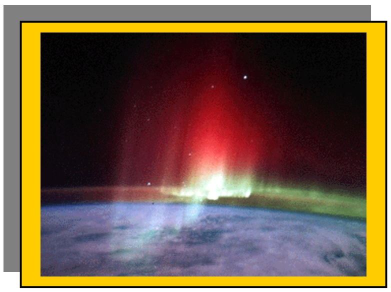
GENESIS SEARCH FOR ORIGINS Education

Cosmic Chemistry: Planetary Diversity

Plasma Wars

TEACHER GUIDE

BACKGROUND INFORMATION



The outpouring of the solar wind plasma from the sun has important consequences for all the planets. Some of the effects of the variability of solar energy on Earth's atmosphere, like the auroras, are spectacular to observe; others can prove to be disruptive, not only to our electronic communications, but also to our weather patterns.

The Earth is a huge electromagnet which, in turn, generates a very large magnetic field that extends well into space. It is this magnetic field that provides our protection from the solar wind plasma. It is also the interaction of Earth's magnetic field with the solar wind that makes it necessary for the Genesis mission to go outside the Earth's magnetosphere to obtain a "clean" sample of the solar wind.

Even though we can extend the general concept of the Earth's magnetic field to all other planets, we find that planetary diversity once again makes it difficult to generalize the characteristics of the planets' magnetospheres.

Part of the difficulty stems from the fact that there is some uncertainty as to the underlying causes of a planet's magnetic field. Scientists think that the following conditions must be present for a planet to have a magnetic field: a) there must be a liquid region within the planet, b) this liquid region must be capable of electrical conduction, and c) the planet must have an energy sources that sets the liquid region in motion and keeps it moving.

Because there are questions about whether the internal structures of some planets fulfill these conditions, this activity focuses on the observed sources and the measured strengths of the electrically charged particles in the planets' magnetospheres. However, students will be asked to revisit the internal structures diagrams they studied in the Student Data Sheet, pages 3-5, "Are We Related?" in this module to determine whether or not they can find any underlying structural patterns that could contribute to variable planetary magnetospheres.

Most students probably have been introduced to magnetic field lines using iron powder and a magnet, either as a physical science laboratory activity or demonstration. In the present activity students use iron powder to model the solar wind, moving under pressure created by a pipette, encountering and interacting with an enclosed magnetic field. The student text introduces the idea of planetary diversity not only in the shape, size, and strength of the planetary magnetospheres, but also in the types and sources of the high-energy charged particles that occupy them.

The follow-up questions allow for a range of student results and interpretations of those results in the same way that information from planetary probes leads to variable scientific interpretations.

NATIONAL SCIENCE STANDARDS ADDRESSED

Grades 5-8

Science As Inquiry

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry

Physical Science

Structure of atoms
Properties and changes of properties in matter
Motions and forces
Transfer of energy

Interactions of matter and energy

Science and Technology

Understandings about science and technology

History and Nature of Science

Science as a human endeavor
Nature of science and scientific knowledge
History of science and historical perspectives

Grades 9-12

Science As Inquiry

Abilities necessary to do scientific inquiry
Understandings about scientific inquiry

Earth and Space Science

Earth in the solar system
The origin and evolutions of the Earth system
Energy in the Earth system

Physical Science

Structure of atoms
Properties and changes of properties in matter
Motions and forces
Transfer of energy
Interactions of matter and energy

Science and Technology

Understandings about science and technology

History and Nature of Science

Science as a human endeavor
Nature of science and scientific knowledge
History of science and historical perspectives

(View a full text of the National Science Education Standards.)

MATERIALS

For each student
- Copy of Student Activity, "Plasma Wars"
- Copy of Student Text, "Plasma Wars"
- Copy of Student Handout, "Plasma Wars"

For each group:
- One sheet of white paper (8.5" x 11")
- One round magnet (between 1 and 1.5 cm in diameter), available locally at craft shops
- Iron powder (approximately 5 g)
- 2 strips of masking tape
- Beral pipette or medicine dropper

Caution!!!
If you are planning to use this activity with more than one class each day, fresh iron powder samples should be used for each group of students. Once the iron powder is magnetized, it should not be used again for this activity until the granules are completely demagnetized. Heating the powder between uses will enhance the demagnetization process.

For follow-up discussion:
- Overhead transparency of figure showing the interaction of the solar wind with the moon (see Procedure 8, below)

PROCEDURE

1. Before class collect the materials necessary for the activity and make copies of the following handouts:
   - Student Activity, "Plasma Wars"
   - Student Text, "Plasma Wars"

Safety Note

Safety goggles should be worn according to local regulations.

2. Divide the class into teams of two students each.

3. Distribute copies of the Student Activity, "Plasma Wars" to each student and the materials listed for each team.

4. Instruct the teams to complete instructions #1-#3 on the Student Activity sheet. (If it is necessary for them to repeat the procedure, for best results, they should not use the same iron powder.)

5. Have copies of the Student Text, "Plasma Wars," available for them when they have finished their drawings.

6. Assign any unfinished portion of the student activity as homework for the next period.

7. Start the next period's class discussion on magnetospheres with questions regarding the method students used in determining:
   a) Which planet's magnetosphere most closely matched their drawings?
   b) How the drawings should be labeled?
   c) What planetary characteristics appear to influence the size, shape, and composition of its magnetosphere?

8. The moon has no magnetic field or significant atmosphere, so the solar wind strikes its surface directly. *Make a copy of the figure on the next page, showing the interaction of the solar wind with the moon, either on the board or on a transparency. Ask students to compare this figure with those of the planetary magnetospheres.

9. Have students review pages 3-5, "Diagrams of Internal Structures of Planets" from the Student Data Sheet "Are We Related?" in this module. Ask them whether or not they find any correlation between the internal structures of the planets and the characteristics of their magnetospheres.

(*See page 4 for figure showing interaction of the solar wind with the moon.)

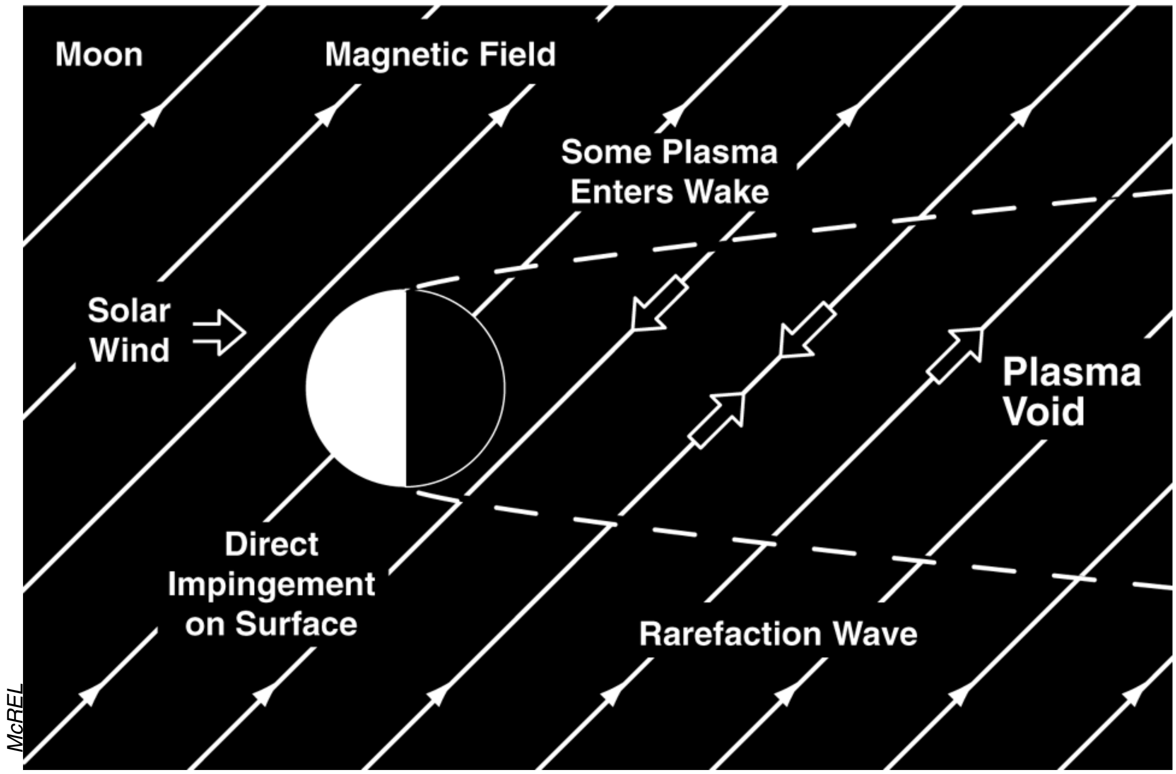
Alternate Strategy Tip

The NASA IMAGE satellite program's public outreach and education project has developed an inexpensive experiment called "soda bottle magnetometer." It lets students monitor changes in the Earth's magnetic field in their classroom and look for signs of magnetic storms and solar activity. For more information, visit the MagNet site at: http://image.gsfc.nasa.gov/poetry/workbook/magnet.html

Alternate Strategy Tip

When completing this activity it was noted by one reviewer that students needed to practice using the pipette. If your students have not used pipettes in the past, you may want to have them practice controlled puffs using sand on paper.

Figure 1



<u>Note.</u> The arrows in this diagram represents the Earth's magnetic field. The rarefaction wave is a wave of decrease in the density and pressure. The data in Figure 1 are from <u>The New Solar System</u>, by J. K. Beatty and A. Chaikin, (Eds.), 1990, Cambridge, MA: Cambridge Publishing Press.