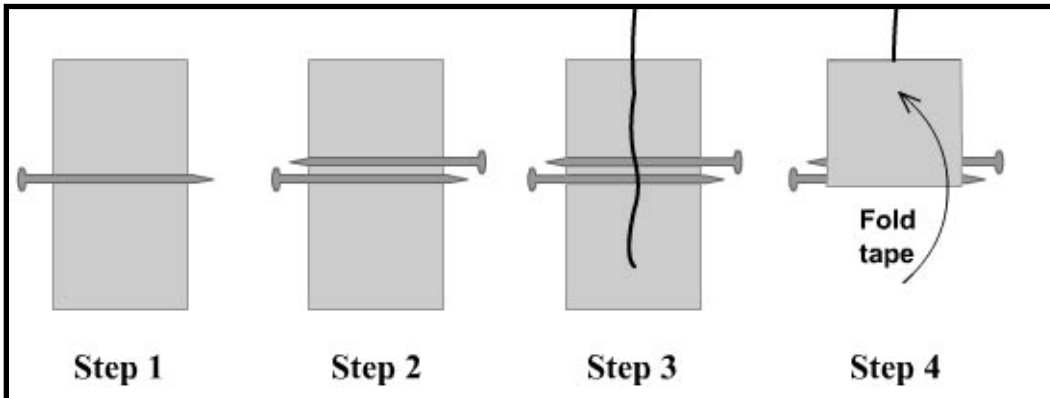
Step 2: Add a second pin facing the opposite direction. (If the heads of the pins stick out further than the points, the points won't poke you.)

Step 3: Lay one end of the thread across the pins and tape, oriented perpendicular to the pins.

Step 4: Fold the tape over so that the pins are in the crease.

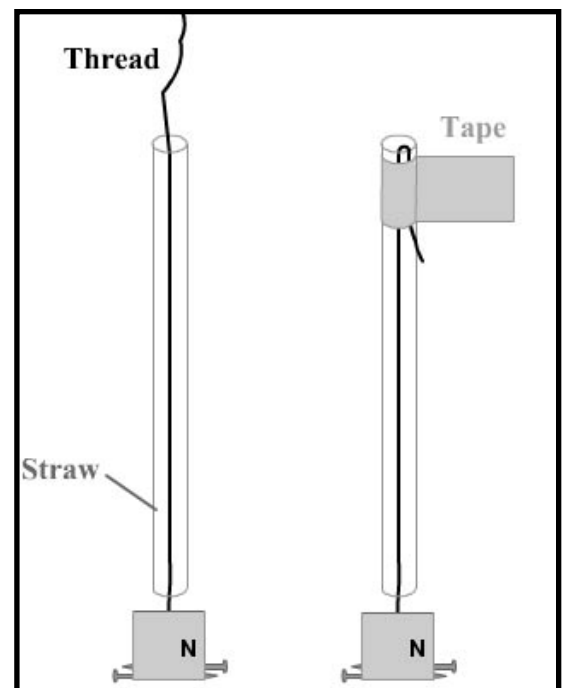
What you'll need:

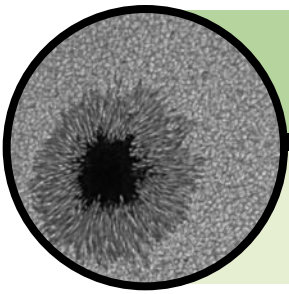
- A piece of drinking straw about 4 inches long
- 2 steel straight pins
- 2 inch-long pieces of masking tape
- A piece of thread that's about 7 inches long
- A magnet



Then...

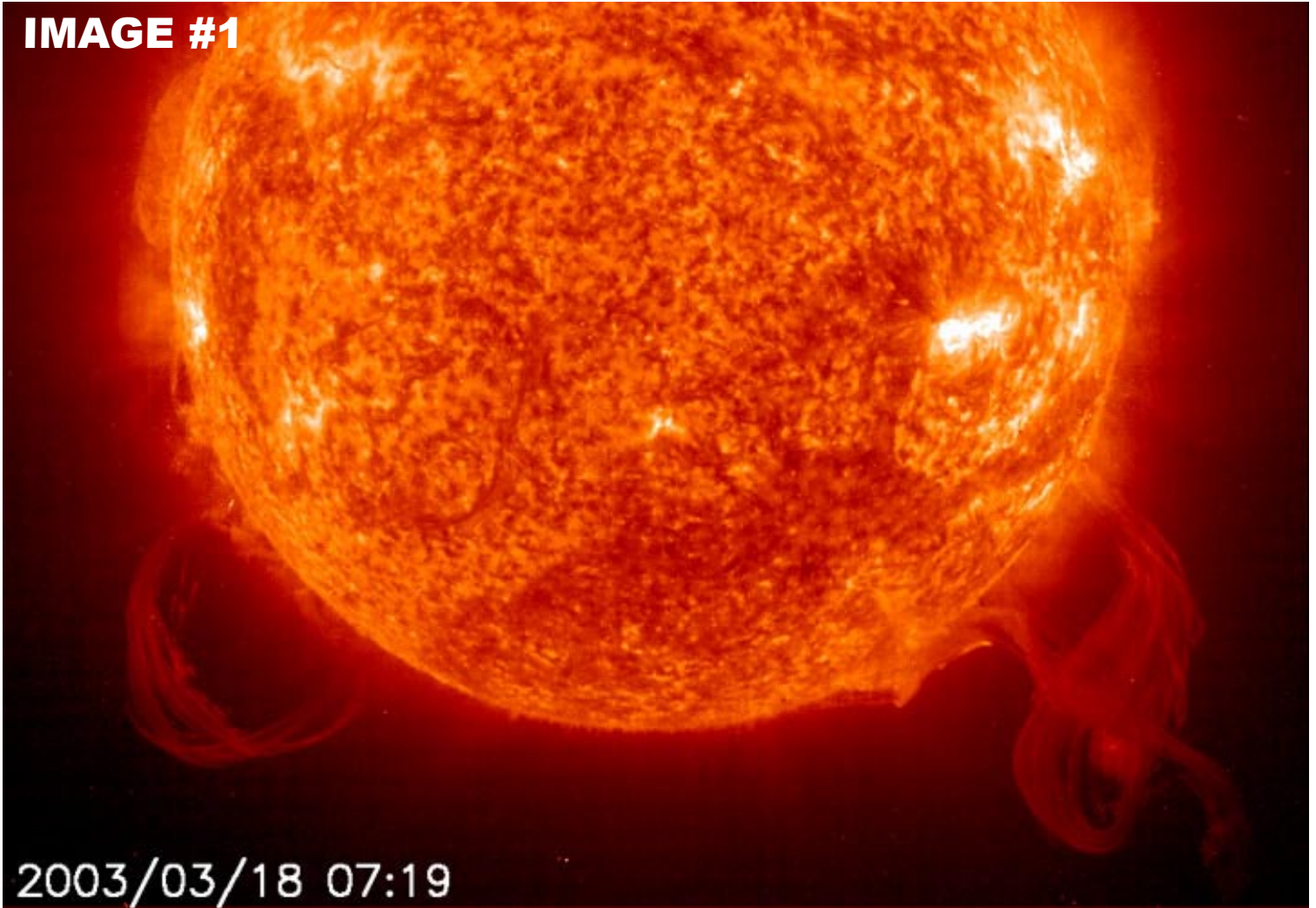
- Push the thread through the straw.
- Hold the straw vertically. Adjust the length of the thread so that the taped pins dangle just below the bottom of the straw. Make sure that they do not touch the straw.
- Fold the free end of the thread over onto the outside of the top of the straw and tape it into place.
- To magnetize the pins, stroke them (along their length) with a one pole of the magnet.
- Then, check to see if the pins point toward the magnet!





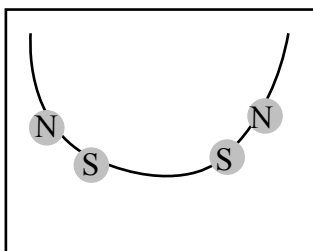
The Magnetic Sun

IMAGE #1



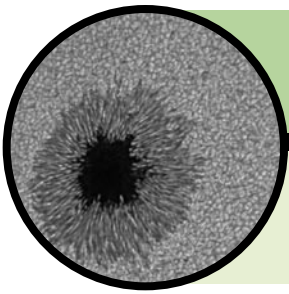
2003/03/18 07:19

Key: Image 1



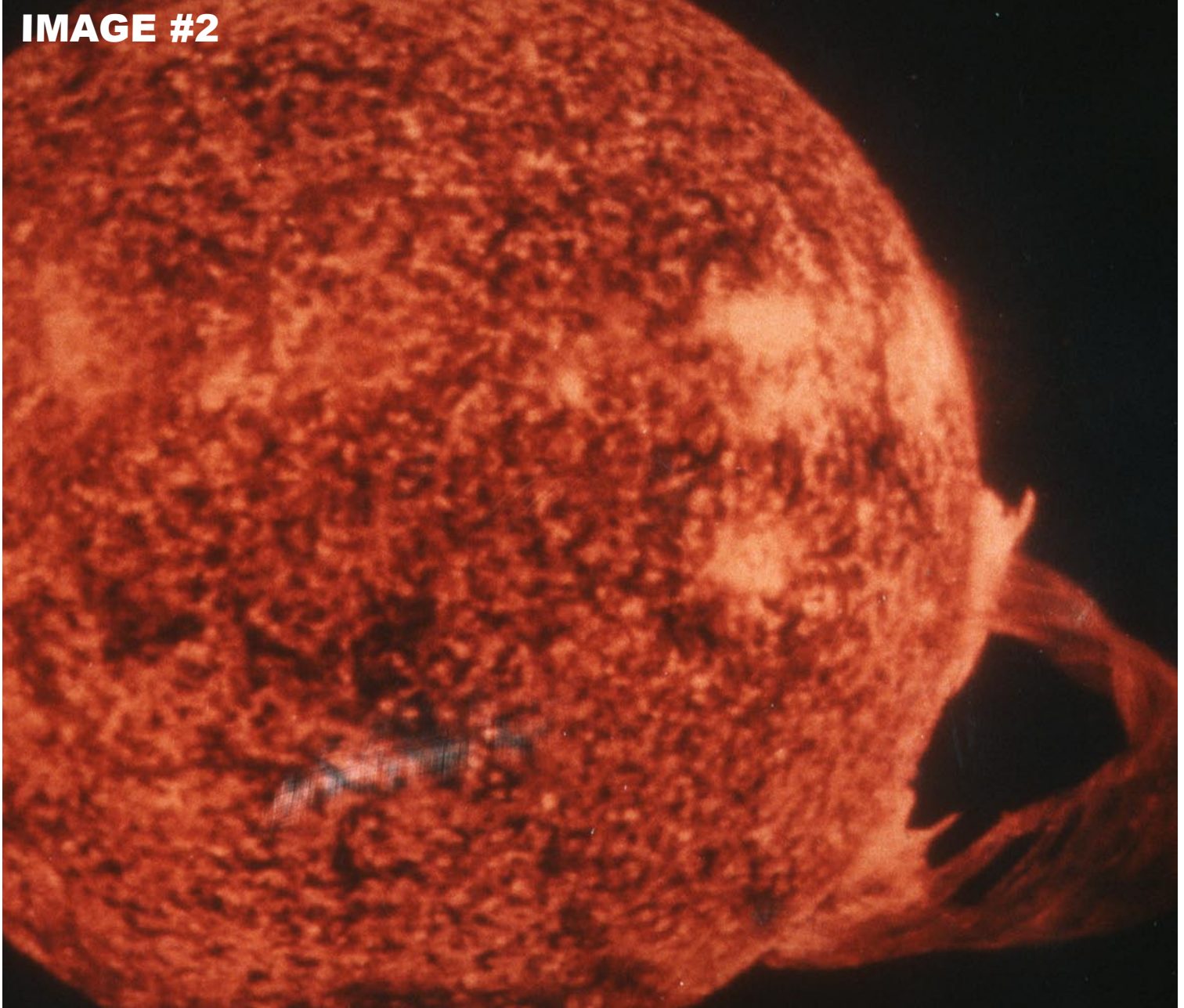
Description: These two large prominences (lower right and lower left) erupted from the Sun in March 2003. This ultraviolet image was captured by the SOHO spacecraft. (Image courtesy SOHO, NASA & ESA)

Directions: Put a magnet where each prominences connects with the solar surface. Orient magnets so that each prominence has a pair of opposite poles facing up.

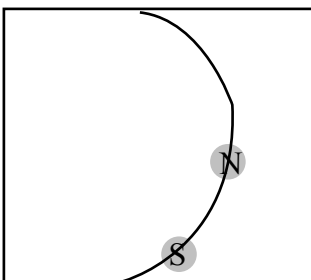


The Magnetic Sun

IMAGE #2



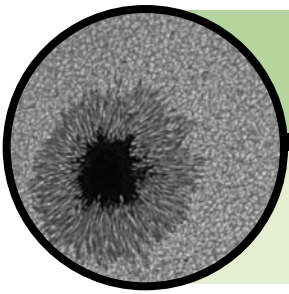
Key: Image 2



Description:

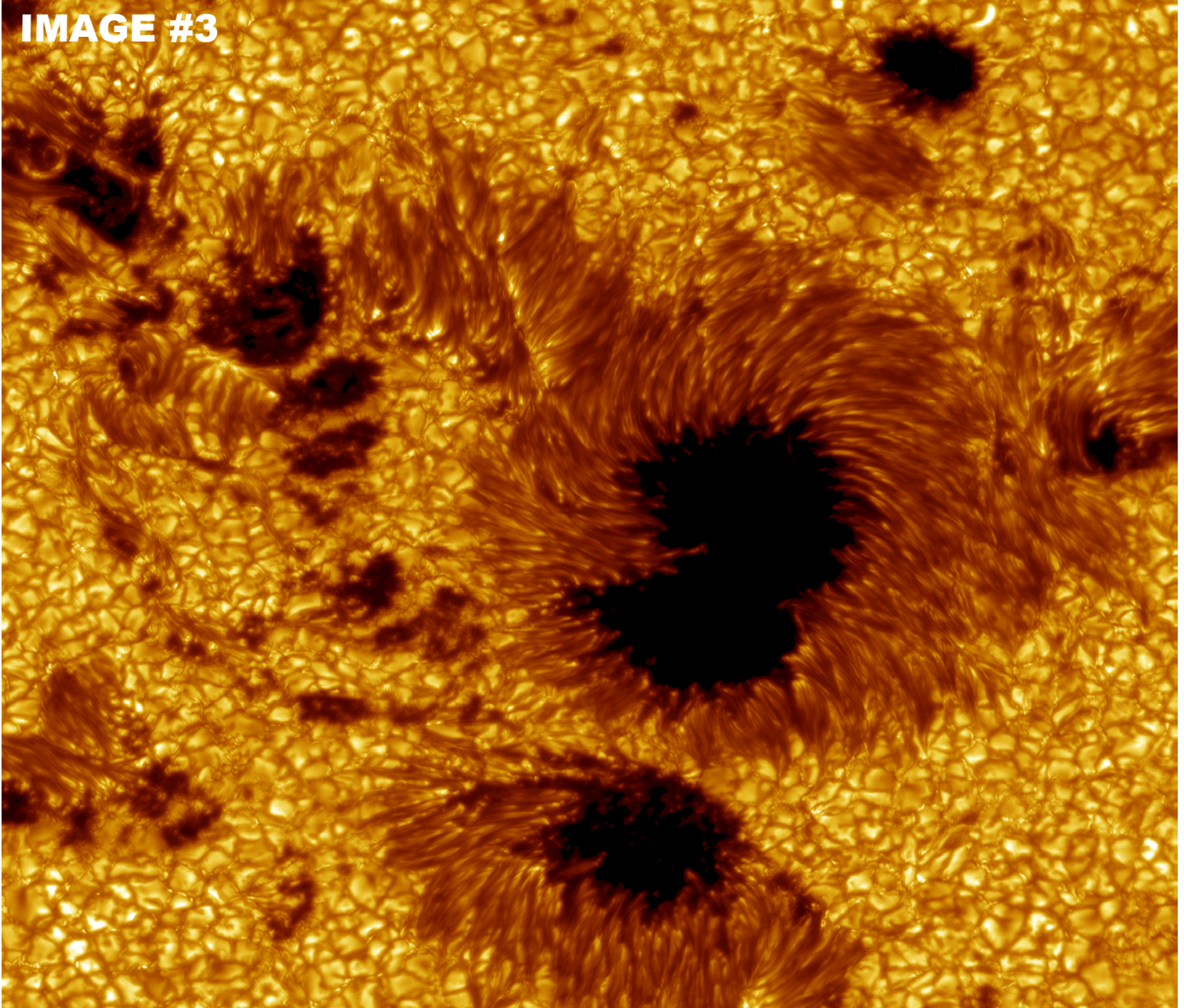
A solar prominence is an eruption of hot gas from the upper chromosphere or the inner corona of the sun. Some of this erupting matter escapes into space. Solar prominences are of higher density than the surrounding portions of the solar atmosphere, but their temperatures are lower. (UCAR Digital Image Library)

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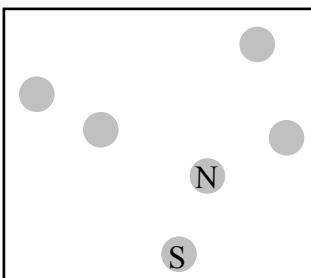


The Magnetic Sun

IMAGE #3



Key: Image 3

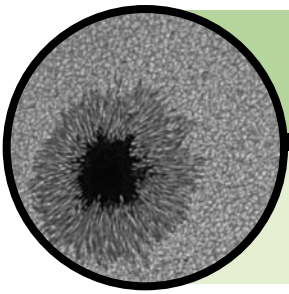


Description:

Large field-of-view image of sunspots in Active Region 10030 observed on 15 July 2002. The image has been colored yellow for aesthetic reasons. (Royal Swedish Academy of Sciences)

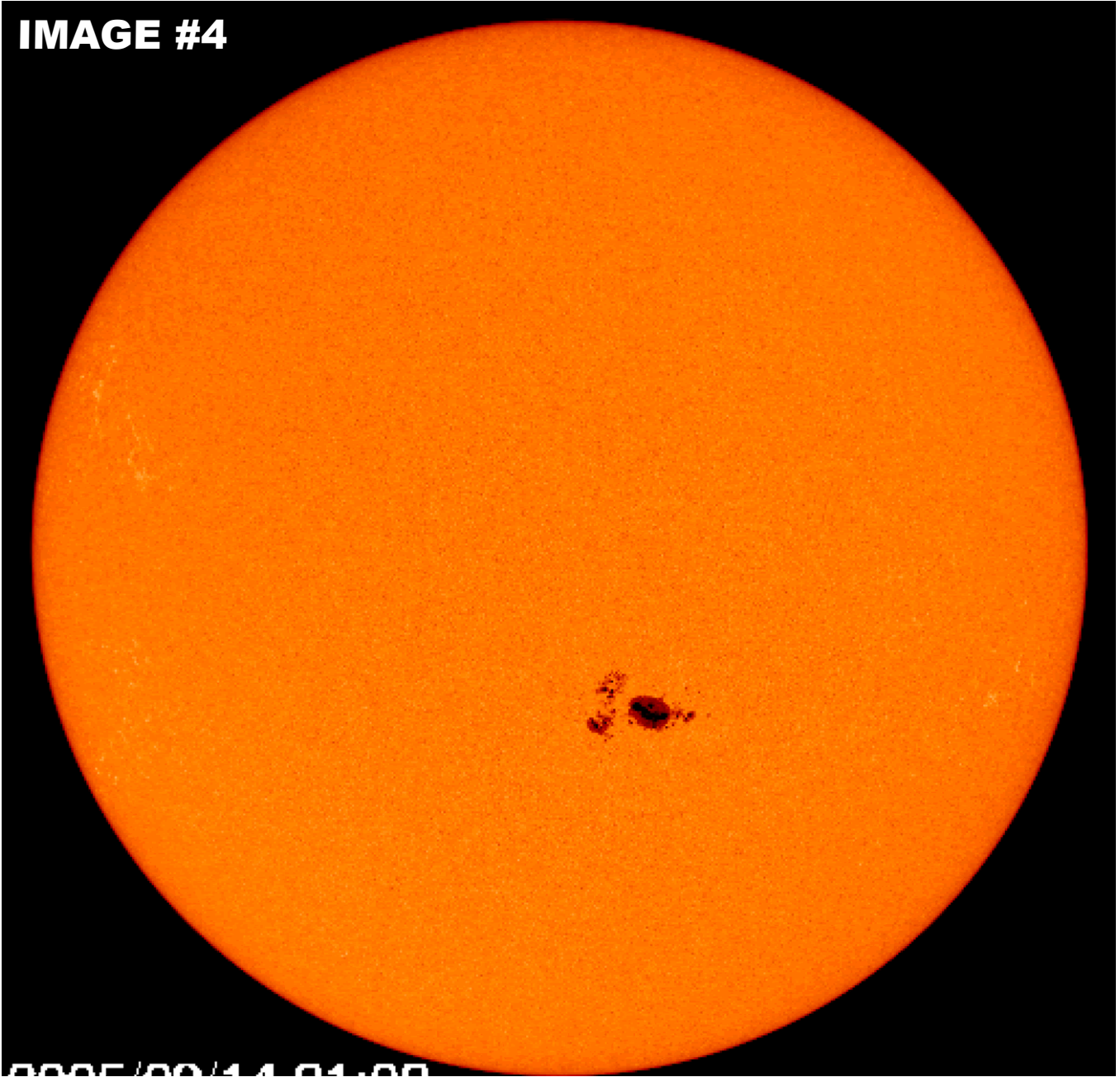
Directions: Add additional small magnets to smaller dark areas if possible.

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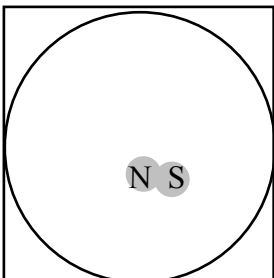


The Magnetic Sun

IMAGE #4



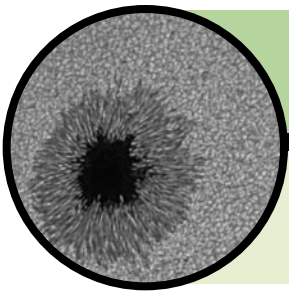
Key: Image 4



Description:

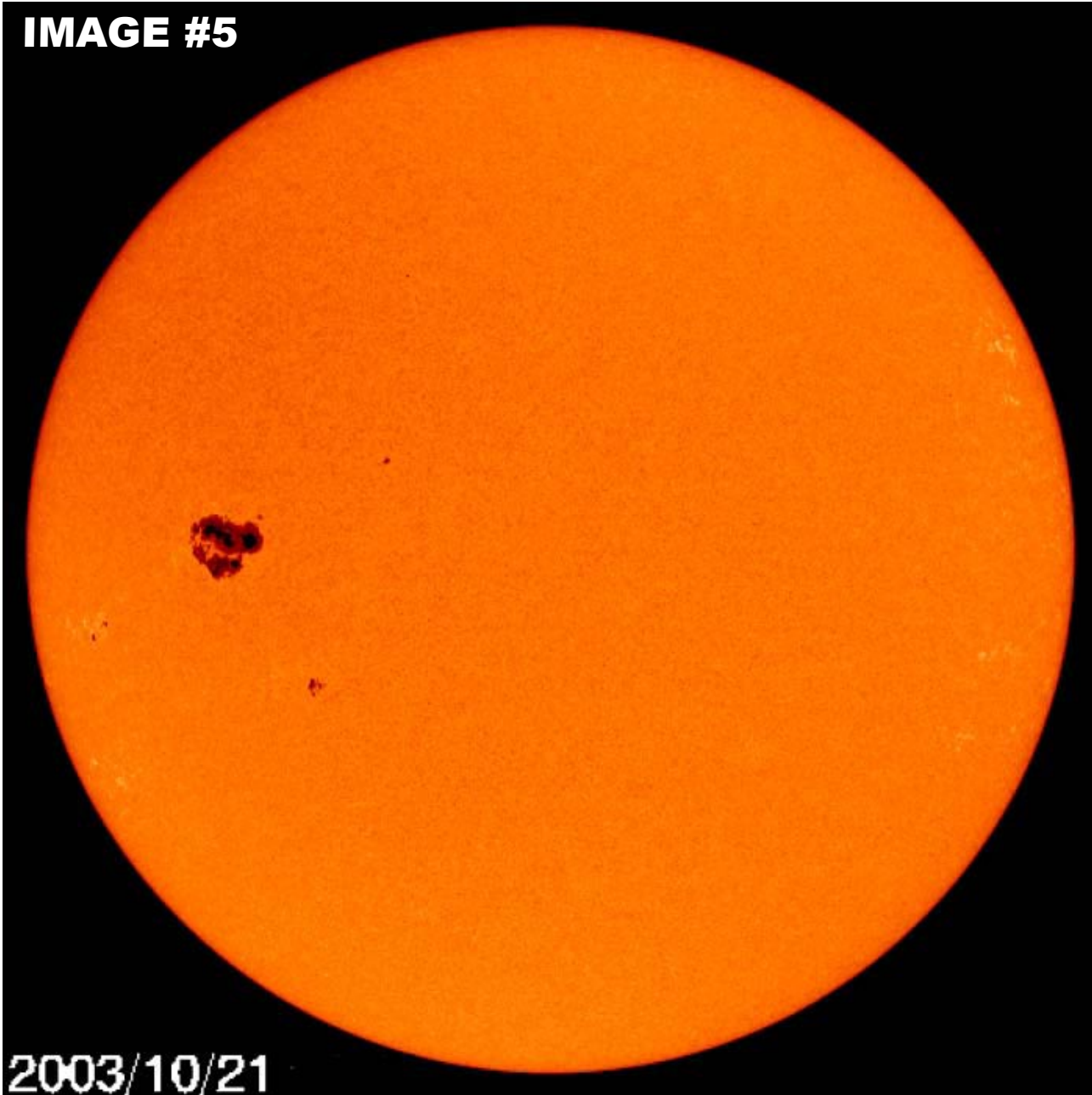
The fast-growing sunspot 9393 (in the white circle) covered an area of the solar disk equivalent to the surface area of 13 planet Earths on March 29, 2001. That makes it the largest sunspot of the current solar cycle. (<http://epod.usra.edu/archive/images/sunspots.jpg>)

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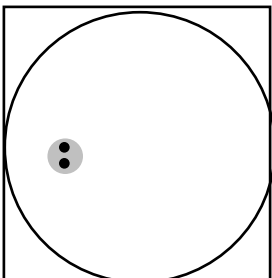


The Magnetic Sun

IMAGE #5



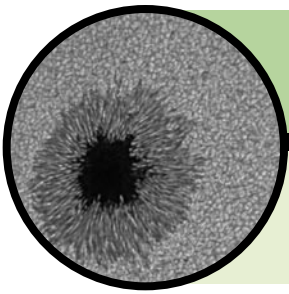
Key: Image 5



Description: NOAA Region 484 developed rapidly during 2003. It was about 10 times larger than the Earth, near the solar equator, and produced a major flare, producing a radio blackout on October 19, 2003. (NOAA)

Directions: The gray circle at left indicates position of ceramic magnet. However, if rare-earth magnets are available, place a pair with opposite poles facing up (indicated by the black dots.)

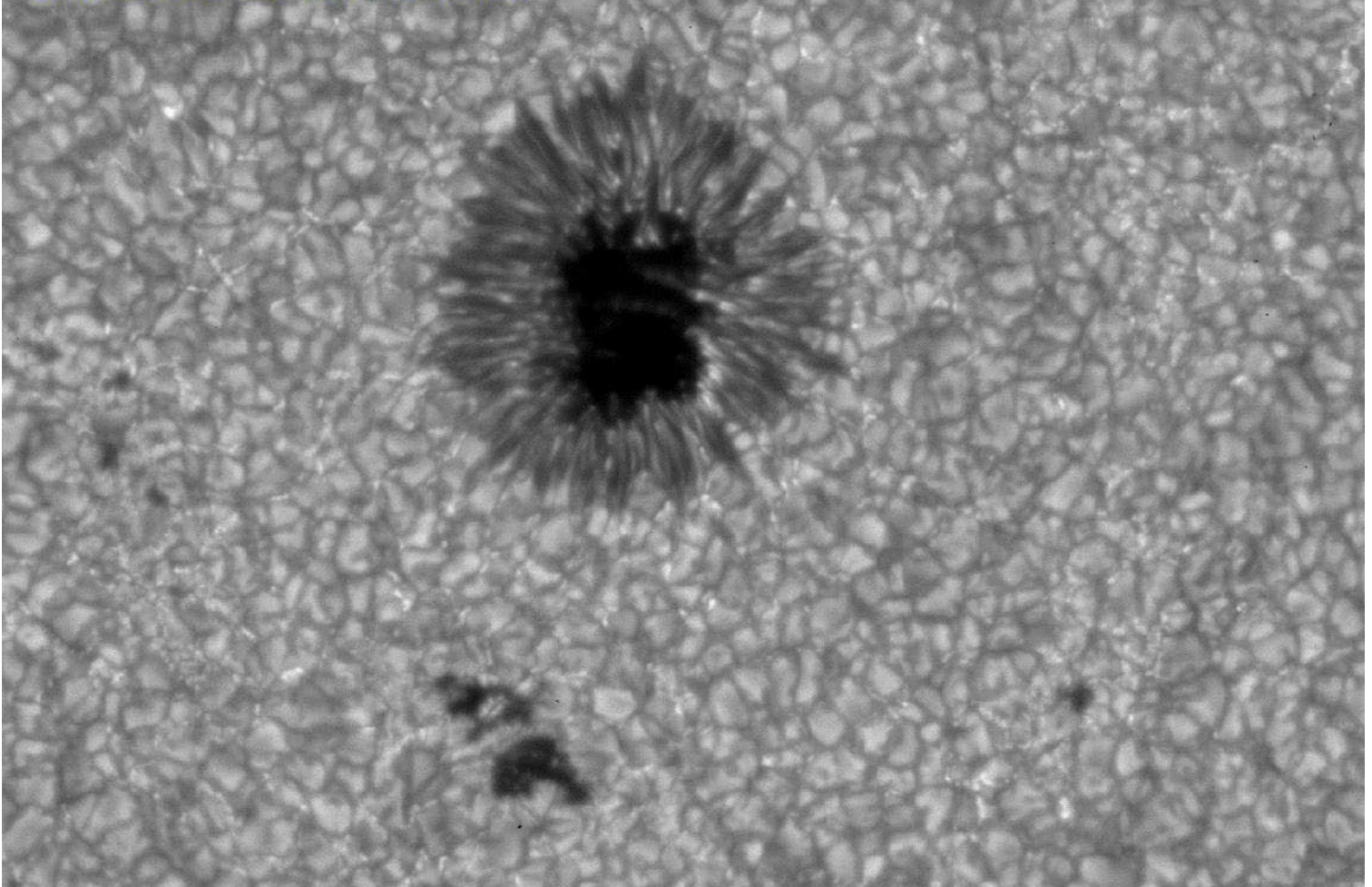
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The Magnetic Sun

IMAGE #6

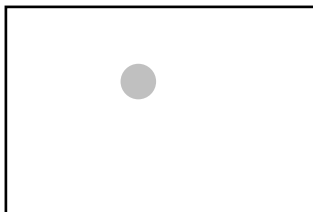
14 June 1994: Continuum Intensity



Source: Kiepenheuer/Uppsala/Lockheed (P. Brandt, G. Simon, G. Scharmer, D. Shine)

HAO A-003

Key: Image 6

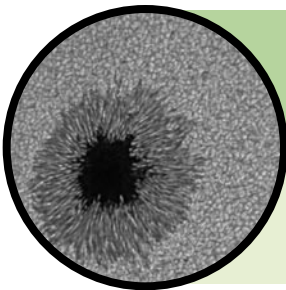


Description:

A sunspot (<http://image.gsfc.nasa.gov/poetry/workbook/sunspot1.jpg>)

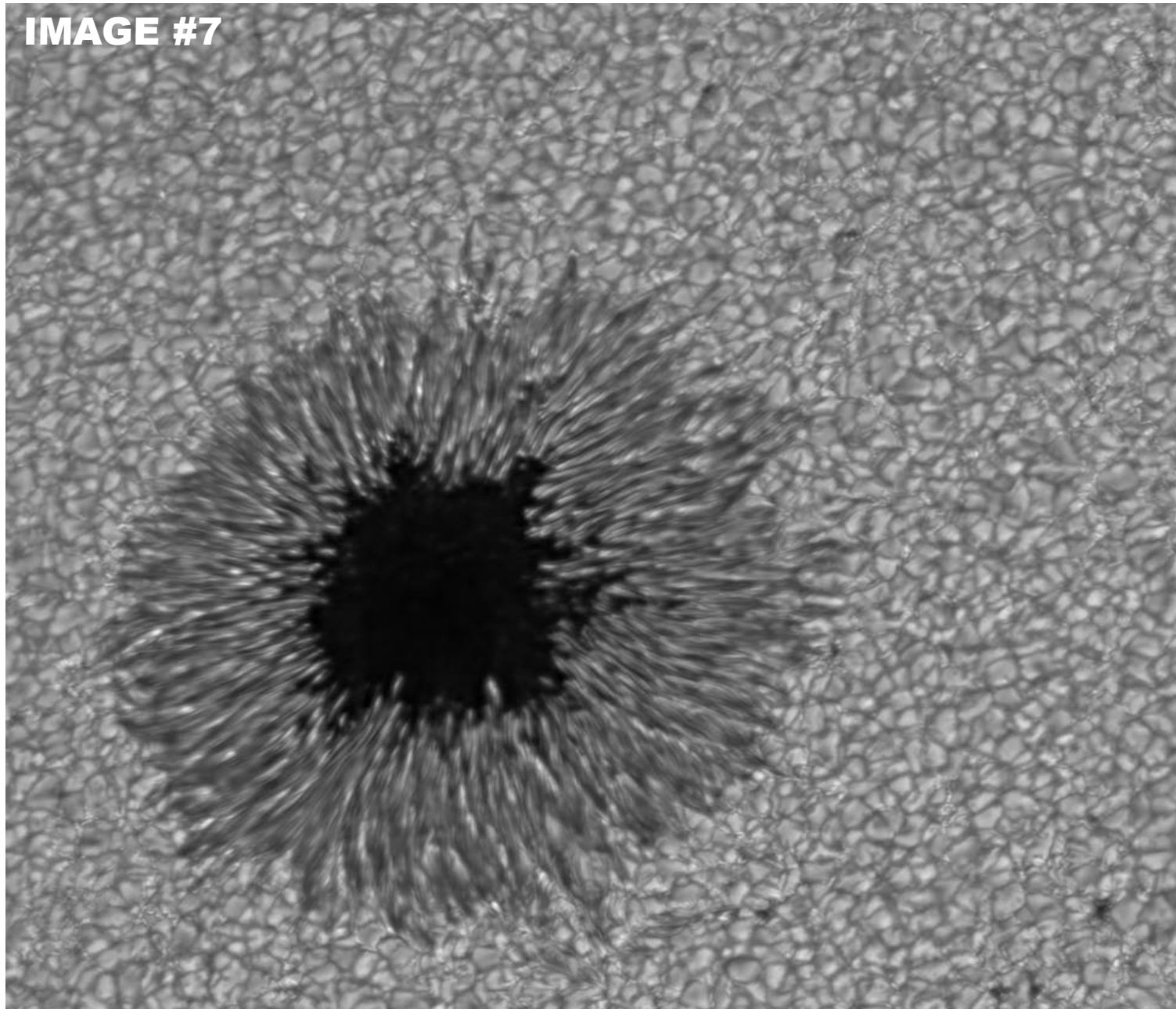
Directions: The gray circle at left indicates position of ceramic magnet. You might also add another magnet below the small black area in the lower part of the image with the reverse pole upfacing.

Cut here

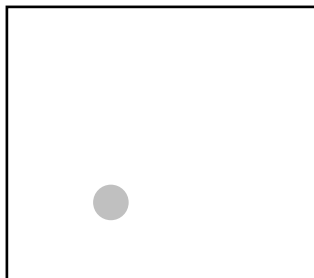


The Magnetic Sun

IMAGE #7



Key: Image 7

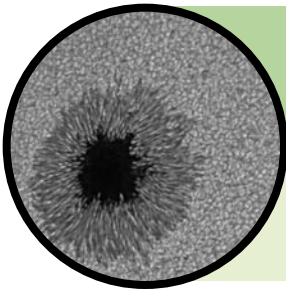


Description:

A sunspot in 2001 (<http://www.gsfc.nasa.gov/topstory/20010919sunspot.html>)

Directions: The gray circle at left indicates position of ceramic magnet.

Cut here



CLIMATE DISCOVERY STUDENT PAGES

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

The Magnetic Sun

Name _____

Date _____ Class _____

Using your magnetometer, investigate the eight images for areas of strong magnetic field. Below, and on the reverse side of this Student Page, there is space for data that you collect about each image. Find the space with the appropriate number, **note the number of strong magnetic fields you found on each and describe with words and pictures what each area of strong magnetic field looks like.**

IMAGE #1

IMAGE #2

IMAGE #3

IMAGE #4

IMAGE #5

IMAGE #6

IMAGE #7

Other things I noticed:

