Discovering the Sun- Galileo

NATIONAL STANDARDS:

National Science Education Standards

Content Standards 5-8

• Abilities necessary to do scientific inquiry.

• The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.

• Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the Moon, and eclipses.

• In historical perspective, science has been practiced by different individuals in different cult looking at the history of many peoples, one finds that scientists and engineers of high achievement are considered to be among the most valued contributors to their culture.

• Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

• Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.

• Telescopes reveal that there are many more stars in the night sky than are evident to the unaided eye.

National Educational Technology Standards (NETS)

• Students use technology to locate, evaluate, and collect information from a variety of sources.

Mathematics Standards (NCTM)

• Work flexibly with fractions, decimals, and percents to solve problems.

• Use two-dimensional representations of three-dimensional objects to visualize and solve problems.

• Select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels of precision.

INSTRUCTIONAL OBJECTIVES:

Students will learn to observe the Sun safely and will discover that the Sun has spots that appear and disappear over time.

Students will discover that the Sun rotates. This activity can be extended to determine the average time of rotation of the Sun.

VOCABULARY:

• Convective zone - the outer most region of the interior of the Sun. The convective zone lies just below the visible surface of the Sun (the photosphere)and is about 200,000 km thick. Within this region energy is transferred through the mass motion of

plasma. Hotter plasma moves upward and cooler plasma sinks.

• Magnetic field - the region of magnetic influence around a magnetic object such as a bar magnet, a current carrying wire, the Sun, Earth and of the magnetic planets.

• Photosphere - the lowest layer of the solar atmosphere where the Sun's visible spectrum of light is released. It is the visible "surface" we see in white-light images of the Sun.

• Plasma - One of the four states of matter. (The other three are solid, liquid and gas.) Plasma is a gas of positively charged and negatively charged particles with approximately equal concentrations of both so that the total gas is approximately charge-neutral. A plasma can be produced from a gas if enough energy is added to cause the electrically neutral atoms of the gas to split into positively and negatively charged atoms and electrons.

• Sunspot - An area seen as a dark spot on the photosphere of the Sun. It appears dark because it is cooler than the surrounding photosphere.

PREPARING FOR THE ACTIVITY:

Student materials:

• Galileo's sunspot drawings

• 4x6 index cards with reference circle (use Circle Template- provided)

• Pencils

• Sunspotter® for each group

• Sunspot Observation Graphs (provided)

Teacher Materials

• Sun

• Copies of sunspot drawings from Galileo Web site

• Daily images of sunspots taken by SOHO (Solar and Heliospheric Observatory) spacecraft from the past 5 days

Time

•2- 40 - 50 minute sessions, Getting Started and conclusions

• 3 sunspot-viewing sessions (at least) of 15-20 minutes each on consecutive days (or as nearly as possible) and the same time of day, if possible.

Advance Preparation

• A critical component of this activity is a device to project an image of the Sun on a piece of paper.

Remember: never look directly at the Sun, especially through a telescope or binoculars unless you have specially prepared solar filters.

One of the best devices is a commercial product, the Sunspotter®, available directly from Learning Technologies, Inc (800-537-8703). This activity is designed for use with the Sunspotter, however, you can use a small telescope or binoculars to project the image of the Sun.

• Practice with the Sunspotter before class! The Sunspotter must be pointed correctly at the Sun.

The image of the Sun will move due to the Earth's rotation, so the Sunspotter must be constantly adjusted.

• Prepare 4x6 index cards with reference circle (use Circle Template)

• Prepare sunspot drawings from Galileo Web site at Rice University:

http://galileo.rice.edu/sci/observations/sunspot_drawings.html

Print two sets of at least four drawings from consecutive days. Keep a master with the dates rearrange the pictures of the second set, white out the dates and label them A, B, C, D, etc., and make copies for each group of students.

Print the daily images of the Sun taken by SOHO showing sunspots from the last 5 days

http://sohowww.nascom.nasa.gov

At the SOHO site click on The Sun Now. You want images of the MDI Continuum, so click on More MDI Continuum, click on the image- then go to file- print. Print images that were taken at the same time of day. The date and time are provided for each image.

• Prepare Student Observation Graphs for each student.

The Activity:

1. Assign groups according to the number of Sunspotters available to enable participation for all students. Provide each student with a 4x6 card, a pencil, and a Sunspot Observation Graph.

2. Tell students about Galileo and his observations of the Sun. However, do not tell the students that Galileo discovered that the Sun rotated.

Pass out the Galileo drawings of sunspots with the dates erased and randomly arranged (see Advanced Preparation). Tell the students the pictures were drawn on consecutive days, but you accidentally dropped the drawings and the pictures are out of order.

Within their groups have them make a prediction about the correct order of Galileo's original drawings. Tell them this is only a prediction. Have each group record its prediction of the order of drawings on the board.

After every group has recorded predictions, have each group explain their rationale for its prediction. This will tell you what they know about the topic. (Galileo drawings at the end of the discussion for use later.)

3. Use the images taken by the SOHO spacecraft.

Identify the sunspots charted for the previous few days. Discuss the differences you see and make predictions for observations you will take during the next few days.

4. Configure the Sunspotter in an area of direct sunlight.

Assign each of the student groups to one Sunspotter. Have each student place his or her 4x6 card in the Sunspotter and draw the sunspots he or she sees. Encourage discussion of other physical characteristics if any.

Always remind the student to ***never look directly at the Sun.***

Have students record the number of sunspots on the Sunspot Observation Graph. Remind students that the day

axis refers to the number of days since the beginning of observations.

If a day is skipped because of a weekend or cloudy weather, that day must be skipped on the graph.

5. Encourage small group discussions, especially if one drawing varies from the others.

6. Have one student go to the SOHO Web site address listed above and check the image for that day. If a printer is available, print a copy and post it in the classroom for comparison and discussion.

7. Repeat steps 4-6 for the next 3-5 consecutive days or longer, depending on the weather. After the first day the observations will take only 15-20 minutes, so you should plan other activities about the Sun.

8. On one of the observing days have each student choose a favorite sunspot and estimate its size.

They could use their own drawings, or, for greater accuracy, use the Space Weather Viewer- Earth Sun size comparison(lower left).

9. Students can create their own “flip” book of index cards to see how the sunspots have changed position.

10. Have each student complete the Sunspot Observation Graph. Then have students access the monthly mean sunspot numbers

ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/AMERICAN_NUMBERS/MONTHLY

Have students graph the last 3 to 5 years of data. You may wish to have students graph different years and then put all graphs together to observe long-term trends.

Ask students to compare the pattern they observed for numbers of sunspots on the Sunspot Observation Graph with the trend they can see on the graph of data from the data they used from the monthly mean sunspot numbers.

11. Facilitate a large group discussion on the last day to analyze final observations and compare charts.

Students may observe that the size or number of sunspots may change. Students should observe that the sunspots change position in a regular way.

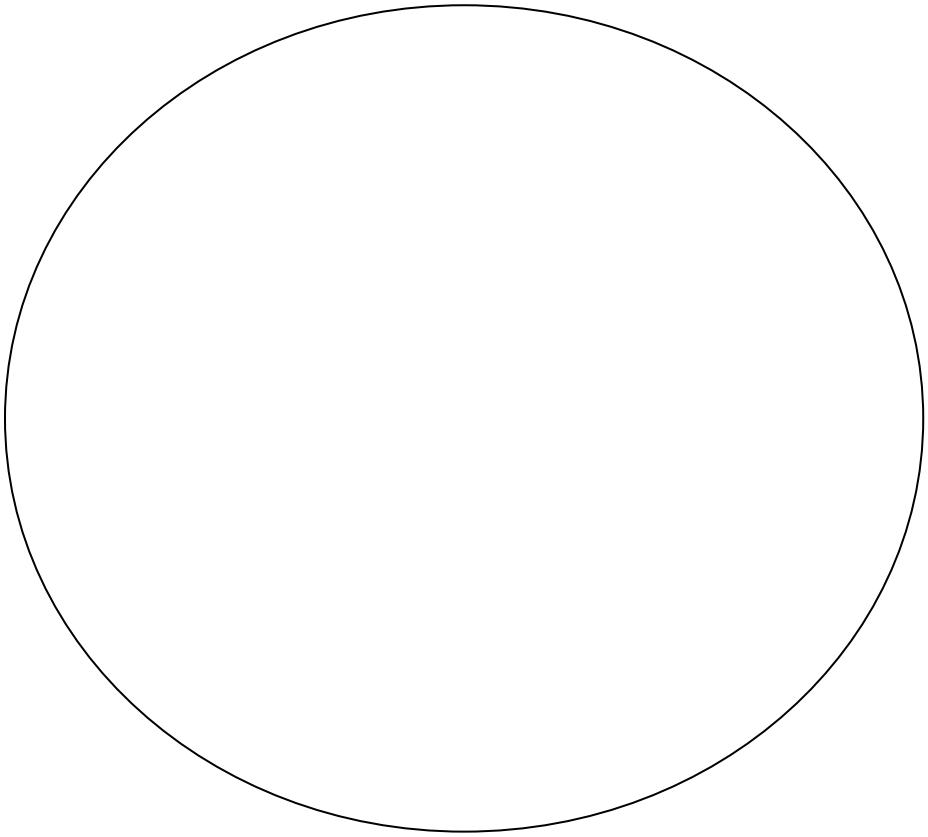
Ask the students to provide an explanation for the change in position of the spots.

Several explanations are common: that the Sun rotates (correct), that the Earth’s daily rotation is responsible, or that the Earth’s orbit around the Sun is responsible.

12. Hand out Galileo drawings from the first day and again ask each group to determine the correct order for the drawings and reflect upon their original predictions. Have each group record its solution of the order of drawings on the board

Circle Template:

Below is a circle the size of the Sun's image on the Sunspotter®. Copy this image onto the 4x6 index cards before the observations.



Sample Graph: