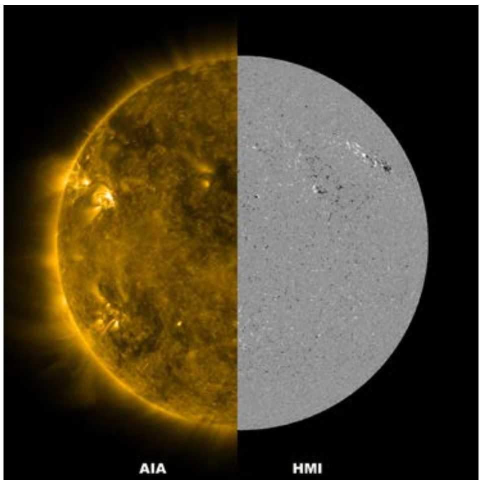
Module 2: Why do we study the Sun?

Activity B: Solar Activity & Magnetism

Overview

Solar scientists are using NASA's Solar Dynamic Observatory (SDO) to better understand the Sun's magnetic field. The magnetic field is generated by electrical currents caused by the flow of hot, ionized gases in the Sun's convection zone. This flow of electrical currents is believed to act as a magnetic dynamo inside the Sun, which drives the sunspot cycle. The sunspot cycle lasts about 11 years and is an indicator of the Sun's level of magnetic activity.



Images: NASA

During the first half of the sunspot cycle, the Sun's magnetic north pole is in its northern hemisphere while its magnetic south pole is in the southern hemisphere. Half way through the sunspot cycle, solar activity and the number of sunspots are at their greatest (solar maximum) and the magnetic poles "flip", or exchange places. The Sun's magnetic north pole is now located in the southern hemisphere and its magnetic south pole is in the northern hemisphere. After the magnetic poles exchange position, the level of solar activity and the number of sunspots decrease (solar minimum). The sunspot cycle, along with the Sun's "pole flipping", repeats approximately every 11 years.

Teacher Overview

The aim of Solar Module 2 is for student-led teams to develop a basic understanding of how and why scientists study the electromagnetic spectrum and magnetic fields of the Sun to gain a greater understanding of our nearest star. The focus of Module 2B is to provide an authentic opportunity for students to learn about and apply concepts of magnetism through the context of the Sun.

Most of the variability of the Sun is magnetic in origin. Sunspots are magnetically active areas of the Sun. Scientists have discovered that the solar cycle is actually a magnetic cycle where the Sun's magnetic poles reverse approximately every 11 years. This 11-year period is known as a sunspot cycle, which is divided between the solar maximum (greatest amount of solar activity and number of sunspots) and the solar minimum (the least amount of solar activity and number of sunspots). The Sun's magnetic field varies on an approximately 22-year cycle making a full cycle of solar activity complete after two sunspot cycles, when the solar magnetic poles return to their starting positions.

The invisible magnetic field lines can be seen when hot gas moves along them, forming coronal loops. Solar flares and CMEs occur when magnetic fields in these loops are stressed beyond their limits and violently eject the Sun's energy and matter into Space. Also, many of the observed properties of the corona and solar wind come from the Sun's magnetic field.

• HMI – Helioseismic and Magnetic Imager

There are three key instruments onboard SDO that are researching the Sun in amazing detail - AIA, EVE, and HMI. HMI records the Sun's magnetic fields and related solar activity. It maps the Sun's entire magnetic field in detail. HMI also measures sound waves on the surface of the Sun (helioseismology) to interpret how "sunquakes" are evidence of the motion that is occurring beneath the Sun's surface. HMI enables solar scientists to "see" what the magnetic field is doing on the solar surface and how the Sun's surface and upper atmosphere interact.

Team Goal

Your goal is to observe and record magnetic fields and connect the concept of magnetism to solar activity on the Sun.

Materials

- "Magnetic Solar System" PowerPoint
- "Making Sense of Magnetism!" PowerPoint & activity sheets
- 1 flat horseshoe magnet
- 1 spherical magnet
- 4 sections of "breakable" magnets
- 2 bar magnets
- 2 compasses
- Iron filings
- Magnaprobe (used with care)
- 10 index cards
- 1 piece of card stock
- 2 or more flat round magnets
- 1 or more pipe cleaners
- Pencil

Objectives

Students will be able to:

- Locate magnetic poles and identify the polarity in magnetic objects.
- Diagram magnetic fields by the direction and polarity of magnetic field lines.
- Explain the relationship between sunspots and magnetic fields.

Essential Vocabulary

- Dipole
- Helioseismic
- Helioseismology
- Magnetic Field
- Magnetism
- Photosphere
- Polarity
- Sunspot

Module Lesson

Time: 1-2 block periods/2-4 class periods

Materials: per team

- "Magnetic Solar System" PowerPoint
- "Making Sense of Magnetism!" PowerPoint & activity sheets
- 1 flat horseshoe magnet
- 1 spherical magnet
- 4 sections of "breakable" magnets
- 2 bar magnets
- 2 compasses
- Iron filings
- Magnaprobe (used with care)
- 10 index cards
- 1 piece of card stock
- 2 or more flat round magnets
- 1 or more pipe cleaners
- Pencil

Teacher Prep:

- Make copies of "Making Sense of Magnetism" activity sheets
- Prepare activity materials

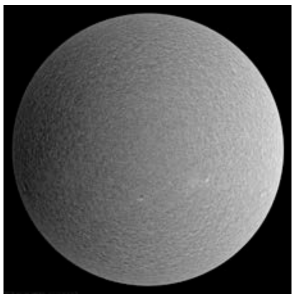
Engage & Explore!

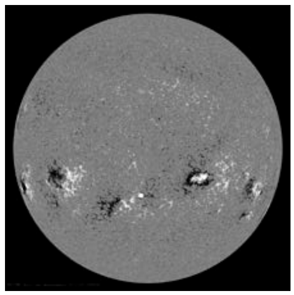
1. BUILD Knowledge:

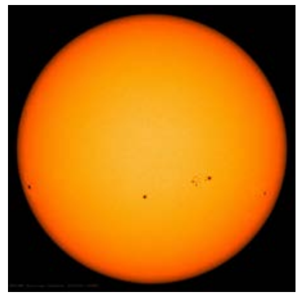
SDO Magnetism Instrument

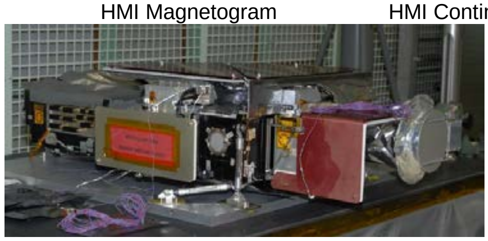
Watch these three videos, as a team, to learn about the connection between magnetism and the Sun's activity. See how SDO's HMI is monitoring the Sun's magnetic fields to gain a greater understanding of the Sun's structure and function.

Images: NASA


HMI Dopplergram


HMI Magnetogram


HMI Continuum Filtergram


Helioseismic and Magnetic Imager (HMI) - Stanford Solar Group

[NOVA Sun Lab: The Dynamic Sun Video]
[SDO HMI Video]
[Sun's Magnetic Field Flip Video]

Student Engage/Explore Activity
1. BUILD Knowledge:
SDO Magnetism Instrument

First, student teams watch the three video clips to gain background knowledge on magnetism on the Sun and how the Helioseismic and Magnetic Imager (HMI), one of three instruments on the Solar Dynamic Observatory (SDO), measures the magnetic field of the Sun to better understand solar activity and subsequent space weather.

HMI is an instrument designed to study oscillations and the magnetic field at the Sun's surface, or photosphere. HMI collects four kinds of data:

- dopplergrams (maps of the velocity on the Sun's surface)
- continuum filtergrams (photographs of the Sun's photosphere)
- magnetograms (two kinds of maps of the photosphere's magnetic field)

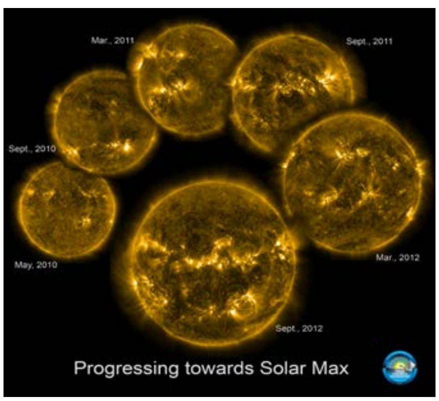
NOVA Sun Lab: The Dynamic Sun Video
SDO HMI Video
Sun's Magnetic Field Flip Video

2. APPLY Learning:

Solar Magnetism

The 11-year sunspot cycle is actually half of a longer cycle of solar activity. The Sun's magnetic field varies on an approximately 22-year cycle making a full cycle of solar activity complete after two sunspot cycles. This is indicated when the Sun's magnetic fields are back to the way they were at the start of the solar cycle.

Even though magnetic fields are invisible, they can be "seen" due to the presence of sunspots on the surface of the Sun. Sunspots are active regions on the Sun that are caused by the magnetic fields generated inside the Sun poking through the visible region at the Sun's surface. Active regions of the Sun can cause fast, violent outbursts of solar energy, called flares. Active regions can also cause huge coronal mass ejections (CMEs) that explode incredible amounts of hot gas trapped by the magnetic field in the Sun's corona (atmosphere) out into space. Solar Flares and CMEs are the two events that cause space weather.



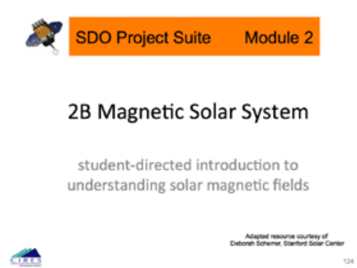


Image: NASA

Take turns reading the "Magnetic Solar System" PowerPoint slides together as a group (some slides have additional notes that are worth reading). While going through the PowerPoint, create 10 "Solar Magnetism Fast Fact" index flip cards about magnetism and how magnetic fields affect the Sun's activity and are one cause of Space Weather.

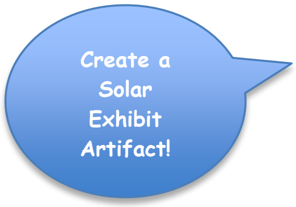
Magnetic Solar System PowerPoint (see attached file)

2. APPLY Learning:

Solar Magnetism

Provide access to the "Magnetic Solar System" PowerPoint for student groups and index cards. Student teams review the "Magnetic Solar System" PowerPoint to learn about magnetism and the Sun's magnetic fields. Students work together to create 10 "Solar Magnetism Fast Facts" flip cards based on information they learn from the "Solar Magnetism" PowerPoint. The index flip cards are artifacts for teams' Module 4 SDO Exploration Museum 3-D Solar Exhibit.

Magnetic Solar System PowerPoint (see attached file)

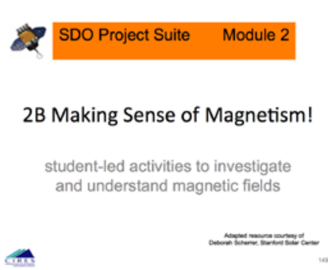


3. DEMONSTRATE Ability:
Magnetic Fields

A sunspot is a dark spot on the surface of the Sun; it appears dark because it is cooler than the surrounding areas of the Sun's surface. Sunspots are formed by concentrations of strong magnetic fields. They usually occur in pairs or groups of opposite polarity - one sunspot has a positive charge and another sunspot has a negative charge. Remember, opposite ends of magnets attract each other so oppositely charged sunspots are attracted and move together across the surface of the Sun as it rotates. The number of sunspots visible at any time is used to measure the activity of the Sun (solar activity).

This module contains three magnetism activities to help explain the relationship between sunspots and the Sun's ever-changing magnetic field. Using the "Making Sense of Magnetism" PowerPoint, complete the step-by-step activities as a team to reinforce, apply, and demonstrate the principles of magnetism and model the connection between magnetic fields and sunspots. Take turns leading the hands-on activities and completing the related discussion questions.

Making Sense of Magnetism PowerPoint (see attached file)



Student Engage & Explore Activities (cont.)

3. DEMONSTRATE Ability:
Magnetic Fields

Provide access to the "Making Sense of Magnetism" PowerPoint and activity materials for student groups. Student teams then complete three sequential hands-on lab activities that explore the concept of magnetism. The "Making Sense of Magnetism!" PowerPoint provides a step-by-step guide for student-led teams to reinforce, apply and demonstrate the principles of magnetism and then model the relationship between magnetic fields and sunspots.

3-D Magnetic Sunspot Model

Next, teams create a simple 3-D model to demonstrate the magnetic fields of sunspots. The model is created using a 2-D cardstock model of the Sun with two small magnets glued to the Sun's disc to represent sunspots. Pipe cleaners are then connected to the magnetic "sunspots" to visualize the magnetic field lines generated between sunspots of opposite polarity. The previous lab activities can be demonstrated as part of teams' Module 4 SDO Exploration Museum 3-D Solar Exhibit in addition to including the Magnetic Sunspot Model.

Making Sense of Magnetism PowerPoint (see attached file)
Solar System Magnetism

3-D Magnetic Sunspot Model

Your team will now create a simple model to demonstrate the magnetic fields of sunspots. Make a large, round 2-D cardstock model to represent the Sun and label it "The Sun". Next, glue one or more pairs of small, round magnets to the surface of the Sun's disk to represent sunspots (make sure that each magnet in a pair has an opposite polarity facing upwards) and label two magnets as "Sunspots". Use one pipe cleaner per magnet pair and put a label on one of the pipe cleaners that reads "Magnetic Field Lines". Then connect the pipe cleaners to the magnetic "sunspots" to represent the magnetic field lines that are generated between sunspots of opposite polarity. The previous lab activities can be demonstrated as part of your team's Module 4 SDO Exploration Museum 3-D Solar Exhibit in addition to including this Magnetic Sunspot Model. Click the link for another NASA activity to demonstrate the invisible magnetic fields of the Sun.
Solar System Magnetism

Marvelous, your team members are Solar Magnetism Masters!

Differentiation/Extension

- After reviewing the "Sun as Art" file, choose and print an SDO image from the SDO Gallery and incorporate it into a 3-D piece of art that portrays the Sun's magnetic fields. Write a short summary that explains the meaning and representation of your artwork.
- Explore the powerful magnetic fields of the Sun with multiple activities and demonstrations. This link is a great resource to create additional artifacts for the Module 4 3-D Solar Exhibit.
Night Sky Network Our Magnetic Sun
- NASA Solar Math
Grade Level 3-5, p. 9
Grade Level 6-8, p. 42
Grade Level 9-12, p. 77

Internet Resources

Magnetic Sun Videos
Exploring Magnetism
Magnetic Image & Solar Activity Matching Game
Space Weather Center: Solar Cycles Explained
Stanford Solar Center Magnetism and the Sun
NASA Mapping Magnetic Influence
SDO Magnetism Activity pp. 73-80
Magnetic Fields of the Earth and Sun
Stanford Solar Group HMI
NASA Space Weather Media Viewer: Illustrations "The Magnetosphere"
NASA Space Weather Media Viewer: Videos "The Magnetosphere #1-7"