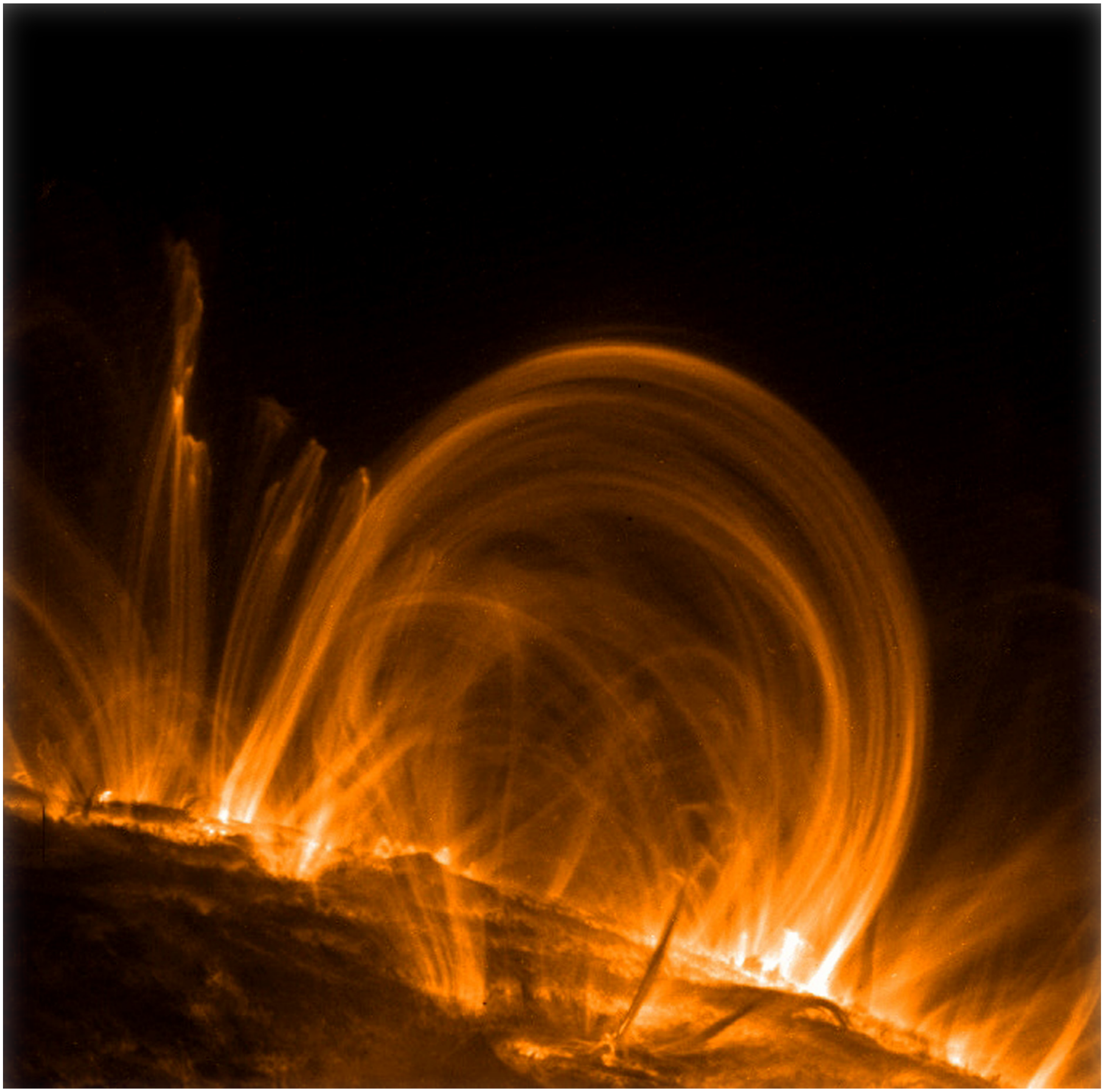
Our Very Own Star



by Toshi Komatsu, Alan Gould,
Amelia Marshall, and Deborah Scherrer

Cover photograph of solar flare on the Sun courtesy of NASA TRACE satellite.

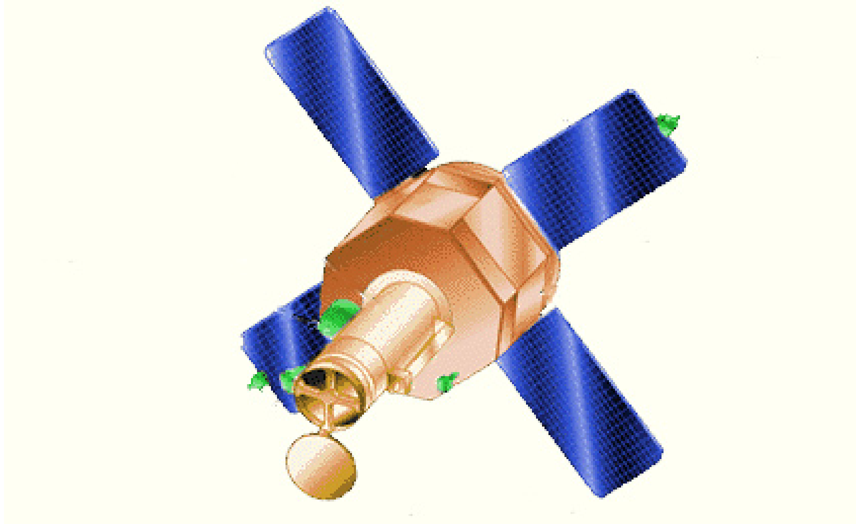


Photo courtesy of NASA

The Transition Region and Coronal Explorer (TRACE) satellite observes the Sun from space. Launched in April, 1998, TRACE enables solar physicists to study the connections between fine-scale magnetic fields and the associated plasma structures on the Sun's photosphere, corona, and the transition region in between.

The TRACE mission addresses questions such as: What is the 3-dimensional structure of the Sun's atmosphere? How does it change in response to changes in the photosphere surface. For more information about TRACE, see http://trace.lmsal.com/.

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Contents

Introduction

This program encourages students to view the Sun in a variety of ways. It has a symmetry starting out with direct Earth-based observation, then with observations through telescopes and spacecraft instruments, and finally back to Earth-based views again. This is also the first PASS program to have an extensive audio narration version of the script. Although we still strongly encourage live presentation of the entire program, with audience activities, we realize that some planetariums like to have pre-recorded programs and a number of facilities prefer to have hybrid shows: part pre-recorded and part live. For this reason, we have made the program as modular as possible, each section of the program having a recorded narration with visuals, so that your planetarium can create a custom program from the some or all of the different modules. We give here a brief overview of the sections of the show (modules).

Introduction to Our Very Own Star

The program starts with beautiful views of the optical effects of sunlight in Earth's atmosphere (rainbows, halos, sun dogs). There is no explanation for cause of these phenomena given, only the names. In the reference section, To Learn More About the Sun, there are resources given that have more about sunlight-atmosphere effects and their causes. For the program, these images are simply an artful, visually pleasing way to "get in the mood" for a show about the Sun.

The Sun as a Time Keeper

This section focuses on views of the Sun for Earth, without instruments, and how the apparent paths of movement of the Sun change from season to season. Activity: The audience keeps track of where along the eastern horizon it rises, how high it gets in the sky at noon, and where along the western horizon it sets at different times of year. We realize that there are other PASS planetarium programs that have a similar audience activity, but this one is different in that it entails a very fast time machine effect to see movements rapidly. Also, the audience measures how high the Sun gets at noon, which is not done in any other PASS program. The section concludes with a diagram that summarizes the findings, showing a winter path with sunrise in southeast, a "low noon" position, and sunset in southwest; a summer path with sunrise in northeast, a "high noon" position, and sunset in northwest; and an equinox path midway between the summer and winter paths.

Different Views of the Sun

In this section, we jump from sketches of the Sun by Galileo to the view of the Sun from from the vicinity of Pluto—an artist's conception from the New Horizons mission and an actual image from Voyager. The audience then sees spectacular TRACE and SOHO spacecraft images of the Sun.

Objectives

In this planetarium program, students will be able to:

1. **Describe how the Sun's daily movement changes from season to season.**
2. **Explain how sunspot observations can show us how fast the Sun rotates and that the Sun is not a solid body.**
3. **Describe the differences between the structure of the magnetic field of the Earth and that of the Sun.**
4. **Explain that features we see in spacecraft images of the Sun are related to magnetic fields.**

Sunspots

The audience sees sunspots and learns that the numbers of sunspots can vary in cyclical patterns.

Differential Rotation

Activity: Students use time-lapse movie sequences of magnetogram images of the Sun to measure its rotation rate. By tracking sunspot clusters at different latitudes on the Sun and noticing that the rotation rates are not all the same, students can conclude that the Sun is not a solid body, but giant spinning ball of gas.

A Magnetic Earth Around a Magnetic Sun

Students either watch and/or use models of Earth and Sun with magnets embedded to create magnetic fields. Magnets in the Sun models are arranged in sunspot pairs. Students see how the Earth's magnetism affects space around Earth using (a) a simple magnetic field detector consisting of a specially-bent piece of paper clip loosely fastened to the eraser end of a pencil with a push pin, and (b) tiny washers that act as magnetic field indicators. They see the difference between the structure of the magnetic field around the Earth (magnetic dipole) and the magnetic field of the Sun (loops associated with sunspot clusters).

Conclusion

The program concludes with some discussion of solar storms, coronal mass ejections (CMEs), and then a return to Earth views of sunlight-atmosphere phenomena.

Customizing "Our Very Own Star"

Depending on demands of school districts in your area, state science education standards, and target age/grade audience, you can select a subset of show sections to create a custom show. Also, if you have a larger size planetarium (more than a 30-foot(10m) dome), you may elect to either not do the hands-on activity about magnetic fields, or do it as a pre- or post-activity in classroom space if that is available in proximity to the planetarium. In either case, you can still use the narrated video for the section that illustrates the field models.

Materials

1. **Our Very Own Star (OVOS) DVD with recorded narration or unnarrated modules, as needed**

   For each show segment, there are two versions: one with recorded narration and one without narration (with music only), for those doing the show with a live presenter. We strongly encourage you to present this show live and with audience participation, using the 3 activities (*The Sun as a Time Keeper*, *Differential Rotation*, and *A Magnetic Earth and Magnetic Sun*). It is also possible to use recorded narration sections on the OVOS DVD for certain parts of a customized show. Due to the need to time speaking to fit the diurnal rate of the Sun, as well as the advantage of asking questions live, the first activity (*The Sun as a Time Keeper*) is nearly impossible to do in recorded fashion, so even if you elect to have most of the show in recorded mode, *The Sun as a Time Keeper* activity should be done as a live segment.

   a. For live shows, you can assemble the still images, QuickTime movies, and/or music in a Powerpoint presentation or other presentation software that your facility uses. Another way is to use the DVD with no sound or with music only (have a live presenter), and select scenes as needed or pause it as needed, for live presentation. A live presenter would likely need to manually control the music sound track. In the first activity, "The Sun as a Time Keeper", the only visuals needed are stars and a moving Sun, so that is no problem in live presentation.

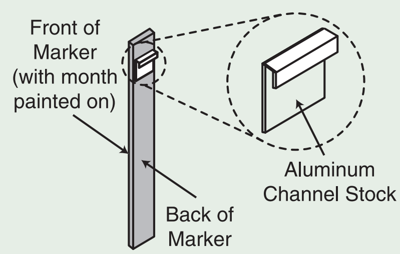
   b. For "all-recorded" or hybrid "recorded-and-live" shows, you can mix and match which sections you want to include, or which sections will be recorded and which will be live. An opening unnarrated *Atmospheric Phenomena* segment is optional—designed for showing as people enter the planetarium, when this show is given as a public show. In this mode, you may want to create a "looped" version with the QuickTime file that can run indefinitely until you're ready to start the program.

2. **Horizon markers**

   You'll need 8 horizon markers. The presenter and/or students need to mark sunrise and sunset positions along the planetarium horizon. Two to six volunteers can be called on to go to the horizon and mark sunrise or sunset, as needed. In very large planetariums, an azimuth projector, as described below, allows the audience to note rise and set positions by azimuth numbers. Two versions of horizon markers are show on this page

Horizon Markers
Version A: A marker to hang from the cove

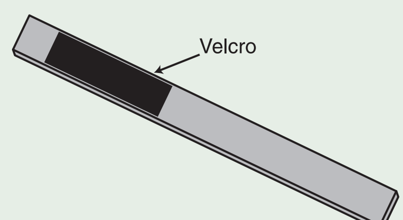
The marker can be a wood, cardboard, reflective metal, or plastic strip, about 5 centimeters wide and 40 centimeters or more tall, depending on the height of the cove. Fasten a hook on the back so that the marker can be hung on the cove to mark a position on the horizon. The markers should be numbered 1 through 6, or better still, labeled with month abbreviations, two each for Jun, Sep, Dec, Mar. The markers could also be attached by having small pieces of Velcro® attached to the back, and a band of the mating material all around the dome at the horizon. In a STARLAB, it's best to attach the "hook" component of the Velcro® on the markers, and the "loop" or fuzzy part on the dome. See Fig. 1.



Horizon Marker Design 1

Version B: Post-Its™

This is a fast, cheap alternative to a prepared marker, if your horizon is within reach by hand. Your nearest stationery store will have rectangles in various sizes (3M Post-it® notes). Get the largest size. Label them as in version I markers.



Horizon Marker Design 2

Fig. 1. Horizon Marker Design 1 and Design 2

3. Flagpole projector

You need a “Flagpole Projector” that can be used to mark how high the Sun gets in the sky at noon in the different seasons. There are many ways to do this, the easiest being using a graphic in a digital planetarium projection system. The file " flagpole.gif" in the "OurVeryOwnStar" folder of the Interact PASS Classic DVD can be used for this purpose.

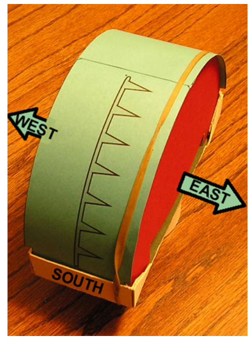


Fig. 2. Cylinder for flagpole projector

Another method that works is a form of “brute force” projectors consisting of a cylinder with light bulb inside and a mask with the desired pattern of clear area to let light through to make the pattern on the dome. If you already have a meridian projector, with numbers marking altitude angle extending from the southern horizon to the zenith, then you’re all set—the altitude measuring scheme need not necessarily resemble a flagpole. If you need to make a projector, your cylinder can be an ice cream container, large coffee can, large oatmeal drum, one-gallon plastic jug, or nearly any other kind of opaque cylinder. It is positioned with the axis horizontal, pointing in an East-West direction. A slot is cut in the cylinder such that when a light bulb is mounting inside the cylinder, a band of light comes out and projects a band along the planetarium meridian, extending a quarter circle from southern horizon to zenith (Fig. 2).

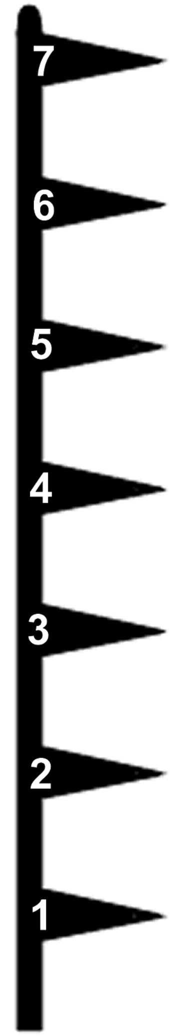
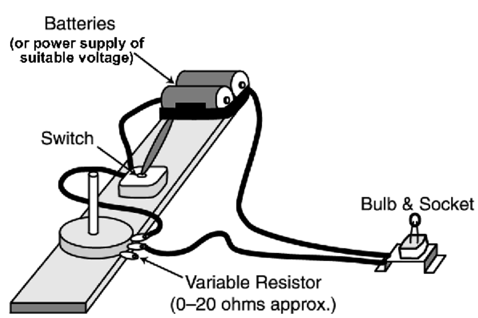


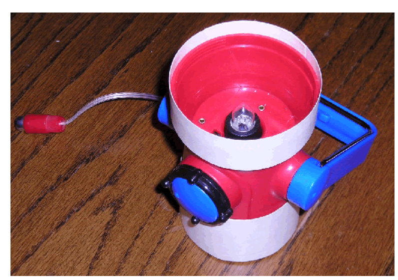
Fig. 3. Mask for flagpole projector

Make a mask that has the outline of a flagpole with 7 to 9 triangular flags evenly-spaced and marked with numbers. You can add various color gels to give each flag a color also, but if you do, use extremely light gels to keep the flagpole image as bright as possible. A mask is shown in Fig. 3. You can enlarge or reduce, as needed, and invert the image to make a transparency (white pole and flags with black numbers). It’s good to cut a mask from heavy card stock to get the maximum light blockage, but a transparency, in addition, is a convenient way to do the numbers. Stacking two copies of the transparencies can give darker background.

For a light source inside the cylinder, you need a light bulb with a very small filament, e.g. a #605 light bulb (6V), a Mini Maglite® flashlight bulb (3V), a STARLAB main star bulb, or other suitable lamp (Fig. 4). Part of your decision will be if you’d like your power source to be a wall plug or batteries. For a wall plug, you’ll need a transformer or power supply to give the right voltage for your bulb. If you supply power with batteries, you need to decide if you want rechargeable batteries or “throw-away” batteries. You may opt to use a variable resistor to make the brightness adjustable. Mounting the bulb requires a suitable socket. It’s also possible to mount a flashlight in the cylinder, or mount the cylinder on top of a flashlight with some type of stand. In any sort of flashlight arrangement, the reflector must be removed, painted black, or covered by black paper or cloth.

Once the projector is ready, it must be mounted so that it projects the “flagpole” extending from due south on the horizon upwards toward the zenith. It must extend high enough to reach the highest point of the Sun in the sky at noon (summer solstice).





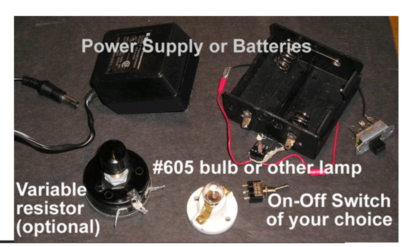


Fig. 4. Possible light sources for flagpole projector

4. **Azimuth scale projector(s)**

For observing and marking where the Sun rises and sets, you need azimuth scale projector(s). Usually, it's best to have two such projectors, one for the eastern horizon and one for the western horizon, so that each can project on half of the dome without the main star projector getting in the way. The scales can be marked in degrees, or sections of the horizon can be labeled with letters or numbers. If your planetarium does not already have azimuth projectors, you can make them in a way similar to that described previously for the flagpole projector. The main differences are:

a. the cylinder axis is mounted vertically (Fig. 5).

b. the scale is different (Fig. 6). As with the flagpole projector mask, you can invert the graphic on this page and resize it as needed.

c. you can cut the cylinder into half along the axis to create the two projectors.

Once the azimuth projectors are built, they must be mounted so that the East and West marks project to the horizon points due east and due west respectively.

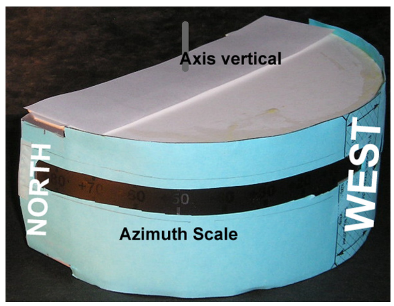
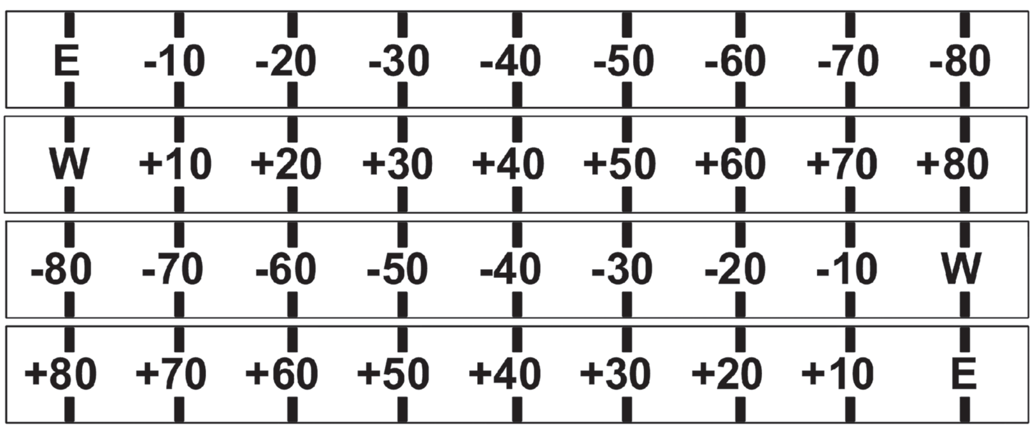
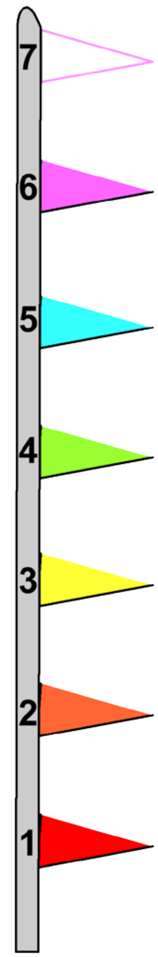


Fig. 5. Azimuth projector

Fig. 6. Azimuth Scale



Color version of flagpole



5. **Fast Sun projector**

If your planetarium Sun can move pretty fast, traversing the sky in under 30 sec, then you can forgo the need to make a "fast Sun projector." STARLABs and other manually-operated Suns fall into this category, as do many newer planetarium systems. However, if you have an older system, where the top speed of the Sun is too slow for the "The Sun as a Time Keeper" activity in this show, here is how to make a simple, hand-powered Sun projector:

Parts

For light source: LED flashlight with single bright LED—White or Yellow (Google "1 LED flashlight white" or '+flashlight +LED +"Great Neck"')

For lens assembly:

- lens, plastic, about 50 to 90 mm focal length works well, with diameter equal to or less than the diameter of the head of the LED flashlight.
- cardstock—about 4 cm x 24 cm (1-3/4" x 9.5")—can be file folder material—black looks nice.
- cardboard—about 4 cm x 24 cm (2" x 1")

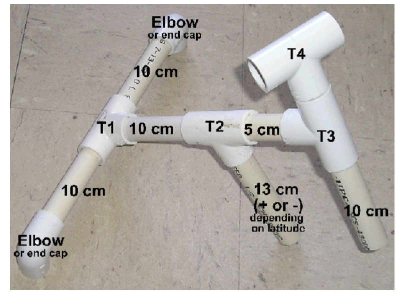


Fig 7. Equatorial tripod stand made of PVC

For PVC stand (Fig. 7):

- 1/2" dia. PVC tubing:

  1 piece about 13 cm long (actual length must be altered to increase or decrease the angle of the polar axis, depending on home latitude of your planetarium—shorter piece for lower latitudes, longer piece for higher latitudes.)

  3 pieces, 10 cm long

  1 piece, 5 cm long

  1 piece, 2 cm long
- PVC fittings

  3 Ts for 1/2" tubing

  1 T - 1" x 1" x 1/2" (Fig. 7)

  1 - 45° elbow for 1/2" tubing

  2 end caps or elbows for 1/2" tubing

Tools

- scissors
- hole punch
- drill and 1/16" drill bit
- PVC tubing cutter or mini hack saw

* For other ideas about materials for this program, see the PASS website under updates for Our Very Own Star http://www.lawrencehallofscience.org/pass.

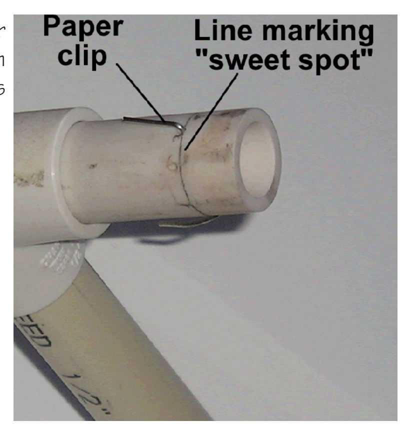
Assemble the tripod stand

1. Assemble the PVC parts to make a "equatorial tripod" as shown in Fig. 7.
2. At the top of the polar axis tube, add a paper clip to make the polar axis bearing work freely and smoothly. Slide T #3 onto the polar axis and gently lower it until you find the "sweet spot" where it is both snug and rotates freely. Mark the sweet spot with a pencil line. Then either:

   a. Drill 1/16" holes by the pencil mark, on both sides of the tube, and insert paper clip so that T #3 is prevented from going lower than the "sweet spot," (Fig. 8) or;

   b. wrap a paper clip around the tube at the bottom edge of the pencil mark, and wrap tape below that to prevent the clip from sliding down the tube (Fig. 9).

Fig. 8. Polar axis paper clip inserted through drilled holes



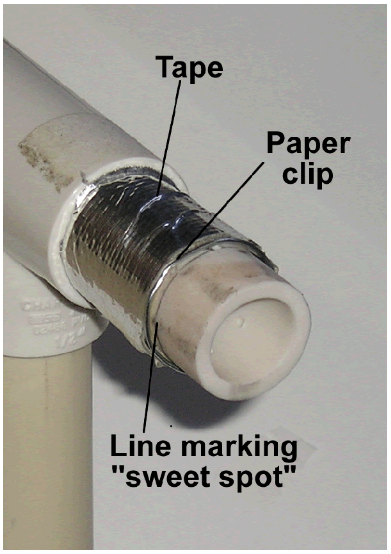


Fig. 9. Polar axis paper clip wrapped and held in place with tape

LED Flashlight Sun

3. Neutralize the reflector of the flashlight light source by removing it, painting it black, or covering it with black paper or cloth.
4. Place mask 1 over the head of the flashlight. It has a small hole (about 1 mm dia. or so) that forms the object on which the lens focuses. Make the mask by putting the head of the flashlight down on a piece of cardstock and drawing a circle the size of the outer edge of the flashlight head. Then ,cut out the circle with scissors. Locate the center of the disk and make a hole through the center with a push pin. Enlarge the hole slightly with a sharp pencil tip. Then, tape the disk over the head of the flashlight.
5. Mask 2 is a baffle that limits stray light. It can be the same diameter as mask 1 and have a hole in the center about about 1/4" diameter (the size made by a standard hole punch). If your lens diameter is much smaller than the head of the flashlight, you can tape the lens right onto mask 2 so that it will fit with the tubes described in the next step.
6. There are 3 cardstock tubes: the inner tube should be a strip that is rolled right around the head of the flashlight so that it forms a cylinder that can slide and be the focusing mechanism. Make the length of this cylinder a centimeter or two longer than the focal length of the lens. The lens cell piece is also wrapped around the head of the flashlight so it has the same outer diameter as the inner tube. The lens cell keeps the lens from sliding out of the top end of the outer tube. The outer tube is wrapped around the inner tube and need only be long enough to securely hold together the lens, mask 2, the lens, and the inner tube. Assemble them as shown in Figs. 10 and 11.

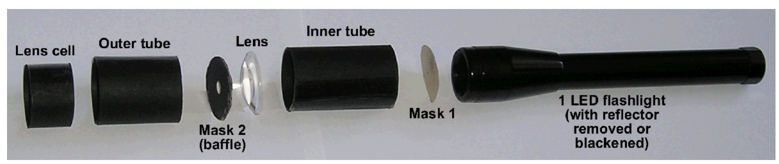


Fig. 10. Exploded view of LED flashlight sun with lens, tubes, and masks

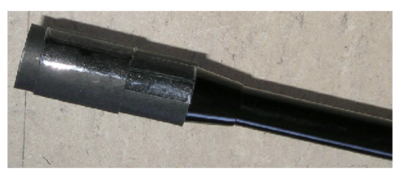


Fig. 11. LED flashlight with lens, tubes, and masks assembled

7. Secure the LED flashlight in PVC "T4" using an appropriate length of cardboard to serve as a spacer, wrapped around the handle of the flashlight such that it fits snugly in the PVC "T" (Fig. 12).
8. Place the fully-assembled "Fast Sun" projector on a surface in the planetarium, such that the polar axis points to the home position of your North Star. Attach the base to the surface with Velcro® or tape, or mount the stand on a heavy board that won't move as you operate the Fast Sun. Focus the image of the Sun on the dome by sliding the inner tube back and forth on the head of the flashlight.

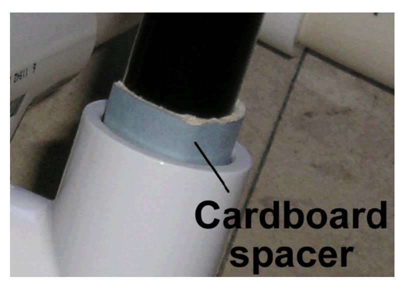


Fig. 12. Fitting the LED flashlight into "T4" with a cardboard spacer piece

Once a focused Sun is achieved, tape the inner tube to the flashlight. To operate the Fast Sun, simply move it by hand smoothly in such a way that the Sun moves from the eastern horizon to the western horizon (Figs 13 and 14). Put a reference mark on T3, and three marks on T4, to quickly move the Sun between seasons (Fig. 14)—the S, E, and W on T4 stand for "Summer solstice," "Equinoxes," and "Winter solstice" respectively (not south, east, and west).

6. **For magnetic fields activity: magnetic Earth and magnetic Sun models, with field bits and field detectors**

   Each group of two to four students needs a kit of painted models of the Sun and Earth with magnets glued on, as well as a small container of "field bits" consisting of the smallest size small metal washers available. In the activity, students use the washer field bits to form loops and trace the real magnetic fields of the magnets. Anything larger than #6 washers do not work well. The magnets must be very strong: preferably neodymium (rare earth). In addition to the "field bits," each kit should have a "paper clip field detector" (Fig. 16) that can be moved around near Sun and Earth models and show direction of magnetic field at different locations.

   - 1 Sun ball (about 4" polystyrene; for source, Google "polystyrene ball"). Optional: paint these yellow with acrylic paint. Otherwise, plain white balls are just fine.
   - 1 Earth (about 1" polystyrene; for source, Google "polystyrene ball"). Paint these with blue and green acrylic splotches, to resemble Earth.
   - 8 neodymium magnets (6 for Sun, 2 for Earth). Magnets should be embedded into the balls *before* painting. Drill or gouge holes into the polystyrene so that the magnets will fit in the holes and be approximately smooth with the surface of the ball. In the Earth balls, put a magnet at each pole making sure they are oriented so that, together, they act as a dipole with north magnetic pole coming out the north pole of Earth and the south magnetic pole coming out the south pole of Earth (Fig. 15). For the Sun, pairs of magnets should be arranged in 3 separate areas of the Sun, with two to five centimeters spacing between the magnets in each pair (Fig. 16). Do some experiments with your first Sun to see which spacing between magnets works the best.
   - about 200 #6 split lock washers in a plastic cup or container with lid.
   - 1 plastic plate or tray to hold everything and to catch stray washers.
   - 1 pencil, 1 paper clip, and 1 pushpin, made into a "paper clip field detector." Bend the paper clip into the shape shown in Fig. 17, and attach it loosely to the eraser head of a pencil with a push pin, so that the paper clip can swivel freely. You will need small long-nose pliers to shape the paper clip easily, and a diagonal or wire cutter to cut the paper clip short, so that the finished paper clip part is only about 2–3 cm long.

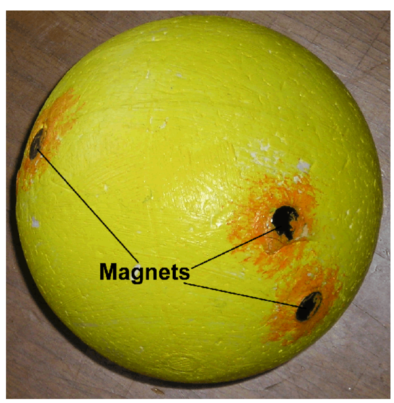


Fig. 16. Sun with magnets embedded and looking like sunspot pairs (one pair and half of another pair). If painted, you can embellish the sunspot clusters a bit

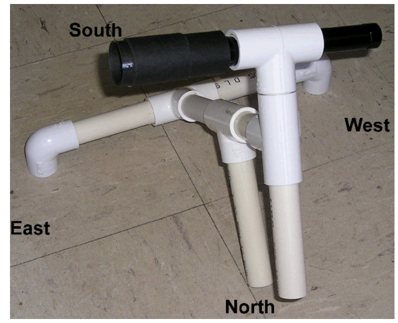


Fig 13. Fast Sun projector position when Sun image is on eastern horizon

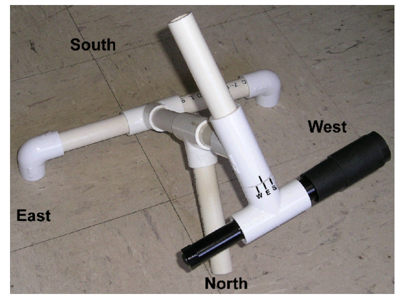


Fig. 14. Fast Sun projector position when Sun image is on western horizon


Fig. 15. Painted Earth showing one (of 2) magnets embedded at the poles

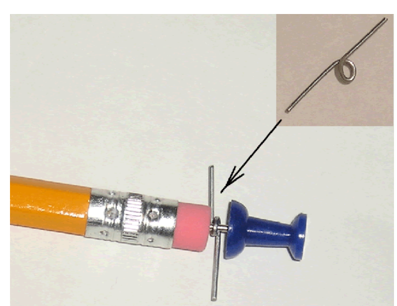


Fig. 17. Field detector is made of a paper clip, pencil, and pushpin

7. **List of images and movies**

Images	Credits
1. Sunlight-Air Phenomena*	see below
2. Sun paths at different seasons	LHS-Alan Gould
3. Seasonal orbit	LHS-Alan Gould
4. Galileo sketch	First Edition of *Galileo Galilei's Istoria e Dimostrazioni Intorno Alle Macchie Solari e Loro Accidenti Rome (History and Demonstrations Concerning Sunspots and their Properties)* published 1613
5. Pluto Encounter Panoramic View	Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute (JHUAPL/SwRI)
6. Voyager's view of the solar system (labeled)	LHS-Toshi Komatsu
7. Satellite imagery of the Sun (V)	NASA, LMATC, and Stanford
8. Great Sunspot of 1947	Carnegie Institution of Washington
9. Sunspot on Sun	NSO/AURA/NSF
10. Sunspot alone in space	LHS, NSO/AURA/NSF
11. Sun at Max and at Min	SOHO (ESA & NASA)
12. Intensitygram of Sun	SOHO (ESA & NASA)
13. Magnetogram of Sun	SOHO (ESA & NASA)
14. Magnetogram 1999 (V)	SOHO (ESA & NASA)
15. Counting Magnetogram 1 (V)	SOHO (ESA & NASA)
16. Magnetogram 2005 (V)	SOHO (ESA & NASA)
17. Counting Magnetogram 2 (V)	SOHO (ESA & NASA)
18. Rotating Sun in visible light: Ic.2001.mpg (V)	SOHO (ESA & NASA)
19. Magnetic field of the Earth, field detection (V)	LHS
20. The Wandering Magnetic North Pole	NASA-IMAGE Education and Public Outreach - Sten Odenwald
21. Modeling the magnetic field of the Earth (V)	LHS
22. Magnetic field of a sunspot, and CME creation (V)	NASA/Goddard Space Flight Center Conceptual Image Lab
23. Modeling the magnetic field of the Earth 2 (short); cme; aurora	LHS; NASA
24. "Magnetic field of the Sun, field detection (V)"	LHS
25. Modeling the magnetic field of the Sun (V)	LHS
26. Modeling the magnetic field of the Sun 2; rotating fields on Sun; TRACE	LHS; SOHO (ESA & NASA)
27. Prominence	SOHO (ESA & NASA)
28. "The Sun: A large erupting and twisting prominence, EIT 304A."	SOHO (ESA & NASA)
29. SOHO and/or TRACE imagery (V)	SOHO (ESA & NASA)

* Sunlight-Air Phenomena (12 still images)

A. Coronae............................... Photo courtesy & copyright Michael Ellestad
B. Crepuscular rays .... Photo courtesy & copyright Lauri A. Kangas
C. Dogs & Pillars..................... "Photo courtesy & copyright Don Brown / Utah Skies / www.utahskies.org"
D. Glories .... "Photo courtesy & copyright Nik Szymanek"
E. Mountain Shadows............. Photo courtesy & copyright Nik Szymanek
F. Rainbows .... Photo courtesy & copyright Anthony Arrigo / Utah Skies / www.UtahSkies.org
G. Sunsets................................ Photo courtesy & copyright Lauri A. Kangas
H. Coronae............................... Photo courtesy & copyright Randolph Wang
I. Crepuscular rays .... Photo courtesy & copyright Lauri A. Kangas
J. Glories .... "Photo courtesy & copyright Franz Kerschbaum, Vienna"
K. Mountain Shadows............. Photo courtesy & copyright Dale Ireland / www.drale.com
L. Rainbows .... Photo courtesy & copyright Jan Curtis
M. Diffraction Rings.....................Photo courtesy Steve Becker

About Image File Names

The latest edition of PASS (Interact PASS Classic) is sold entirely electronically with all images/media included. The image file names are numbered to correspond with the narration script in this document. If there is an alternate image available, "alt" is inserted in the file name.

Setup

1. Stars set to show a summer sky.
2. Sun positioned before sunrise on June 21.
3. Cardinal Direction markers on.
4. Horizon markers ready.
5. Azimuth (horizon) projector set.
6. Meridian/flagpole projector set.
7. Cue images.
8. Earth & Sun models, field detectors, & field bits ready.
9. Solar phenomena video running.
10. Optional: "Where Does the Sun Go?" Sheets

Recommendations for Using the Script

We don't expect the script which follows to be memorized (as an actor might memorize a part) but to be used as a guide in learning, rehearsing, and improving presentations. We recommend that you read the script once or twice, then work with it in the planetarium, practicing the projector controls, slides, special effects, and music. You should be able to imagine yourself presenting information, asking questions, and responding to participants. For your first few presentations, you can have the script on hand, using major headings as reminders of what to do next.

The script is organized in blocks or sections. The purpose of these separations is only to help you learn and remember what comes next. Once you have begun a section, the slides or special effects and your own train of thought will keep you on track. When beginning a new section, make the transition logically and smoothly.

Directions for the instructor are printed in *italics* in the side column, the instructor's narrative is printed in regular type, and directions and questions to which the audience is expected to respond are printed in ***bold italics***. There is no point in memorizing narration word-for-word since what you need to say will depend upon the participants. The language you use and the number and kinds of questions you ask will depend on how old the participants are, how willing they are to respond, and how easily they seem to understand what is going on.

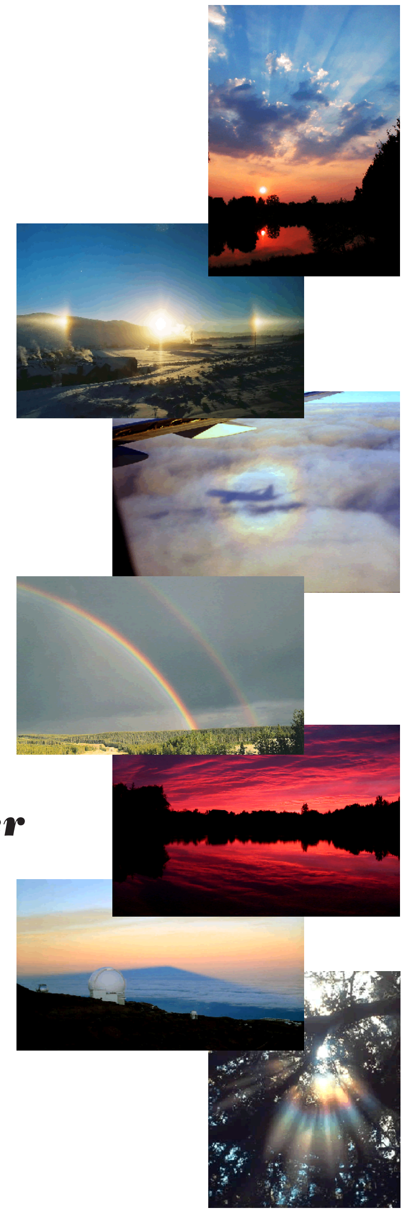
We believe that the most important elements of the program are the questions and the activities since these involve the audience in active learning. If you must shorten your presentation, we recommend that you borrow time from the narration.

Planetarium Show Script
Our Very Own Star

Introduction to Our Very Own Star

Cove lights down.

Image1 (Video): Solar Phenomena. ►



Do you know the name of the closest star to the Earth? [It's the Sun, of course!]

This show is called "Our Very Own Star" because many people forget our Sun is a star, just like the thousands we see in the night sky.

Coronas, rays, halos, glories, rainbows, sun pillars, and sun dogs are all beautiful phenomena, fleeting and rare. People wonder about what causes them. Some, like rainbows, are quite familiar to us. Others like glories and sun dogs are more mysterious.

Yet they all have a single source—the Sun! Sunlight interacts with the atmosphere, clouds, and moisture in the air to make these gorgeous displays. A dance of geometry and physics, these phenomena are now well understood, but their source—the Sun—still holds many mysteries.

The Sun has been many things to many people throughout history—a god, a demon, a giver of life. It is the energy source for nearly all life on our planet. The Sun gives light and warmth for plants and animals, but too much Sun can be deadly. Bursts of solar energy can cripple our electrical grids and interfere with radio, TV, and cell phones. So what else do we know about the Sun? Join us as we look to explore . . . our very own star!

The Sun as a Timekeeper

People have observed the Sun for thousands of years—they had to observe the Sun as a matter of survival.

Why would that be? [Before we had nice wall calendars, the Sun helped keep track of the seasons, and critical times for planting crops.]

Let's watch the Sun as our most ancient ancestors did. Here we are, waiting for sunrise. I have set the planetarium sky to June 21.

Do you know anything significant about that date? [This is the date of the summer solstice—the longest day of the year.]

Let's watch and see where the Sun rises.

Sun rises above the eastern horizon.
Pause Sun just after rising.

Take a look where the Sun rose, and let's all remember that position in the northeast.

Mark horizon position of sunrise.

Now, where do you think the Sun is going to set?

Activate Horizon projector.

Think about that as we let the Sun rise, and see if your neighbor agrees with you. Now, let's see where the Sun sets.

Run Sun's motion; pause before crossing the meridian.

The Sun first rises higher and higher, but eventually it reaches the highest point it is going to reach in the sky. The Sun reaches this highest point for the day when it crosses an imaginary North-South line called the meridian.

Optional

The presenter may choose to distribute the "Where Does the Sun Go?" tracking sheet at this point.

Many will probably predict sunset at the diametrically opposite point, or predict due west.

Activate the meridian projector, and pause Sun's motion when the Sun crosses the meridian.

Optional

Make a mark on your sheet at the appropriate place on the flagpole, and label it "June"

Here we have our planetarium meridian [or flag pole, if used]. Let's take note where the Sun is along the meridian.

All right—let's let the Sun continue across the sky.

Switch off meridian projector, and continue motion until sunset.

Where did the Sun actually set? [We can see that it set to the north of west.] Is that where you predicted it would set? [Maybe some of you thought it would set due west or maybe in the southwest. (Take any answers.)]

Optional

Mark on your sheet where the Sun set, and label that "June".

For now, note that the Sun actually set in the northwest.

Mark horizon position of sunset. Fade daylight off, and fade stars on with diurnal motion.

So, here we see the stars of the midsummer's night.

Can anyone find the seven bright stars of the Big Dipper? [Take any answers.]

Scorpius is a famous summertime constellation that should be visible too. Or, maybe someone can find the Summer Triangle—three bright stars making up a large triangle easily visible in the summer.

Invite the audience to point out the Big Dipper, and any other familiar constellations/asterisms. Con-

tinue to run diurnal motion until more of an autumn sky is showing. Then fade stars off and fade daylight on. Be ready to show the next sunrise.

And here we are back at morning.

> ***Now, what if we were to change the date by a few months? Would the Sun rise at the same position along the horizon? [Take any answers.]***

Let's use our planetarium as a time machine now and speed ahead three months into the future, to about September 21.

> ***Do you know something special about that date? [It's the date of the Fall Equinox when day and night are of equal length.]***

Change date to September 21 and note/ mark position of sunrise.

Once again, take a look at where the Sun has risen now on September 21st. [Mark horizon position of sunrise.] Note that the Sun has risen quite a bit further to the South than before—in fact it has risen due east. Where do you suppose the Sun will set? Make a mental prediction, and then check with your neighbor to see what they think.

> ***One more thing: do you think the Sun will cross the meridian at the same level as before? Will it cross higher? Lower? [Take any answers.]***

Let's take a look.

Allow audience to discuss new predictions. Then allow the Sun to reach its zenith and activate meridian projector.

Make a note of the Sun's position on the meridian [mentally, or on their sheets with "September"]—and notice that it is lower in the sky than before.

> ***Does that help you predict where the Sun will set? Does your neighbor agree with you?***

Turn off meridian projector, and run motion until sunset.

> ***Were your predictions correct? [Accept any answers, and have the audience mark their sheets with "September."]***

On September 21st, we see the Sun sets due west.

Mark horizon position of sunset. Fade daylight off, and fade stars on with diurnal motion.

Where is the Big Dipper now? Notice it's in a different part of the sky during this time of year—low towards the horizon. Notice also that Scorpius is gone, but now in the fall we can see new constellations like Andromeda and Pegasus.

Note the position of the Big Dipper and other seasonal constellations.

Continue to run diurnal motion until more of winter sky is showing. Be ready to show the next sunrise.

Now let's change the date one more time. If we skip ahead another three months, we'll be at December 21st.

> ***Does anyone know anything special about this date? [It's the date of the winter solstice, the shortest day of the year.]***

Change to December 21 and note/mark position of sunrise.

Note again where the Sun has risen [mark horizon position of sunrise]—even further south on December 21st.

> ***Now where do you suppose the Sun will cross the meridian? Higher now, or lower? [Take any answers.]***

Allow audience to discuss new predictions. Then allow the Sun to reach its zenith and activate meridian projector.

Make a note of the Sun's position on the meridian [mentally, or on their sheets with "September"]—and notice that it is lower in the sky than before. Now, make one final prediction for where the Sun will set. Does your neighbor agree with you?

Turn off meridian projector, and run motion until sunset.

> ***Were your predictions correct? [Accept any answers, and have the audience mark their sheets with "December."]***

On December 21st, we see the Sun sets further towards the south, in the southwest.

Mark horizon position of sunet. Fade daylight off, and fade stars on with diurnal motion.

Where is the Big Dipper now? Once again, it's in a different part of the sky during this time of year—just above the northern horizon. Notice also that Andromeda and Pegasus are gone, but now in the winter we can see new constellations like Orion and Taurus.

Note the position of the Big Dipper and other seasonal constellations. Stop diurnal motion when you have a good winter sky.

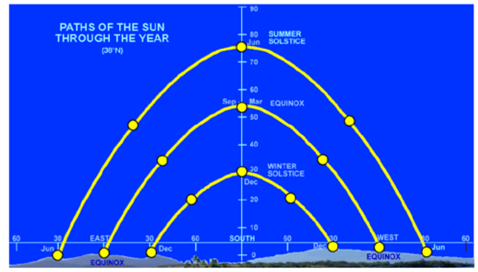
> ***If we were to skip ahead another three months to March 21st, where do you think the Sun would rise? [Further south? (Take any answers.)]***

In fact, after the winter solstice, the Sun starts to rise further north each day.

Now, many of us learn that the Sun rises in the east and sets in the west.

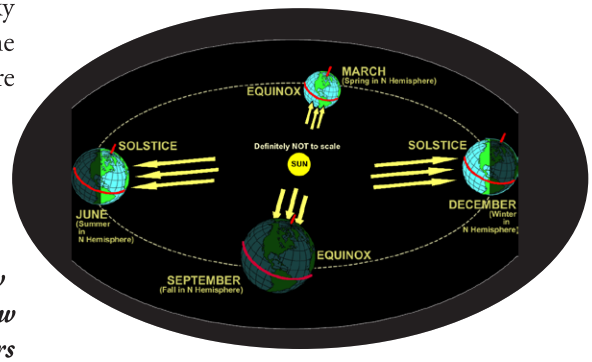
But does the Sun always rise due east and set due west? [No! We have just seen it does not.] In fact, the Sun only does this on two days of the year—can anyone guess when these days are? [The Fall and the Spring equinoxes.]

Image 2: Sun Paths at Different Seasons. ►



What we've observed the Sun doing is summarized in this picture. In the summer, the Sun rises and sets in the north, is higher in the sky at noon, and there are a lot more hours of daylight. In the winter, the Sun rises and sets in the south, is lower in the sky at noon, and there are a lot fewer hours of daylight.

Image 3 (Still): Seasonal Orbit. ►



This picture shows how the sunlight shining on Earth changes through the year. It's definitely not to scale.

Looking at the Northern Hemisphere in June, can you see how more of it is lit? [Point to June Northern Hemisphere.] See how the Sun might be higher in the sky, thus making more hours of daylight?

Parts of northern Alaska get 24 hours of daylight!

Looking at the Northern Hemisphere in December, can you see how less of it is lit? [Point to December Northern Hemisphere.] See how the Sun might be lower in the sky, with fewer hours of daylight?

Parts of northern Alaska get no daylight at all!

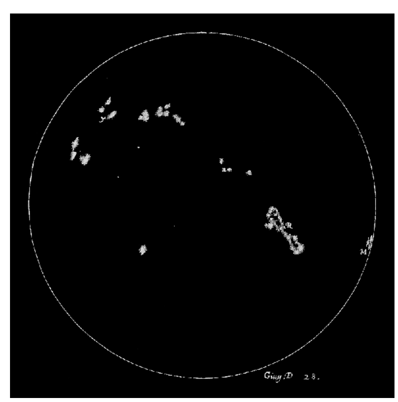
Ancient people kept track of the position of sunrise or sunset to keep track of the time of year. Many ceremonies and festivals were held at solstices and equinoxes.

Can you think of holidays that happen near, say, the winter solstice? [Allow time for responses for different cultures and religions.]

Different Views of the Sun

The Sun follows different paths across the sky, but what does the Sun itself look like?

Image 4 (Still): Galileo Sketch of Sunspots. ►



Long ago, many people assumed that the Sun was a perfect glowing sphere, but when Galileo first looked at the Sun with his telescope (which you should never, ever do without proper protection), he discovered something shocking—spots! The Sun is not perfect after all—it has blemishes on its surface.

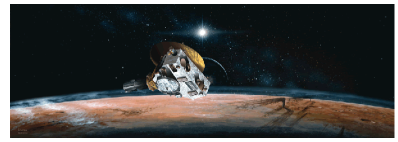


Image 5 (Still): Pluto Encounter Panoramic View. ►

Pluto is almost 40 times further from the Sun than Earth. In this artist conception of the arrival of the New Horizons mission to Pluto, the Sun appears merely as the brightest star in the sky—similar to how bright Venus looks to us in the sky here on Earth.

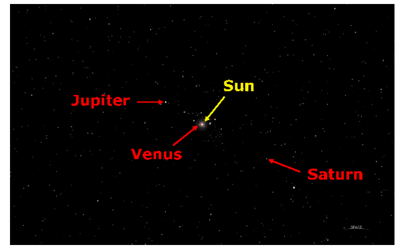


Image 6 (Still): Voyager's View of the Solar System. ►

When the Voyager probes moved beyond the orbit of Pluto, this is what their view of the Sun was. The planets are barely visible, and the Sun looks simply like a brighter version of the many other stars seen here.

All visuals off. Only stars showing.

When we look out into the night sky, we can see the biggest and the brightest of the stars in our galaxy. Most of those we see without telescopes are giant stars and supergiant stars.

> ***How many stars do you think are really Sun-like? [With the naked eye, we can only see 3 or 4 truly Sun-like stars.]***

Stars can be very young or very old, very dim or very bright, and a wide range of colors. Our Sun is a yellow star of average size, and is in the middle of its life cycle.

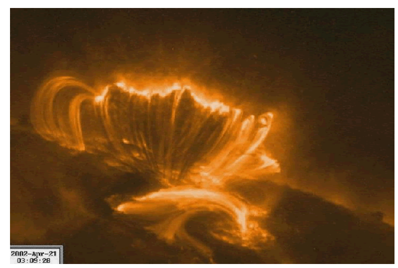


Image 7 (Video): Satellite Imagery of the Sun Montage. ►

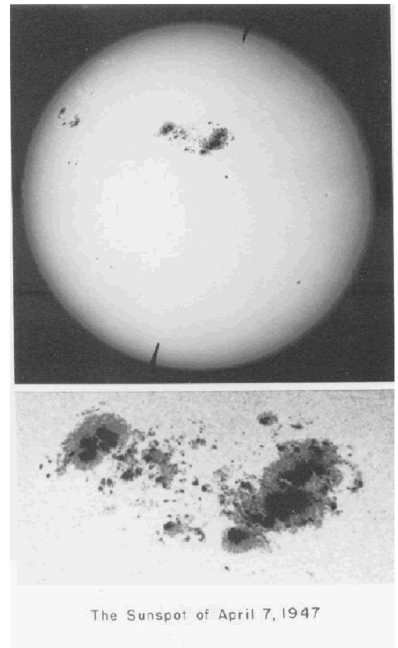
With today's technology, we can get an excellent view of what is happening right on the surface of the Sun. Here are some views of the Sun, close up from various satellites.

Here is a movie from the Transition Region and Coronal Explorer (or, TRACE) satellite, which shows us beautiful images of a series of plasma loops forming, twisting, and breaking right on the surface of the Sun. We also get some views in X-rays, and some in ultraviolet. Some are from the SOHO satellite—the Solar and Heliospheric Observatory—which stares at the Sun 24 hours a day, studying flares and the solar corona, which give rise to the solar wind—a stream of electrically charged particles flowing from the Sun through the Solar System. The Sun goes through an 11-year cycle of high activity and low activity, and we can see a contrasting view here. During a period of high activity we expect to see many more sunspots and bursts of energy from the Sun. These bursts are called flares, and occur when a buildup of magnetic energy is suddenly and violently released—comparable to millions of hydrogen bombs exploding simultaneously. Flares are the most powerful explosions in the Solar System.

Sunspots

The Sun is a constantly changing star. At its surface, it is driven by magnetism. Sunspots are areas of intense magnetic activity—almost like storms—on the Sun. The Sun goes through an 11-year cycle with lots of sunspots at the peak, and hardly any sunspots at the low point of the cycle. Often, sunspots form in pairs, one with a positive-type polarity, and one with a negative-type polarity. They typically last several days, but larger sunspots can last for several weeks.

Image 8 (Still): The Great Sunspot of April 7, 1947 (top photos). ►



The largest one ever recorded was observed in March and April of 1947. It covered an area of about 7 billion square kilometers. About 18 Earths would be able to fit inside of this area. Although most sunspots are not this big, most of them are larger than Earth.

But why are sunspots dark? In reality, sunspots themselves are not dark.

Image 9 (Still): Sunspot on Sun (center). ►

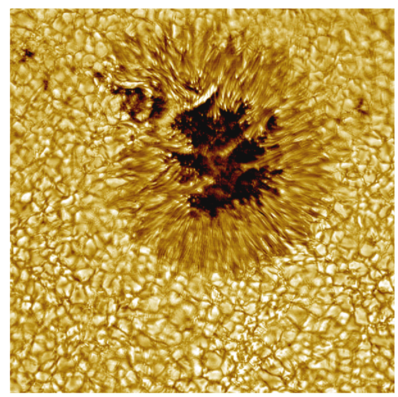
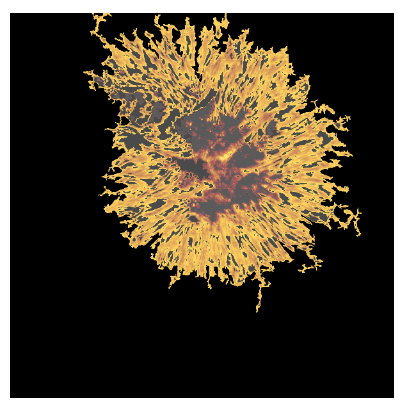
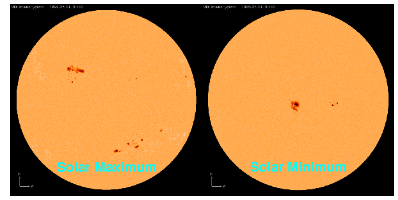


Image 10 (Still): Sunspot “Alone” in Space (bottom photo). ►



If you could somehow strip away a sunspot from the Sun and put it by itself in the sky, you would see it as a bright orange gas—maybe as bright as a full moon. It only appears dark relative to its surroundings. These magnetic storms prevent some heat from the Sun’s core from getting to the surface. So they become cooler and are less bright. Sunspots are about 2000 degrees cooler than the rest of the solar surface which is about 6000 degrees Celsius (11,000 degrees Farenheit).

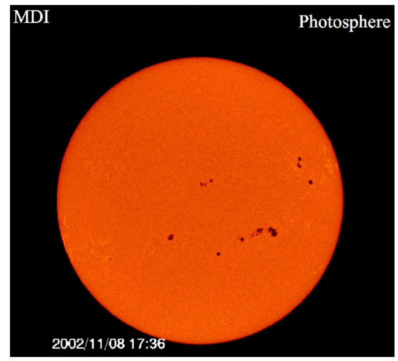
Image 11 (Still): Sun at Max and at Min. ►



The number of sunspots is related to how active the Sun is. When there are more sunspots, there are more flares, more eruptions, and more bursts from the Sun. There is also some evidence that solar activity can have a dramatic effect on the Earth. For example, in the 1600s and 1700s, there was a great reduction in the number of sunspots, which may correlate to unusually cold temperatures on the Earth around the same time.

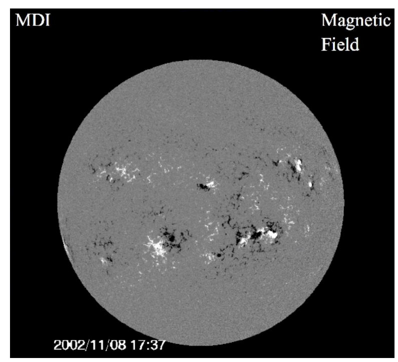
Differential Rotation

Image 12 (Still): Intensitygram of Sun. ►



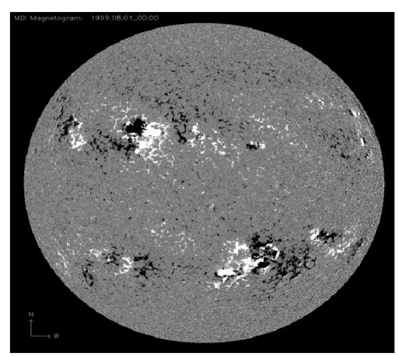
We can learn more from sunspots by looking at images different than the type we see here.

Image 13 (Still): Magnetogram of Sun. ►



This is the same Sun, but this is a magnetogram, showing the Sun's magnetic intensity. You can see the polarity of the sunspots—white for positive and black for negative.

Image 14 (Video): Magnetogram 1999 (Mid-latitude Sunspots). ►



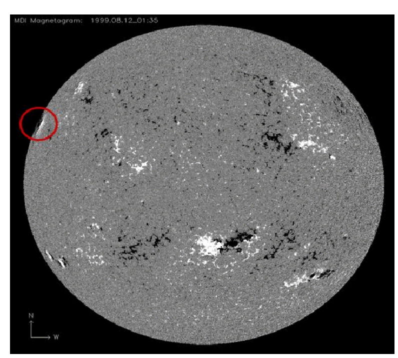
In this movie, each frame shows a single day of magnetogram observation. As you take a look at sunspots, you will notice they seem to move.

> ***Do you see some pattern to how they move? [Take any answers.]***

As you can see, sunspots move in fairly straight lines, all in the same direction. Galileo noticed this too, and he thought that if these spots were on the surface of the Sun, this might mean that Sun rotates on an axis, just like the Earth.

Let's see how long it takes for a sunspot to cross the disc of the Sun. Since we can see half of the Sun's surface as a disc, the time it takes for a sunspot to cross this disc is about half the time it takes the Sun to rotate.

Image 15 (Video): Counting Magnetogram 1 (Mid-latitude Sunspots). ►



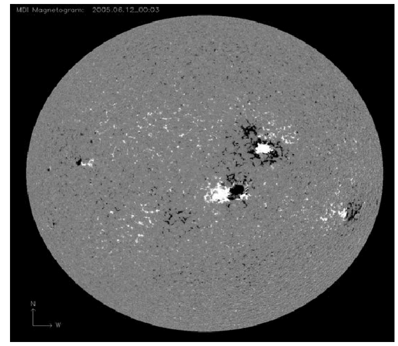
Note: The first frame is to highlight where the sunspot will appear, and should therefore not be counted.

A nice big sunspot is highlighted here. Let’s count how many days it takes to cross the whole disc of the Sun.

Have the audience count the days out loud. You should get 14 days.

According to our calculations here, how fast does the Sun rotate? [14 times two gives us 28 days.] Now let’s see what happens if we look at a second set of magnetograms made a few years after the ones we just saw.

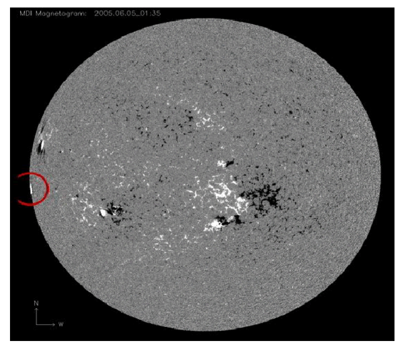
Image 16 (Video): Magnetogram 2005 (Equatorial Sunspots). ►



Notice sunspots are now grouped near the equator, instead of the more mid-latitudes we saw before. Also notice that there are far fewer sunspot groups.

Do you think if we measure the rotation rate it will be different this time? [Take any answers.]

Image 17 (Video): Counting Magnetogram 2 (Equatorial Sunspots). ►



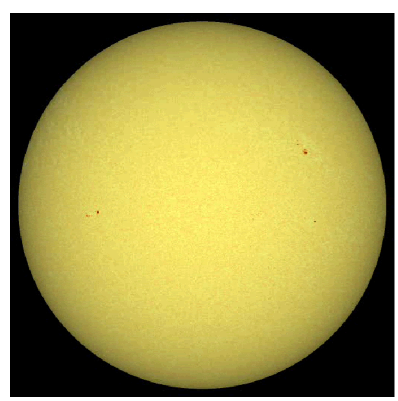
Note: The first frame is to highlight where the sunspot will appear, and should therefore not be counted.

Here is a new sunspot group highlighted for us.

Have the audience count the days out loud. You should get 13 days.

So, how fast does the Sun rotate? [13 times two is . . . 26 days??] What does it mean if we got a different answer? [We miscounted; rotation rate at the equator is faster than at higher latitudes. (Take any answers.)] Hmm. Does that mean different parts of the Sun rotate at different rates? Why doesn’t the Sun all rotate at the same rate, like the Earth does? [The Sun is not a rigid body like the Earth. (Take any answers.)]

Image 18 (Video): Rotating Sun in Visible Light. ►



The Sun is a big ball made of gas and plasma and streaming particles. So, different parts can rotate slower or faster—slowest near the poles, and faster near the equator. The Sun’s rotation rate is measured to be about 27 days at the equator, and about 28.5 days at higher latitudes.

A Magnetic Earth Around A Magnetic Sun

The Sun is a magnetic star. And Earth is a magnetic planet!

Image 19 (Video): Magnetic field of the Earth, Field Detection. ►

Second Narrator (on Video):

"Here we have a model of the Earth, with magnets at its poles. I'm sure you have all played with magnets before, and know that every magnet has two poles—a positive pole and a negative pole.

"Here we have a 'field detector.' It traces the magnetic field of the Earth, starting at one pole, and then going to the other. Notice at the poles, the field sticks straight up out of the Earth, but as you move away from the poles toward the equator, the field is parallel to the surface of the Earth."

Distribute magnetic Earth models and field detectors to groups and allow them time to play with the field detectors and magnetic Earths.

If we take a closer look at exactly where the magnetic poles of the Earth are, we find something interesting. The Positive Pole of the Earth is actually not at the North Pole. The Earth has a pair of geographic poles that are different from its magnetic poles.

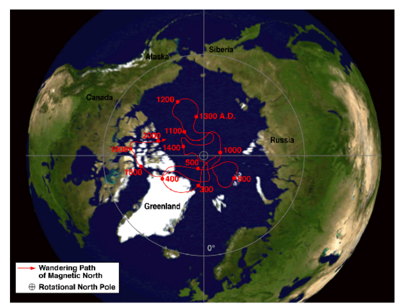


Image 20 (Still): Wandering Magnetic Pole. ►

The geographic North Pole is determined by the spin axis of the Earth, but the magnetic Pole actually wanders around. The red line on this map shows where the magnetic Pole has been for the past 2000 years or so.

The entire magnetic field of the Earth is like a bar magnet. Of course you can't actually see magnetic field lines, but we can sometimes trace those lines with small magnetic "bits."

Image 21 (Video): Modeling the Magnetic Field of the Earth. ►

Second Narrator (on Video):

"The magnetic field of the Earth acts like there is a powerful bar magnet at the center of the Earth. Near the poles of the Earth, the field is vertical—which is why the bits tend to stand up at the poles. The field also bunches up at the one pole, and then wraps around the Earth to bunch up at the other pole. Again, at the equator, the field is parallel to the Earth's axis."

Distribute field bits (washers) and instruct audience on how to use the kits:

1. Have one person hold the Earth ball, polar axis horizontal.

2. One person should start at the North (Positive) Pole, and stretch their field bits towards the equator.

3. Another person can start at the South (Negative) Pole, and move towards the North chain.

They should see the field "gathers" on the Earth's surface at the poles, but can be stretched out along longitudes. Note that bits will not stick by themselves at the equator.

If individuals insist on doing it themselves, have them trade off after each person has made their own field line.

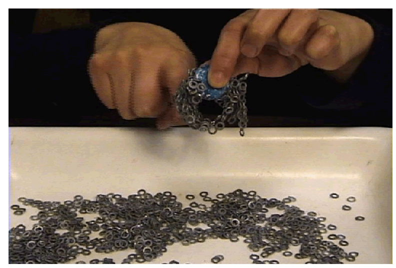
Now let's think about the magnetic field of the Sun—it's quite different.

On the Sun, we have sunspots—areas of intense magnetic activity where the "surface" appears dark. Sunspots tend to be found in pairs or clusters. In a sunspot pair, usually one spot has positive magnetic field and the other a negative magnetic field. In a sunspot cluster, each spot has a positive or negative magnetic field, but the cluster overall has about equal amounts of positive and negative magnetic field.

Image 22 (Video): Magnetic Field of a Sunspot, and CME Creation. ►

The field originates beneath the surface of the Sun, and radiates out to the surface at these sunspots. If these loops break, a tremendous amount of energy is released, and can result in a coronal mass ejection—or CME—which is a huge eruption of material from the surface of the Sun. CMEs can carry up to 10 billion tons of plasma, and travel at 1000 km/s, and have the energy equivalent of a billion hydrogen bombs. This energy is then spread across the Solar System.

Image 23 (Video): Modeling the Magnetic Field of the Earth (Short); CME Approaching Earth, Creating Aurora Oval; Aurora. ►



But remember that the Earth has a magnetic field? That violent release of solar energy can reach the Earth and interact with the Earth's magnetic field and the atmosphere to create TV and radio communication interference. This energy has even been responsible for blackouts! But this interaction also creates other phenomena, like auroras. So, what's happening on the Sun can affect us here on Earth in many ways.

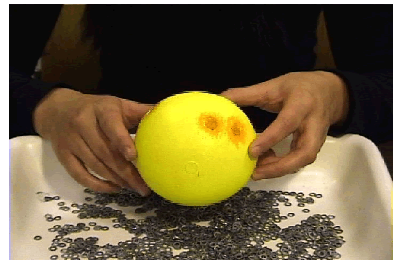
Image 24 (Video): Magnetic Field of the Sun, Field Detection. ►

Second Narrator (on Video):

"Can you tell how these models are different? [Obviously, this model of the Sun is bigger than the Earth. Also the Sun has multiple magnets—representing sunspot groups.

"Unlike the Earth, the Sun as a whole does not act like a giant bar magnet. You can get an idea of what the field is like by again watching our 'field detector.' Each sunspot pair acts like a bar magnet.

Image 25 (Video): Modeling the Magnetic Field of the Sun. ►

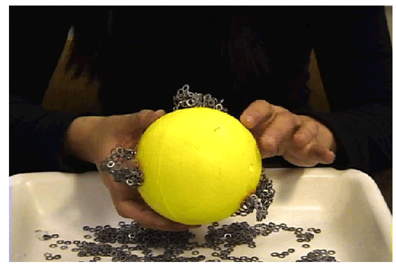


"Each sunspot pair is like a bar magnet resting on its side, parallel to the surface of the Sun. One member of the pair has a positive-type polarity, the other a negative-type polarity. From these pairs of sunspots, magnetic field loops are formed, and they form at every pair all over the Sun."

Hold up a Sun magnet model for the audience to see.

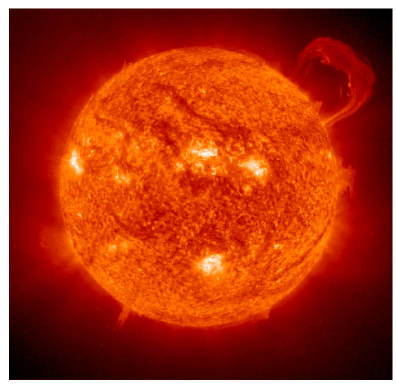
Exchange Earth models for Sun magnet models and allow time for people to explore the magnetic fields of the Sun models. Encourage audience to create different size loops, and making sure they are forming loops—and not allowing the field to "flatten" between two sunspots.

Image 26 (Video): Modeling the Magnetic Feld of the Sun (Short); Sun's Rotating Magnetic Felds; TRACE Imagery. ►



So, we have magnetic loops all over the Sun, but the Sun's rotation affects the overall field. This animation shows how the Sun's magnetic field actually winds up and loops out—warping, twisting, and tangling. These magnetic field loops cause the plasma loops seen on the Sun by satellites, constantly forming, breaking, and changing.

Image 27 (Still): Solar Prominences. ►



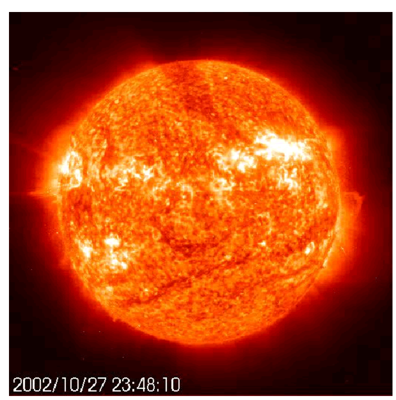
From Earth, we can sometimes see the loops on the edge of the Sun's disc, and we call them prominences. These prominences, like sunspots, are relatively cooler clouds of gas following along magnetic field lines. Sometimes these prominences can even erupt into flares.

All of these phenomena on the Sun are driven by magnetism. The more active the Sun is, the more you can expect to see these phenomena. Observing a lot of sunspots is good indication the Sun is active.

Collect Sun magnet models and field bits.

Conclusion

Image 28 (Video): Sun. ►



It's the center of our Solar System, and holds 99.8% of all the mass of our Solar System. From the time-keeper Sun, to Galileo's first view of sunspots, to modern satellite views of the Sun, we have learned much. However, there is even more we do not know. What causes the cycles of solar activity? What's happening deep below the Sun's surface and in it's core? Can we predict when solar storms will happen or if a CME will hit Earth? How will future changes of the Sun affect life on Earth?

We estimate the Sun has shone for almost 5 billion years, giving warmth and light to almost all life forms that have lived on our planet. We also estimate it will continue to shine for another 5 billion years, giving warmth and light to us and our fellow life forms.

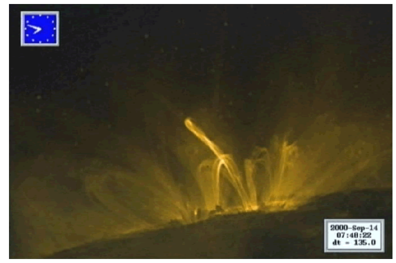


Image 29 (Video): SOHO/TRACE Imagery. ►

But you don't really need a spacecraft to see the beauty of the Sun. As it spins, nearly 100 million miles away from us, we can see the beauty of its light right here on our spinning Earth . . .

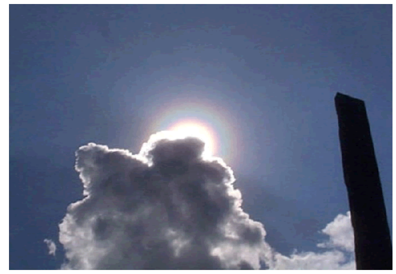


Image 30 (Video): Solar Phenomena. ►

. . . and makes us all very lucky to have our very own star!

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In 2004, the NASA Living with a Star (LWS) Education and Public Outreach allocated funds for creating an audience participation planetarium program about the Sun. The program *Our Very Own Star* is the product of work done by the Lawrence Hall of Science (LHS) astronomy staff with that funding. We are grateful to Evelina Felicite-Maurice, our technical officer, and Gilberto Colón, LWS PI (both from Goddard Space Flight Center, Greenbelt, MD) for their generous support in creating this program.

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This program underwent the most thorough field test of any PASS program to date. In addition to being pilot tested at Lawrence Hall of Science in the Holt Planetarium in the summer of 2005, it was field tested by these planetarium people who we are indebted to for the feedback they gave us to improve the show and make the best final product possible: Stephanie Gove and Sheldon Shafer (Lakeview Museum Peoria, IL), George Curran (Virginia Peninsula Astronomy Stargazers), Paul Mailloux (Dunn Planetarium - Danvers, MA), Toby Click (Mark Smith Planetarium - Museum of Arts and Sciences - Macon, GA), Becky Lowder (Georgia Southern Planetarium - Statesboro, GA), Ken Brandt, (Robeson Planetarium - Lumberton, NC), Carrie Zaitz (Ensign Planetarium - Dearborn Heights, MI), Rodney Martin (Brish Planetarium, Hagerstown, MD).

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Our Very Own Star

Photos, Illustrations, Movies, Music Credits

Credits and sources for slide images are given in the Slide list in the Materials section.

Galileo sunspot sketches are from First Edition of Galileo *Galilei's Istoria e Dimostrazioni Intorno Alle Macchie Solari e Loro Accidenti Rome (History and Demonstrations Concerning Sunspots and their Properties)* published 1613.

All other illustrations in this volume are by Alan Gould, Toshi Komatsu or from NASA as noted.

Specific sources include:

Johns Hopkins University Applied Physics Laboratory/ Southwest Research Institute (JHUAPL/SwRI), Carnegie Institution of Washington, NSO/AURA/NSF, NSO/AURA/NSF, SOHO (ESA & NASA), NASA-IMAGE Education and Public Outreach, NASA/Goddard Space Flight Center Conceptual Image Lab, LMATC, and Stanford University.

For the sunlight-atmosphere imagery, the sources were (see list of visuals for detail):

Michael Ellestad, Lauri A. Kangas, Don Brown (Utah Skies - http://www.utahskies.org), Nik Szymanek, Anthony Arrigo (Utah Skies - http://www.utahskies.org), Randolph Wang, Franz Kerschbaum, Vienna, Dale Ireland (http://www.drale.com), Jan Curtis.

The video for Our Very Own Star includes narration by Toshi Komatsu; motion picture footage from NASA missions: SOHO and TRACE.

Music by José Cabezas, Ancient Winds, Peaceful Dove CD - (http://www.ancientwinds.com; songs: Conejito, Peaceful Dove, Indian Song, Solitude, Longuita Otavaleña, Inside My Soul); also music by Iasos (http://www.iasos.com).

PASS Classic