# Solar Wind and Magnetosphere Interaction Lab
# A Cereal Analogy
# Lesson Plan

By Lynne Zielinski

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| Key Question: | How do solar wind particles interact with the earth's magnetosphere? |
| General Subject Areas: | Astronomy – Solar wind interaction with Earth |
| Other Content Areas: | Science- Physics or Physical Science – Magnetic Fields |
| Best for Grades: | 5-8, 9-12 |
| Lesson Description? | This open-ended laboratory activity is useful n demonstrating how solar wind particles re deflected by the Earth's magnetosphere and how charged particles are aligned within it. It is recommended that the activity be followed up with student presentations and a lab report. |
| Learning objectives: | After this lesson, students will be able to:<br>1. discuss and describe the components of solar wind particles.<br>2. explain why the magnetosphere and ionosphere protect the Earth<br>3. explain how moving particles behave and (align) in a magnetic field. |
| Key concepts | -Solar wind interaction with Earth's magnetosphere<br>-Magnetic field influence on charged particles<br>-Determination of magnetic field structure<br>-Magnetosphere and ionosphere protect Earth |
| Vocabulary: | Solar wind<br>Magnetosphere<br>Magnetic field<br>Ionosphere/Atmosphere<br>Ion<br>Electron |
| Time Requirements | Teacher Preparation: 30 minutes<br>Lab Preparation: 15 minutes<br>Class Lab Time: 20-30 minutes<br>Class Discussion Time: 40 minutes |
| Technology Requirements: | None |

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| Materials Required:<br><br>(per group) | Student worksheet<br>Iron fortified cereal * (like Total, Wheaties, Oatmeal, etc.) – this is a cereal which contains iron filings in it. Different cereal brands should probably be tested before doing this experiment with students as the "iron fortified" brands differ in quantity of iron filings present and how the iron is distributed within the cereal. Sometimes the iron is more visible if the flakes are crushed.<br>Raisins<br>Medium viscosity clear (or lightly colored) oil, glycerin, or Karo Syrup<br>Two strong magnets<br>400 mL beaker or larger<br>*Iron filings may need to be added to the cereal in case you find the cereal used does not contain enough for a "dramatic" effect |
| Student Prerequisites: | Prior to this lab, students should have done an experiment where they map out the magnetic field lines of a bar magnet and understand the basic implications of magnetic field line convergence and direction.<br>Students should also know and be able to define what a solar wind is and how it is created. They should have a picture or image of solar wind interaction with the magnetosphere.<br>This lab is meant to be a component of a larger lesson on solar wind and magnetosphere interaction. |

## Teacher Preparation:

Teacher should become familiar with this lab activity by trying it first so that it can be modified, if necessary, for use with available resources. There should be one lab set up for each group of 3-4 students. Each lab set up should include a small cup containing cereal (with iron filings in it) and some raisons, a beaker half full of oil-type product, and two strong magnets. They should also have the direction worksheet.

## Procedure:

Opening discussion with students' should include a review of solar wind, magnetic field, and atmospheric protection. The question should be posed: How are charged particles effected by the Earth's magnetic field and ionosphere? Students should write down their ideas in answer to this question on the lab worksheet.

Next, the students should be asked to get into their lab groups, perform the experiment, and fill out the rest of the worksheet.

Finally, students in their groups will be asked to present their ideas, hypotheses, and conclusions to the class, which answer the question.

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## Background Material for the Teacher:

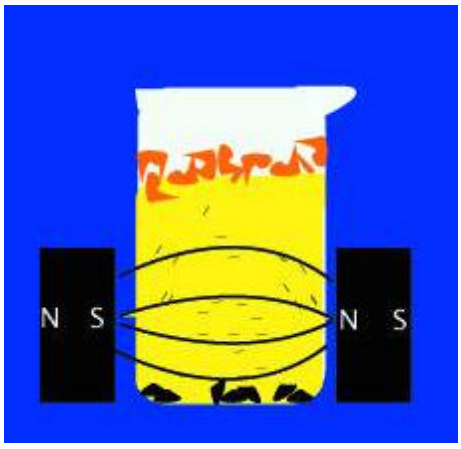
The manner in which the solar wind interacts with the earth's magnetosphere can be demonstrated in this laboratory activity. When large events occur on the sun, such as solar flares, coronal mass ejections, and coronal holes, the extra energy emitted effects the earth's magnetosphere. Most solar wind particles are deflected around the earth with only a few actually entering its magnetosphere. Charged particles within the magnetosphere are guided to the polar regions by the earth's magnetic field.

There are two websites that contain good explanations of how the auroras are formed. It is advisable that the material present in these tutorials be reviewed by the teacher and presented to students before the lab or that the students are allowed to go through the tutorials themselves. The tutorials can be found at:

Dawn of the North - An Auroral Tutorial for grades 10-12
http://sprg.ssl.berkeley.edu/rocket_cast/aurora_intro.htm
Paintings in the Sky - An Auroral Tutorial for grades 5-9
http://www.exploratorium.edu/learning_studio/auroras/happen.html

In this laboratory activity, students will use a mixture of cereal, raisins, and iron filings to represent the mixture of particles that come from the sun when a major event occurs. The viscous liquid or oil will be used to represent the earth's magnetosphere. Placing the magnets near the oil will simulate the earth's magnetic field.

When the cereal mixture is poured into the oil, most of the flakes will rest on top and the raisins will move quickly through the liquid to the bottom. This result represents how the majority of the solar wind particles are deflected by Earth's magnetosphere and how only a small percentage enters it.




Eventually, the iron filings will move into the liquid. They will align and be guided by the magnetic field present. This is similar to how Earth's magnetic field guides charged particles to the polar regions.

When the magnets are oriented in different configurations, the alignment of the iron filings will be different. Therefore, magnets can be oriented to represent different types of magnetic field configurations. It is good to have students draw a picture of the earth's magnetosphere and indicate on it how their magnet conjuration is represented.

IMPORTANT TEACHER NOTE: It is very important to try this lab yourself first, as the cereal that is used may not visibly contain the desired iron filings. Sometimes crushing the flakes will release them if the manufacturer happens to spray them on with a coating. If you find that the filings are not in the amount desired for the full effect of the lab, add some. Iron filings can be purchased from science supply companies.

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**Assessment:** Assessment can come in many forms. Two that are recommended for this lab are group presentation and experiment laboratory reports

## Laboratory Report Content Example

Laboratory reports can be completed in many formats based on the assessment values of the teacher. A typical standard report should contain all of the elements associated with a good lab report. The typical report should include:

Purpose: *A statement of purpose and hypotheses should be made in this section.*

The purpose of this experiment is to determine how the solar wind interacts with the earth's magnetosphere.

It is hypothesized that when the cereal is introduced into the fluid that the heavier components, like the raisins will move to the bottom, the lighter flakes will not penetrate the fluid, and the iron filings will align with the magnetic field.

Procedure: *A statement of the procedure actually used.*

The oil was placed in the beaker so that it was 2/3's full. The magnets were placed on either side of the beaker with the north and south poles facing each other. The cereal was poured into the beaker and observations were made with respect to how its components interacted with the fluid and magnetic field. (Diagrams could also be included here.

Data*:* *Drawings, models, and measurements made from observations*.

Raisins - dropped quickly to the bottom of the beaker.
Flakes - stayed on top of the fluid, only a few began to sink after a long period of time.
Iron filings - moved very slowly through the liquid. See drawing for orientation of how they aligned.

Analysis: *All data manipulation should be stated and described*.

According to our data, the cereal mixture contained iron filings that aligned in bunches horizontally along the north/south magnetic field lines. As discussed in class, different orientations of the magnetic field lines indicate different places in the earth's magnetosphere. Look at the diagram of the earth's magnetosphere. The place circled is where our field lines might be located.....

Conclusion: *A concluding statement which supports or refutes the purpose and hypotheses of the experiment. A defensive argument should be included which is supported by analysis.*

Based on my group's data and the class discussion, it can be concluded that most of the solar wind particles are deflected by the Earth's magnetosphere and never enter it. A small percentage does however. These particles usually have a high energy. The charged particles that are represented by the iron filings indicate that they will align with the Earth's magnetic field. Based on the class discussion, different orientations of the magnetic field will result in unusual iron filing alignment. Some of the patterns seen are shown in the diagrams below.....