Learning about the sun

A Lesson Plan for Grade 9 Students

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Safety Warning

Safety should be your main consideration when you are planning to observe the sun. Never attempt to observe the sun through any optical device--other than a Coronado™ telescope or a device fitted with a proper sun filter--because even a **brief exposure** can cause **permanent eye damage**.

A proper sun filter fits on the front (aperture) of an optical device and not on the rear (eyepiece). Some eyepieces were made in the past for sun observation, but these are considered to be unsafe because they can crack suddenly while being used to observe the sun. Please do not use them. Whenever in doubt about a piece of equipment, contact a local astronomy equipment store or astronomy association for advice.

To minimize the risk of eye damage, it is recommended that you:

- attach sun filters to your telescope(s) indoors before you take them outside; and,
- review the dangers of sun observation with your students.

Introduction

Preamble

The lesson plan presented below will enable you and your students to explore some truly amazing and important properties of the sun, our closest star. The main advantage of studying the sun is that it can be done during normal class hours, unlike night-time astronomy, as laudable as it may be. Other advantages of using this lesson plan include:

- numerous connections (knowledge, skills and applications) to Ontario's science and some math curricula
- numerous connections to important issues affecting human activities
- activities that promote the development of important skills in science such as:
    - making and recording observations
    - thinking about how to make measurements
- activities that relate to and build on basic math ideas
- images that will surely captivate any audience

This lesson fits specifically and nicely into the Ontario grade 9 science curriculum unit "Earth and Space Science." However, teachers in other provinces should be able to use this lesson as well given the similarities in curricula between provinces. You can even use some of the materials in the Ontario Grade 12 University Earth and Space Science course, because it deals with the rotation of celestial objects, magnetic fields, and radiation from the sun.

Theoretical and hands-on work has been included to make this lesson suitable and appealing to both academic and applied level students. In addition, curriculum expectations for both groups have been fully integrated, <u>with a significant emphasis on skills development</u>. These have been referenced as footnotes throughout the lesson plan and workbooklet (teacher version, not student version) with the symbol CE.

You might want to adjust the lesson plan for applied level students. For example, you may want to skim over some of the introduction, and spend more time with the "hands-on" pinhole activity, and more time explaining how to measure the movement of sunspots. You may even want to get the applied level classes to construct a better pinhole device. Use your discretion in deciding how much to teach of the information given here.

How you end up teaching this material will partly depend on the unique circumstances of your class, the equipment available to you and your familiarity with it, but much can be accomplished with very simple teaching aids.

The lesson plan has normal text and text in italics, the former being the actual lesson, and the latter being suggestions to the teacher only.

Overall, this lesson plan and supporting materials were designed to challenge the students and to expand their learning beyond what most textbooks expect, and beyond the average astronomy unit student experience of memorizing facts. It will be challenging for you too, but it is doable because all of the materials and advice you need have been provided. Lastly, the emphasis on skills development will allow you to “check off” many or most of the skills expectations for this unit.

Teaching Materials

The teaching materials comprise:

- the lesson plan (this document)
- the PowerPoint presentation “Studying the sun” that should be used in conjunction with the lesson plan
- a work booklet that students should complete and turn in for marking
- the PowerPoint presentation “sun Images” that is required for a workbook activity
- a PowerPoint presentation named “Lat and Long” that will help students complete some tables in the workbook
- an Excel file containing all data available on yearly sunspot activity (not essential, but provided nevertheless)
- A document with some suggestions and links on how to develop group work skills

Sequencing and Timing

If possible, teach this topic *after* the units on chemistry and electricity have been taught, since there are some references made to concepts from those units. It is assumed that the astronomy unit will take about 4 to 6 weeks to complete, and that each class is 1 hr long. The table below suggests one approach to carrying out this lesson, but you may want to modify it to suit the unique circumstances of your class or school.

This whole topic will take 2 consecutive full periods, and then only about 5 minutes at the beginning of each class for about 11 days.

Lesson	Actions
1	- After giving a brief introduction to this lesson, place students into groups of 3 students. ▪ Group work skills at this grade may not be sufficiently developed to accommodate a group larger than 3 students. It may be helpful to review or give some suggestions on how to work well within a group. A separate paper “Group Work Skills” offers some ideas

Lesson	Actions
	and websites that can be consulted for suggestions that can enhance group work. - distribute the work booklets ▪ give one to each student + an extra one for each group that will be used as the final submission - deliver the “Studying the sun” PowerPoint presentation - carry out the pinhole activity ▪ If the sun is not shining brightly, this activity will not work well. A weather forecast will help you to plan this activity at least a few days in advance. - assign Internet research homework on the sun
2	- take up Internet research homework orally - give the “Lat and Long” PowerPoint presentation - show one (two pictures of sunspots depending on how many classes you can devote to this exercise) from “sun Images” PowerPoint, giving the students about 5 minutes to record observations - Allow students to observe the sun, directly or indirectly, with a telescope or binoculars, if possible
3-13	- show one image of the sun with sunspots each day until all are shown - show the video showing the movement of sunspots - move onto other topics in the astronomy unit - have students submit the workbooklet for marking

Lesson 1 Why Study the sun?

This introduction should be conducted by showing the accompanying PowerPoint presentation "Studying the sun" that should last about 30 minutes, after which you should immediately begin the activity. Get the students to take notes about the introduction by filling out the work booklet to avoid boredom from setting in, but they shouldn't try to copy the presentation down word-for-word. (Unlike most adults, many students cannot keep their focus during a PowerPoint presentation that only requires them to listen, so you need to make sure that the .ppt engages them. Questions throughout the .ppt will help you to engage the students.)

There are at least four reasons to study the sun.[1]

The Climate Connection

- [Slide 3] The sun is the main source of light and heat required for life[2] on Earth. The sun has and continues to play a major role in the world's climate.

- Earth has experienced several cooling periods. These periods coincide with lower than usual solar activity. Scientists continue to study the relationship between climate and solar activity as measured by sunspot activity, which you will learn more about.

    - *During the coldest part of the Little Ice Age, from 1645 to 1715, there is believed to have been a decrease in the total energy output from the sun, as indicated by little or no sunspot activity. Known as the Maunder Minimum, astronomers of the time observed only about 50 sunspots for a 30-year period as opposed to a more typical 40-50,000 spots.*

    - *During the Little Ice Age, access to Greenland was largely cut off by ice from 1410 to the 1720s. At the same time, canals in Holland routinely froze solid, glaciers advanced in the Alps, and sea-ice increased so much that no open water was present in any direction around Iceland in 1695*[3].

- At the top of Earth's atmosphere the total power (*irradiance*) from the sun is about 1366 W/m². Imagine thirteen 100 Watt light bulbs shining all of their energy onto 1 square meter[4].

    - Ask: What common household appliance uses the same amount of power?

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[1] http://solarscience.msfc.nasa.gov/whysolar.shtml
[2] CE: Grade 7 Science, Energy and Control, Heat
[3] http://www.gsfc.nasa.gov/topstory/20011207iceage.html
[4] CE: Grade 7 Science, Energy and Control, Heat

- o A common hairdryer uses between 1000 to 1400 Watts of power.
- o This means that if you had a solar panel on your roof a few square meters in area that was reasonably efficient, you could run a hairdryer or some other appliance.

- [Slide 4] This slide is an image of the sun in the ultraviolet range. It has a false colour of blue because UV is not visible to the human eye.

- During those periods of low solar activity, levels of the sun's ultraviolet radiation decrease. The intensity of ultraviolet light can vary significantly daily and x-rays[5] coming from the sun can change brightness by a factor of 100 or even 1000[6] in just a few minutes. Satellites monitor the energy coming from the sun, and scientists study how that affects climate.

  - *The word factor might have to be explained with an example: a factor of 100 means 100 times more.*

  - It is now accepted that the global cooling during Ice Ages is the result of changes in the distribution and amount of sunlight that reached Earth.

- Ask: Why are humans concerned with UV light? Answer: sunburns and skin cancer

- Ask: How long does it take for this light to reach earth?

- Distance = speed x time, c= 3 x 10^8 m/s, distance from earth to sun = 150,000,000 km = 1.5 x 10^11 m

- $t = \frac{d}{c} = \frac{1.5x10^{11}}{3x10^{8}} = .5x10^{3}\sec = 500\sec = 8.3\min$

- [Slide 5] The sun provides the energy that drives our weather systems such as hurricanes.

  - o A very important exchange of energy occurs when water in the atmosphere changes from gas to liquid as in a thunderstorm. The energy released in a thunderstorm is equivalent to a dozen or so Hiroshima-type bombs. A hurricane releases almost that energy in 1 second[7], and all of that energy originally came from the sun.[8]

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[5] CE: Grade 8, Science, Energy and Control, Optics
[6] CE: Grade 9 Math. Academic and Applied, Linear Relations
[7] Air Command Weather Manual, page 1-1
[8] CE: Grade 10, Earth and Space Science: Weather Dynamics

Solar "Weather"

The idea that there is "weather" in space will probably be news for grade 9 students, and most people for that matter. You could ask the class if weather exists in outer space. Most will likely so no, because their concept of weather is limited to what they have experienced on Earth. Therefore, asking and answering that question can help these students to understand how assumptions and previous experience can sometimes limit a person's understanding of new situations. Weather in space is due to the solar wind, which is not visible to the human eye.

- [Slide 6] Weather on earth is very different from what is referred to as "weather" in space. Ask: What weather is happening in this photo[9]?

This is a photo of fog over downtown Toronto. Fog forms when the temperature of the air drops to the dew point where condensation occurs. The dewpoint is reported by environment Canada for many locations in Canada http://www.weatheroffice.gc.ca/canada_e.html

- [Slide 7] The solar wind[10] and space weather begins with the expansion of the sun's corona (outer atmosphere) into space, as shown in this image.

- The solar wind is a flow of charged particles consisting mostly of electrons and protons that streams past the Earth at speeds easily more than 500 km per second.7

- Disturbances or "gusts" in the solar wind shake the Earth's magnetic field.

- Ask: Can we see with our eyes this solar wind?

The answer is no of course because protons and electrons are not visible to the naked eye, but we can sometimes see its effects.

- [Slide 8] Satellites[11], like SOHO, measure the properties of solar wind. The speed and the density of the solar wind are reported in real time i.e. continuous readout by the minute.

- Ask: If we assume that the sun is 150,000,000 km away from the earth, how long does it take for this wind to reach the earth[12]?

- 377 km/s = 1,357,200 km/hr 150,000,000/1,357,200= 110.5 hrs = 4.6 days

[9] CE: Grade 5, Weather
[10] CE: Grade 9 Science, Earth and Space Science (cause of Aurora Borealis)
[11] CE: Grade 9 Science, applications: data from satellites
[12] CE: Grade 9 Science, skill: formulate scientific questions; communicate scientific ideas

- [Slide 9] The solar wind causes the tails of comets always to point away from the sun regardless of the direction of movement of the comet[13].

Get the students to imagine themselves as astronauts doing a space walk.

- [Slide 10] This solar wind (space weather) can force satellites out of orbit, physically damage them, shorten mission lifetimes, and pose a threat to astronauts.[14]

    - In this slide, you can see a photo of Canadian astronaut Chris Hadfield outside of a NASA shuttle and secured by the feet to the Canadarm[15].

    - *Launched in November 1995, RADARSAT-1[16] ushered in a new age in remote sensing and firmly positioned Canada as a leader in the internationally competitive Earth observation market. Unlike most remote sensing satellites, which use optical sensors to capture sunlight reflected from the Earth, RADARSAT-1 is able to collect imagery of the Earth day or night and through clouds using a radar system. Approximately 800 km above the Earth, RADARSAT-1 produces high resolution images of the Earth's surface. These images are used in monitoring the environment and managing the Earth's natural resources.[17]*

- [Slides 11] The earth's magnetic field protects us from this solar wind. This diagram shows the magnetic field without any influence on it by the solar wind.

- Ask: Is there really a bar magnet[18] in the centre of the earth?

- Ask: Why does this bar magnet have its south pole located at the north pole of the earth? Is this a mistake in the diagram?

- *Magnetic lines go into the south pole of a magnet and come out of the north pole of a magnet by definition. The north end of a compass will point north because it is attracted to what effectively is the earth's magnetic south pole found near the geographic north pole.*

- [Slide 12] Ask: What is the difference between the geographic and magnetic north poles? Ask: What defines the geographic northpole?

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[13] CE: Grade 9 Science, Academic and Applied, Earth and Space Science
[14] See http://www.solarstorms.org/Scommun.html for examples.
[15] CE: Grade 9 Science, Earth and Space Science, contributions of Canada to space exploration
[16] CE: Grade 9 Science, Earth and Space Science, contributions of Canada to space exploration
[17] CE: Grade 9, Science, applications: impact of research on other fields
[18] CE: Grade 6, Science, Electricity

- *The geographic north pole is the location of the axis of rotation of the earth*[19].

- [Slide 13] This artist's diagram—not to scale-- shows how the solar wind can distort the Earth's magnetic field!

- Shaking the Earth's magnetic field can also cause current surges in power lines that destroy equipment on Earth and knock out electrical power grids over large areas. As we become more dependent upon satellites in space we will increasingly feel the effects of space weather and need to predict it.

- [Slides 14, 15, 16,17] These slides reveal the beauty of the Aurora Borealis (northern lights) that is caused by the solar wind interacting with the earth's magnetic field.

The Sun as a Star

- [Slide 18] The Canada-France-Hawaii telescope[20] took this deep-space image, revealing countless galaxies with billions of stars in each one.

- [Slide 19] The sun is a key to understanding these stars and the stars in our own galaxy, the Milky Way. We know the sun's age, radius, mass, and luminosity (power) and we have also learned detailed information about its interior and atmosphere to compare with our "models."

- The sun is mostly made up of hydrogen (about 92.1% of the number of atoms, 75% of the mass). Helium can also be found in the sun (7.8% of the number of atoms and 23% of the mass. Everything else makes up 2%.[21]

- Ask: How can hydrogen make up 92% of the atoms but only 75% of the mass of the sun?

- The temperature at the centre of the sun is 15.6 million degrees Celsius!

- This information is crucial for our understanding of other stars and how they evolve.

The Sun as a Physical Laboratory

- [press B to blank out screen] The sun produces its energy by nuclear fusion where four hydrogen nuclei are fused to form single helium nuclei deep within the sun's core.

[19] CE: Grade 6, Science, Space
[20] CE: Grade 6, Science, Space
[21] CE: Grade 9 Academic and Applied, Chemistry

- Ask: Where are helium and hydrogen located on the Periodic table[22]?

- [Slide 20] Scientists have worked for decades to reproduce fusion (in a controlled manner) here on Earth.

- Some scientists believe that fusion power could be the answer to the world's energy crisis, because of the vast amount of pollution-free energy that could be produced by fusion.

- Fusion is relatively safe and clean. Waste material from fusion decays rapidly, and presents no long-term burden on future generations. It does not need guaranteed isolation from the environment for very long time spans.

- However, fusion power so far has presented insurmountable scientific and engineering challenges**.** Scientists have been working for 40 years and have already spent $20 billion on research!

- Say something like, "Perhaps one of you will help solve this problem!"

- To make nuclear fusion happen, atoms must first be broken down into electrons[23] and atomic nuclei. This produces an electrically charged gas called a plasma. The bare nuclei must then be forced together so that they merge. Because like charges repel[24], this is difficult.

- Most of these efforts involve extremely hot plasmas in strong magnetic fields. (This plasma is not the blood product but rather a mixture of ions and electrons produced at high temperatures.)

- Ask: Where else did we see like charges repelling?

Solar Magnetic Fields

Solar magnetic processes are very complicated, and even astronomers don't fully understand them. In this section, your goal is to contrast the simplicity of the magnetic field of a bar magnet--and by extension that of the earth—to the much more complicated magnetism of the sun.

[22] CE: Grade 9 Academic and Applied, Chemistry
[23] CE: Grade 9 Academic and Applied, Chemistry
[24] CE: Grade 9 Academic and Applied, Electricity

- [Slide 21] Magnetism is a key to understanding certain aspects of the sun. This bar magnet has unchanging magnetic lines of force, but the sun is a very different story!

- [Slide 22] Magnetism or the magnetic field of the sun is produced by the flow of electrically charged ions and electrons inside the sun. The magnetic lines are further complicated by the rotation of the sun, which is made of gas. The turning of the sun twists the magnetic field lines.

- Ask: What is an ion?

- *An **ion** is an atom or molecule which has lost or gained one or more valence electrons, giving it a positive or negative electrical charge.*

- [Slide 23] This slide illustrates how the sun's magnetism is far more complicated than the earth's magnetism.

- [Slide 24, 25] The sun's magnetism supports and forms prominences and flares into loops. Notice how large these flares can be![25]

- [Slide 26] Galileo has been credited with discovering sunspots in 1612 with a telescope, but Chinese astronomers may have been the first ones to see them with the naked-eye. When the sun is near the horizon, it can be viewed safely, and if there are large sunspots, they can be seen.

- You will be doing an exercise to measure the movement of sunspots much like Galileo did almost 400 years ago. In 2009, astronomers around the world will be celebrating this 400th anniversary as "International Year of Astronomy 2009."

- [Slide 27] sunspots are places where very intense magnetic lines of force break through the sun's surface, and because much of the energy is in magnetism, and less in heat, the sunspots are cooler and less bright.

- [Slide 28] This slide shows hot, bright blobs of gas currents 1000 km across --about the size of Ontario--, and a sunspot where the magnetic field squashes the blobs.

- [Slide 29] This slide shows that sunspots come in pairs, one with a north pole polarity and one with a south pole polarity, just like magnets.

- [Slide 30] The sunspot cycle results from the recycling of magnetic fields by the flow of material in the interior. Note that this is very different from the Earth's magnetic field that is relatively much more steady and stable, because the sun is fluid!

[25] CE: Grade 9, Science, skills: plan ways to model

- Ask: What patterns do you see in this graph[26]?

- *The average solar cycle is about 11 years. The maximum number of sunspots can vary quite a bit and it is difficult if not impossible[27] to predict exactly the sunspot activity for the next solar cycle.*

Once the introduction is complete, move onto Activity 1.

[26] CE: Grade 9 Science, skills: analyze quantitative data
[27] CE: Grade 9 Math and other years, Patterns, Thinking and Reasoning

Activity 1 Pinhole Camera[28]

Safety Warning

Warn the students not to look at the sun through the pinhole.

With this pinhole camera activity, you will introduce some simple techniques to measure the size of the sun. A bright sun is required for this activity, and so you will need to be flexible in scheduling. This activity covers optics, mathematical ideas such as similar triangles, and simple measurement errors.

This exercise introduces the concept of measurement error, which will probably be new for the students. See Annex A for some suggestions on how to teach this idea.

You can accomplish the task using different materials, equipment and set-up. The description found in Annex A is one way to carry out this demonstration.

The PowerPoint presentation "Studying the sun" has a few slides that can be used to help the students understand how a pinhole camera (projector in this case) works.

[Slide 31] This illustration gives you a sense of how large the sun is compared to the earth and other planets. You will calculate the actual size of the sun with the pinhole activity, assuming that you know its distance.

[Slide 32, 33] Notice how the light rays form images on the screen and how these rays form similar triangles that can be used to calculate the size of the object.

Once this is accomplished (approx in 30 minutes), assign the homework.

Homework

Assign the Internet research homework as described in Annex B and which is found in the student workbooklet.[29]

[28] CE: Grade 9, Science, skills: model an answer to a question; plan and conduct inquiry; gather and record data; communicate scientific data; calculate size of objects
[29] CE: Grade 9, Science, skills: select and integrate information from various sources

Lesson 2 Sunspot Movement[30]

Take up the Internet research homework orally.

In particular, get the students to discuss what they saw in the <u>sun Now</u> *pictures. Since sunspot activity is currently at a low point in 2008, there may not be any present on the MDI Magnetogram (gray) pictures, which reveal sunspots the best.*

The students may have questions about how or why there are so many different views of the sun. You can simply say that different sensors that pick up different wavelengths of energy are being used to produce these images of the same object, and that if they continue studying science, they will learn more about this in grades 11, 12 and university.

Show the Presentation "Sun Images[31]," and ask the class, "How can we measure the movement of sunspots?[32]"

There are two possible answers[33]:

- *measure the linear distance between spots, and compare that distance to diameter to get an answer*
- *use an angular measurement technique*

These two answers can lead nicely into a rich discussion on how to measure change. See Annex C for more details.

Give the "Lat and Long" PowerPoint presentation.

The presentation is self-explanatory.

Use a globe to illustrate these ideas. A 3-D teaching aid will help you and your students immensely. Keep in mind that changing from one frame of reference to another can be very challenging for students. Normally, people see the world and universe around them from the perspective of standing on the surface of the earth. With these diagrams, you are asking the students to view the earth from a position out in space. Explaining this to your students may be helpful.

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[30] CE: Grade 9, Science, skills: formulate scientific questions; gather and record data; plan ways to simulate an answer to the question; plan and conduct an inquiry; record information; analyze qualitative and quantitative data; communicate scientific ideas
[31] CE: Grade 9, Science, applications: satellite exploration
[32] CE: Grade 9, Science, skills: formulate scientific questions
[33] CE: Grade 9, Science, skills: plan and conduct and inquiry

Activity 2: Measuring sunspot Movement

Next, introduce Activity 2 that is in the work booklet. Re-show the first slide from the PowerPoint presentation "sun Images" and give the students time to record their observations.

To minimize error, you could project the global grid onto the image of the sun using a separate overhead projector. An alternative would be to project the image onto a large semi-permanent grid on the wall or board. If you choose this method, then the technique that explains how to measure angular change found in the Lat Long presentation become unnecessary. You may decide to teach it regardless if in your opinion it could be helpful.

All of this could easily take up one class. Each following class, show the next image and allow the students to record their observations. This will take about 10 days, but you can accomplish the task in less time.

A few days into this exercise, show the video found at

http://sohowww.nascom.nasa.gov/gallery/Movies/spotfull/spotfull.mpg

, and get the students to describe how they would accomplish the same objectives using the video clip.

If possible, get the students to view the sun using an optical device. Although it may be difficult to see sunspots, flares will be visible, and seeing these for the first time can be highly motivating. See Annex D for more details.

Annex A: Activity 1 Pinhole Camera

You are strongly urged to practice this exercise ahead of time to increase your chances of successfully carrying out the activity with a class.

Materials

- 20 cm by 20 cm or so stiff board (one for each group of three students) This board should have a 3cm by 3 cm hole cut out in the centre
- 20 cm by 20 cm white board (one for each group of three students)
- 4 cm x 4 cm pieces of aluminium foil
- pins
- tape
- 30 cm metric ruler

Instructions

1. Teach a short lesson on measurement error (see below for some suggestions).
2. Divide up the class into groups of three students.
3. Get the students to tape the foil over the opening and to puncture it with a pin.
4. Get one student holding the pinhole board, another the screen, and the third taking measurements. Use slides 28 and 29 found in the "Studying the sun" .ppt and give explicit instructions on how to do this.
5. Have the measurements recorded on their sun activities work booklet.

Measurement Error[34]

Get the students to measure one object, such as the width of a table, to the closest fraction of a millimeter. The object should have some curved or poorly defined edges to contribute to different measurements. Get the students to repeat the exercise and to record their results.

Record on the board ten pairs of observations from the students—hopefully and more than likely, not all the answers will be the same! Ask the students why the answers are not all exactly the same.

Differences in the answers can be due to several reasons:

- The desk may have been measured at slightly different locations.
- Their rulers may not be identical. (You could compare a clear plastic ruler to another one or an opaque one.)

[34] CE: Grade 9, Science, skills: gather and record data; plan and conduct and inquiry

- The rulers may not be very accurate themselves
- The technique used by each group to measure could be different.
- Mistakes could have been made in taking measurements.
- Mistake could have been made in recording measurements.
- The scale of the ruler might not be fine enough to record an exact measurement, and so a guess was made on the fraction of a millimetre.

These guesses and other factors mentioned introduce error, and it’s important that the potential error on any measurement be recorded, because that could affect the final outcome of the research.

Annex B: Internet Research Homework[35]

Ask the students to research by group the following URLs and to come prepared to discuss what they found or learned:

http://curious.astro.cornell.edu/question.php?number=319

Discusses how the size of the sun and moon are measured using angles. It's a short article and leads nicely into the next activity.

www.google.ca for images of the sun, using those or other similar terms

www.google.ca , select "images" from the top bar and run the search again.

The idea here is get the students to refine their Internet searching techniques.

http://sohowww.nascom.nasa.gov/gallery/Movies/sunspots.html

This site has some amazing video images of the sun as seen in different wavelengths.

http://sohowww.nascom.nasa.gov/gallery/Movies/animations.html

Ask the students to view the animations on sunspot formation, and the CME affecting the earth's magnetosphere.

http://sohodata.nascom.nasa.gov/cgi-bin/data_query

This is the location where the images used in the sunspot activity were retrieved.

Ask the students to view images based on whatever selections they would like.

http://www.astrosociety.org/education/publications/tnl/05/05.html

This site describes and compares the nearest stars to earth. Get the students to find out how the sun compares to other stars.

[35] CE: Grade 9, Science, Academic and Applied, Inquiry and Communication, 2.4, gather and record data

Annex C Measuring sunspot Movement

Linear Measurement of sunspot Movement

Linear measurement of sunspot movement can introduce significant error because of a phenomenon called foreshortening. To see a brief but good explanation—along with some history--visit http://solar-center.stanford.edu/sunspots/galileo1.html .

You can demonstrate this phenomenon easily to the students. Place a small round black piece of tape on large globe. Locate the students on one side of the room (you may have to use a hallway) and put the globe about 13 m away. Turn it slowly at a constant rate. Ask the students how the black *dot appears to move.* They should be able to observe that it appears to move more slowly when it appears on the edge or limb and more quickly when it is facing directly towards the students.

Angular Measurement

The method illustrated near the end of the presentation “Lat and Long” will allow you to measure the change in longitude of sunspots. The method described should work for sunspots at any latitude, but unfortunately, it doesn’t explain why or how this method works. It would be wonderful for the students to learn *why* this works, but that is not an absolute necessity in this project. You may even decide to forgo this task, and focus on other things.

However, if you decide to explain why this method works, you will require the use of 3-D images or a 3-D model.

Some math software programs will allow you to construct 3-D images of a sphere and planes of intersection that can be rotated about the centre of the sphere. By rotating the plane that has some points simulating sunspots and by viewing the diagram from different points of view, you should be able to see why this method works.

You can also try modifying a globe in the manner suggested next. Attach a wire to a globe at the equator so that it can be rotated upwards to the north pole. When this wire reaches the top, the “north pole,” it becomes a line of longitude in effect.

If you place some marks on the wire and then rotate it up to the north pole, should be able to understand after viewing the model from different angles, why this technique works.

Annex D Observing sunspot Activity[36]

Methods and Equipment

There several are methods and optical devices of viewing the sun other than using Internet images:

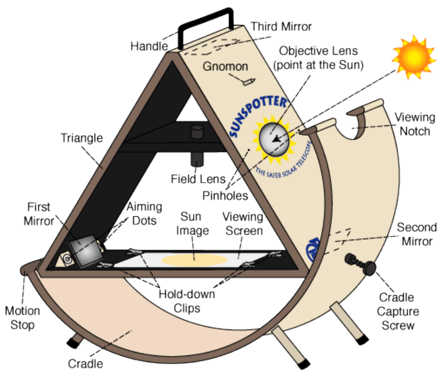
- Coronado™ telescope
- sunspotter™ scope
- A regular scope with a sun filter on the aperture. Eyepiece sun filters are still in circulation, but these are not considered to be reliable or safe, and should not be used under any circumstances.
- A regular scope set-up to project an image
- A pair of binoculars set-up to project an image
- Solarscope™

Coronado™ Telescope

The most exciting, meaningful and safe way to observe the sun is by using a Coronado™ sun telescope, an image of which is shown below. Perhaps your board can purchase one and lend it out to schools as required. The approximate cost is $600, and it's well worth it when your students see flares, sunspots and other details in real time for the first time. More details can be found at www.coronadofilters.com .

[36] CE: Grade 9, Science, Academic and Applied, Inquiry and Communication, 2.4, gather and record data

The Sunspotter™



The Sunspotter™ can be used for: viewing the sun; eclipses; daily record keeping; tracking sunspots as they appear, move, and vanish. Useful for group viewing, the Sunspotter™ allows several observers to simultaneously see the sun's disk and quickly trace the changing positions of sunspots on a piece of paper. Safety is another major advantage of this device, and one can be purchased for about $335.

For more details, go to http://www.starlab.com/ltiprod.html

Regular Scope with sun Filter

You can use a regular scope with a sun filter attached to the aperture. Be sure that the filter is in good shape and safe to use. Phone any local astronomy shop to confirm that if you are unsure.

Regular Scope and Binocular Projection

You can use a telescope or pair of binoculars to project an image of the sun. All of the details about this method can be found at

http://161.58.115.79/education/publications/tnl/05/stars2.html

Alternatively, you can find this article by searching in the Astronomical Society of the Pacific website http://www.astrosociety.org/index.html with these search terms: Percy + guided +tour.

Solarscope™

The Solarscope™ works by projection and is great for studying sunspots, solar eclipses and the transits of Venus and Mercury. You can achieve stunning sun observations with a high degree of accuracy. The Solarscope™ is user friendly - very simple to align, allows easy observation, is robust and gives a high performance. This standard model of the Solarscope™ is designed to be used by one or two persons.

For more details, go to http://scientificsonline.com/product.asp?pn=3036425&bhcd2=1211937464

Annex E Resources

Skyways Astronomy Handbook for Teachers

Of all the activity and resource books that I have reviewed, this text is by far the best one. It has numerous activities that are very well explained, sorted by elementary, middle and high school levels. It is produced and sold by the Royal Astronomical Society of Canada. The cost is $19.95 plus taxes—you can't go wrong!

You can order this in several ways:

- www.store.rasc.ca
- by phoning 416-924-7973
- by sending a fax request to 924-2911

http://solarscience.msfc.nasa.gov/index.html

The NASA/Marshall Space Flight Centre website has a wealth of information on the sun.

http://sidc.oma.be/sunspot-data/

Detailed information on sunspot activity can be retrieved here.

http://sohowww.nascom.nasa.gov/home.html

This site is dedicated to the Solar and Heliospheric Obsservatory (SOHO) satellite and all of the data and images that it has collected. Amazing images and video can be found here.

http://www.cascaeducation.ca/files/index.html

The CASA education website has a wide range of resources for grade 6-9 teachers, from a Canadian perspective.