SOHO is an ESA/NASA mission of international cooperation

SOHO Portfolio 2001

This image set is intended to provide a general audience with easy access to recent and striking images of the Sun in a single, reasonably small, package. It contains images (or groups of images) with a caption and explanatory text on the following page for each. These may prove useful for teaching about the Sun or for gaining a quick overview of some of the most dramatic images that SOHO (the Solar and Heliospheric Observatory) is producing.

Text and graphics can be copied to the clipboard and pasted into most applications (see Acrobat Help if you need assistance in doing this).

We are in the process of having an updated set printed and made available to educators through the NASA Educational Resource Centers. The last page tells you how to order a printed copy from NASA CORE.

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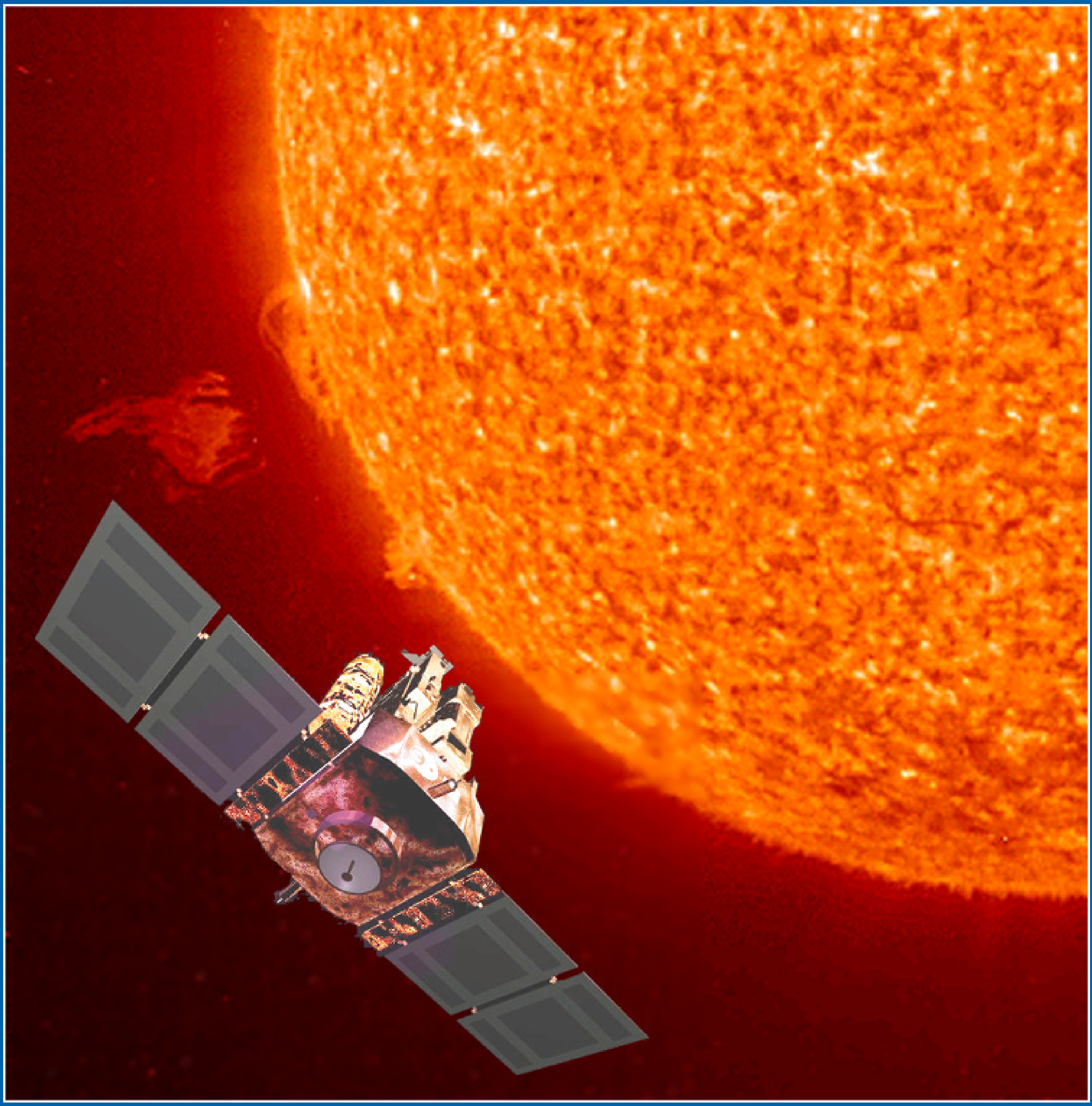
THE SOHO PORTFOLIO OF IMAGES



SOHO, the Solar and Heliospheric Observatory, studies the Sun 24 hours a day from space

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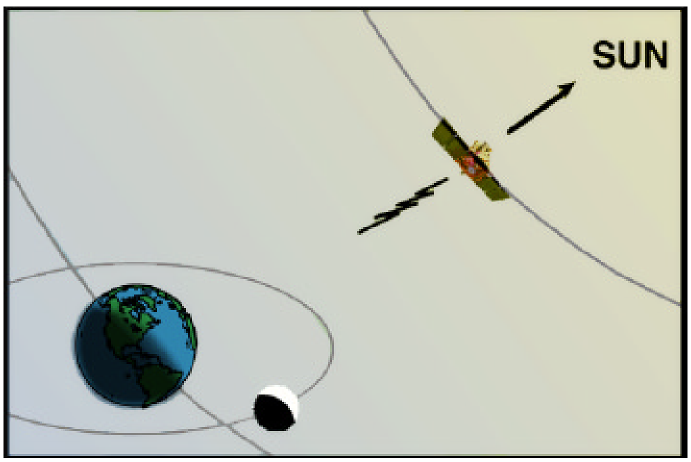
The SOHO spacecraft is a very sophisticated instrument package built in Europe. It weighs nearly two tons (610 kg) and stretches about 25 feet (9.5 m) across with its solar panels extended. It is pictured here in front of an image produced by one of its instruments, the Extreme ultraviolet Imaging Telescope (EIT). Since it first started sending back data and images in March 1996, SOHO has engendered interest and enthusiasm from the space physics community and other scientists, and has led the way to major discoveries about the Sun.

Because it is far above the Earth's atmosphere, SOHO can capture data and images with unprecedented detail and quality. This also allows it to measure scientifically important kinds of light that are blocked by the Earth's atmosphere, i.e., not available to ground-based telescopes.



The location of SOHO a million miles (1.6 million km) sunward of Earth

The SOHO spacecraft being assembled and tested

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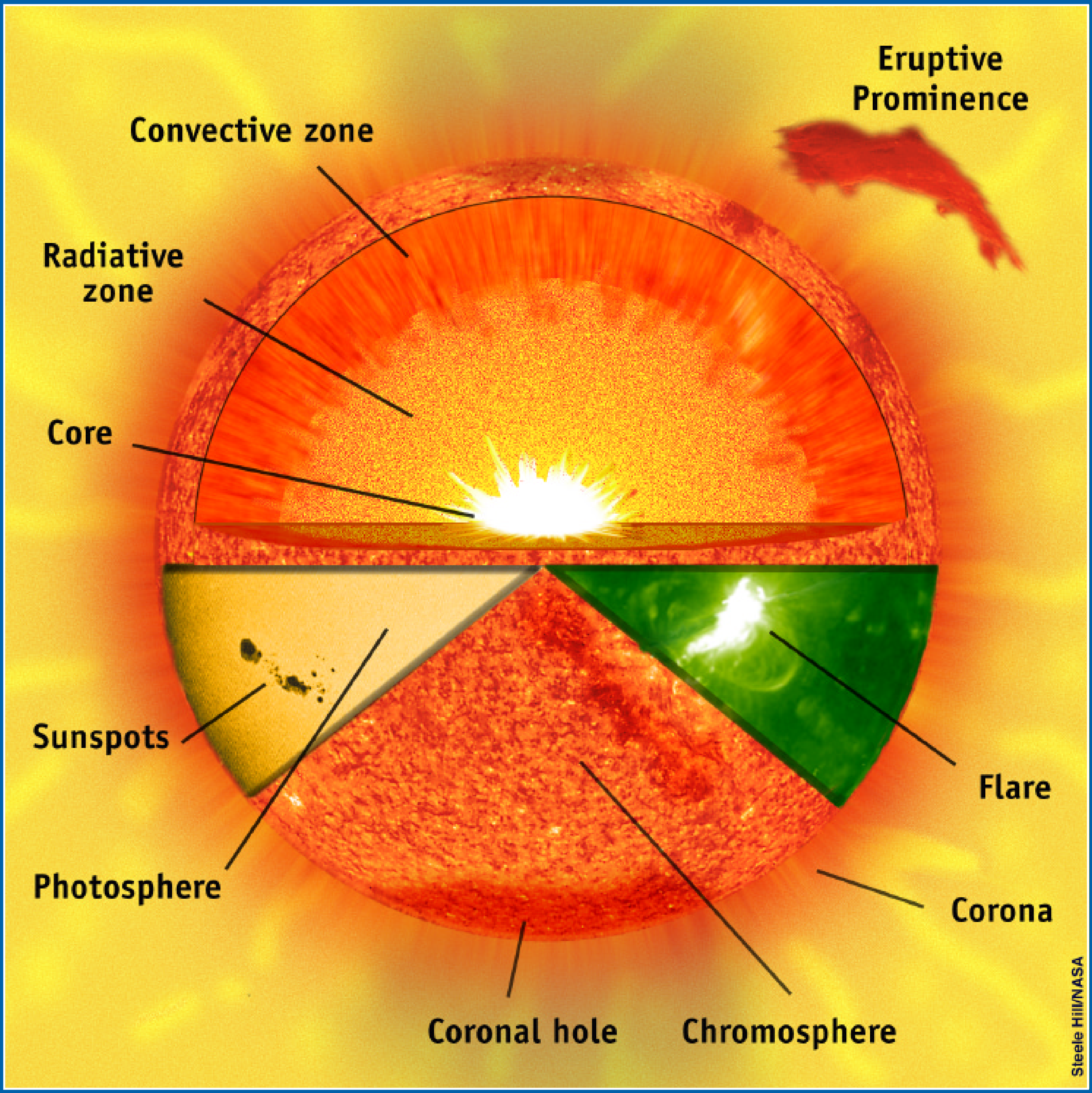

The parts of the Sun

The parts of the Sun

This illustration gives a basic overview of the parts of the Sun. The three major interior zones are the **core** (the innermost part of the Sun where energy is generated by nuclear reactions), the **radiative zone** (where energy travels outward by radiation through about 70% of the Sun), and the **convective zone** (in which convection currents circulate the Sun's energy to the surface).

Some of the other parts identified are:

Sunspot: a temporary disturbed area in the solar photosphere that appears dark because it is cooler than the surrounding areas. Sunspots consist of concentrations of strong magnetic flux.

Photosphere: the visible surface of the Sun. It consists of a zone in which the gaseous layers change from being completely opaque to radiation to being transparent. It is the layer from which the light we actually see (with the human eye) is emitted.

Chromosphere: the layer of the solar atmosphere that is located above the photosphere and beneath the corona. The chromosphere is hotter than the photosphere but not as hot as the corona.

Corona: the outermost layer of the solar atmosphere. The corona consists of highly rarefied gas at a temperature greater than one million degrees Kelvin. It is visible to the naked eye during a solar eclipse.

Coronal hole: An area of the corona which appears dark in X-rays and ultraviolet light and is usually located at the Sun's poles. The magnetic field lines in a coronal hole extend out into the solar wind rather than coming back down to the Sun's surface.

Prominence: a structure in the corona consisting of cool plasma supported by magnetic fields. Prominences are bright structures when seen at the Sun's edge. However, when seen against the bright solar disk, they are dark and are called **filaments.** If they have broken away from the Sun, they are called **eruptive prominences.**

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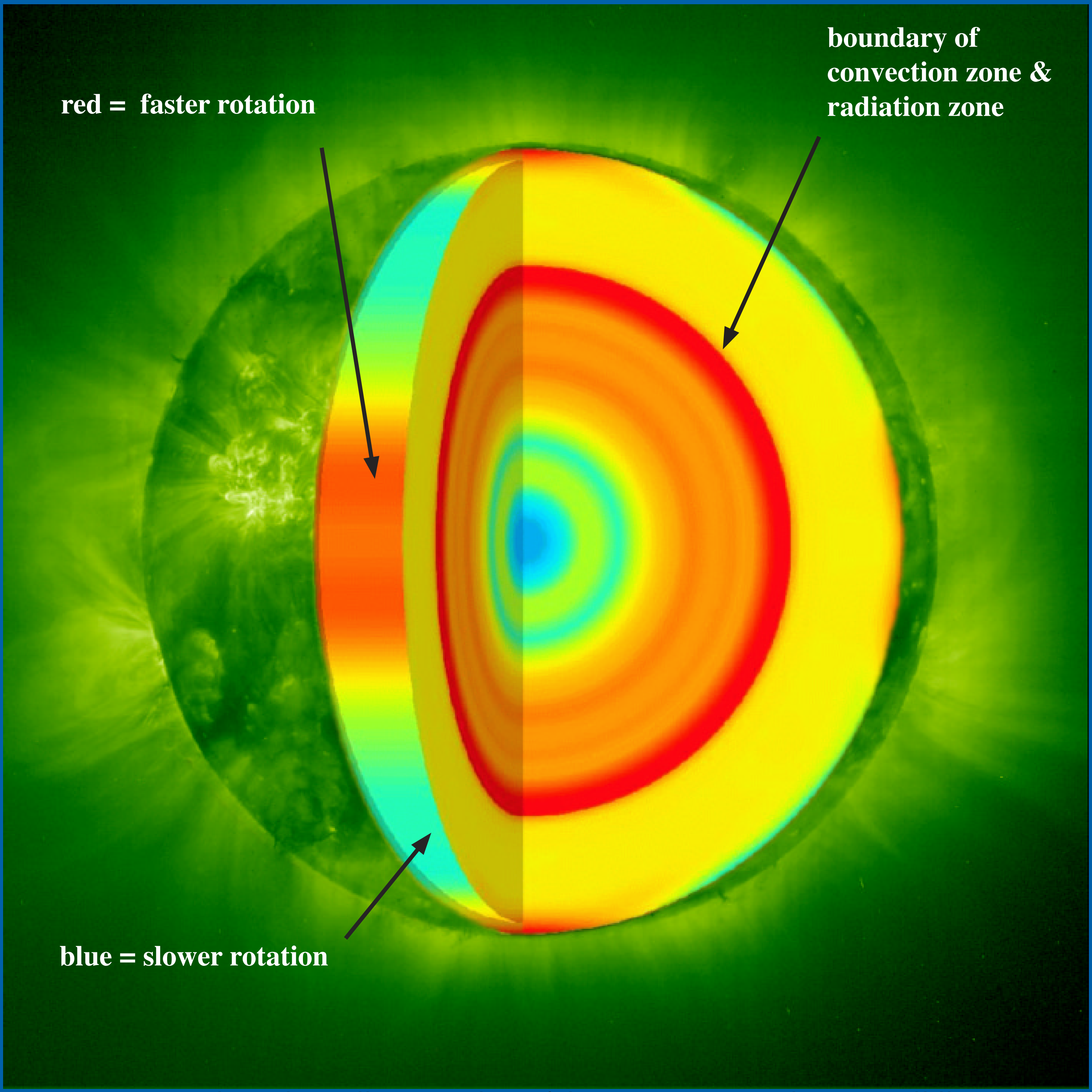

MDI/SOI and VIRGO data imaged by A. Kosovichev , Stanford University; composite image with green EIT assembled by Steele Hill.

Seeing Inside the Sun

Seeing Inside the Sun

With the right instrument, scientists can “hear” pulsations from the Sun. The entire Sun vibrates from a complex pattern of acoustic waves, much like a bell. If your eyes were sharp enough, you could see a bell’s surface jiggle in complex patterns as the waves bounced around within it. Likewise, astronomers can record acoustic pressure waves in the Sun by carefully tracking movements on the Sun’s surface. To do this, they use the Michelson Doppler Image (MDI) instrument. This measures vertical motions due to sound waves reverberating through the Sun, at a million points on the visible surface.

The Sun’s acoustic waves bounce from one side of the Sun to the other in about two hours, causing the Sun’s surface to oscillate, or wiggle up and down. Because these sound waves travel underneath the Sun’s surface, they are influenced by conditions inside the Sun. So scientists can use the oscillations to learn more about how the structure of the Sun’s interior shapes its surface.

Concentric layers in the cutaway image show oddities in the speed of sound in the deep interior of the Sun. Another instrument, VIRGO detects the solar oscillations by rhythmic variations in the Sun’s brightness. From long-lasting observations by these instruments, scientists can test theories of how the Sun works. In red coloured layers, sound travels faster than predicted by the theories, implying that the temperature is higher then expected. The conspicuous red layer, about a third of the way down from the surface to the Sun’s center, shows unexpectedly high temperatures at the transition zone between the turbulent convection zone and the more stable radiative zone inside it. Here MDI has measured a rapid change in the speed of rotation about the Sun’s axis, between the faster-turning outer region and the slower interior. This shear layer may generate the magnetism that battles with the gas in the outer layer and causes frenzied activity at the visible surface.

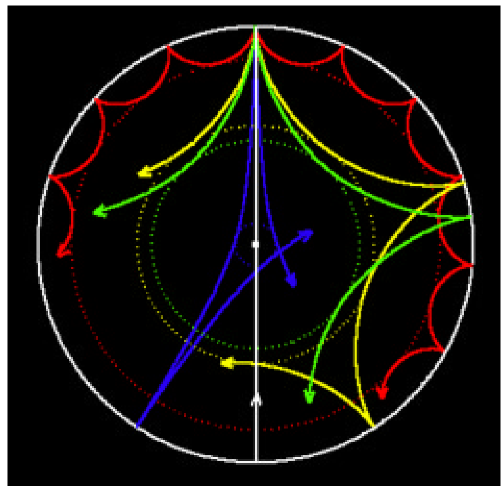

Diagram of the paths of different “sound” waves bouncing and reflecting inside the Sun. Detecting and charting these waves provide scientists with new insights about the solar interior.

To actually hear solar sounds, go to http://soi.stanford.edu/results/sounds.html. To learn more about helioseismology, go to http://soi.stanford.edu/results/heliowhat.html.

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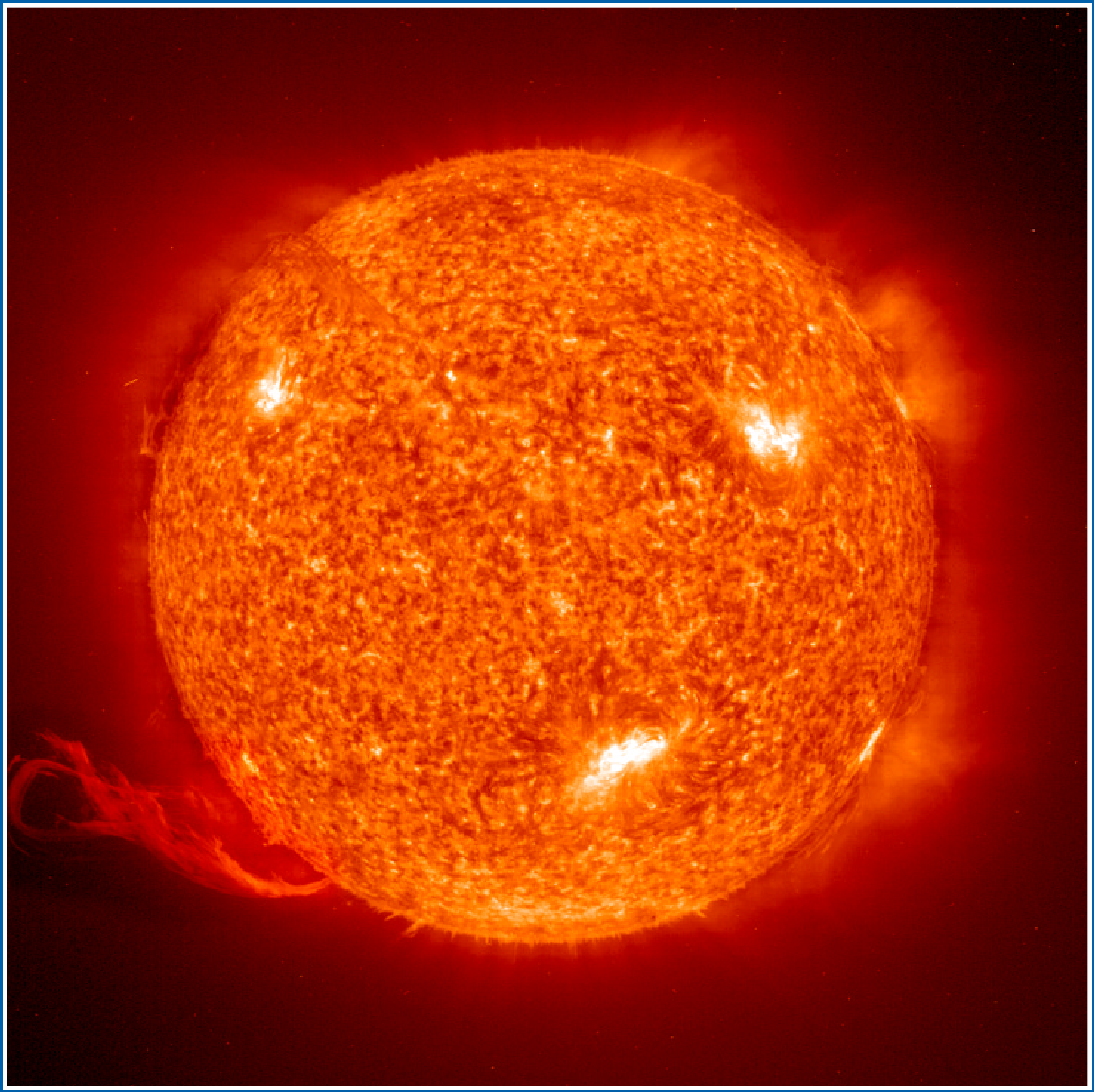
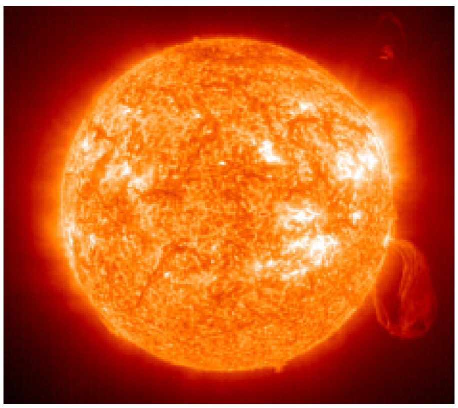


The Sun has eruptions, hotter and cooler areas, and extending prominences

The Sun has eruptions, hotter and cooler areas, and extending prominences

This image, taken by the Extreme ultraviolet Imaging Telescope (EIT), shows the Sun in the He II emission line at 304 Å. It was taken on September 14, 1997. Emission in this spectral line shows the upper chromosphere at a temperature of about 60,000 C. The hottest areas appear almost white, while the darker red areas indicate cooler temperatures.

Note the large erupting prominence at the lower left. These eruptions occur when a significant amount of cool dense plasma or ionized gas escapes from the normally closed, confining, low-level magnetic fields of the Sun's atmosphere to streak out into the interplanetary medium, or heliosphere. When aimed in the direction of Earth, powerful eruptions like the one pictured here sometimes produce major disruptions in the near-Earth environment, affecting communications, navigation systems and even power grids. The effect of these storms can be observed as magnificently shimmering auroral displays (called the Northern or Southern lights) in the skies at the higher latitudes.



Another large prominence from February 12, 2001. Overall, the Sun is more active here than on the other side. You can see more active regions (which appear as whiter areas) over a larger area of the Sun.

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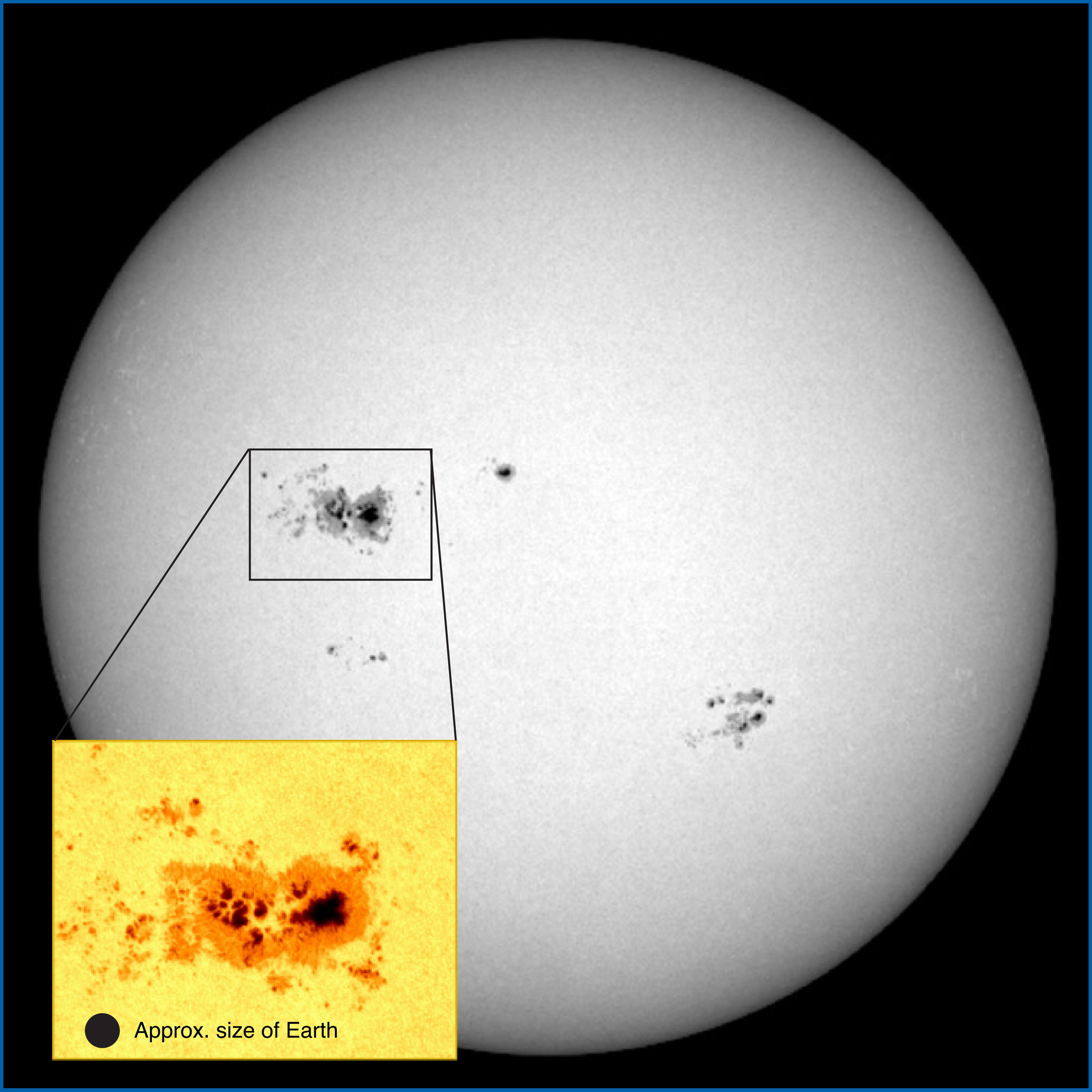


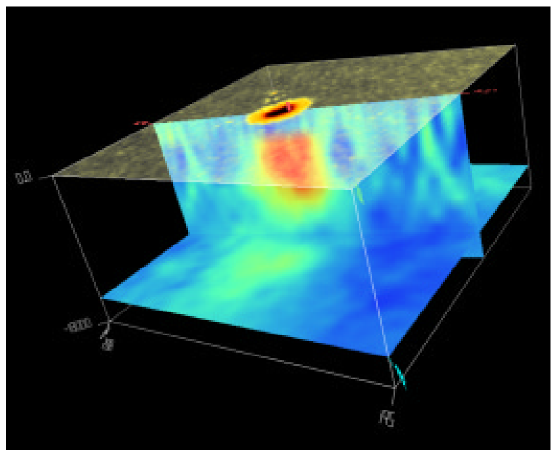
Sunspots, seen as darker spots on the Sun's surface, are cooler regions of plasma

Sunspots, seen as darker spots on the Sun's surface, are cooler regions of plasma

One way we track solar activity is by observing sunspots (relatively cool 4,000 degrees C. areas) that appear as dark blemishes on the face of the Sun. They are formed when magnetic field lines just below the Sun's surface are twisted and poke though the solar photosphere. The twisted magnetic field above sunspots are sites where solar flares occur, and we are now beginning to understand the connection between solar flares and sunspots.

During solar maximum there are many sunspots, and during solar minimum there are few. The last maximum occurred around 1989, and the last was probably sometime in the year 2000 (still too early to be sure). This particular sunspot group was the largest observed in the past nine years. This image was taken September 24, 2000 by SOHO's Michelson-Doppler Imager. At its peak this group was about 13 times the size of Earth.

The subsurface structure (sound speed) below a sunspot as derived from Doppler measurements gives some idea of a sunspot's depth. This technique of time-distance helioseismology, i.e., measuring travel time for a wave along a path, is similar to how we monitor and measure earthquakes on Earth. This represents the first time that scientists have been able to "see" a sunpot in three dimensions.



You can see current images of sunspots at http://soho.nascom.nasa.gov/. Click on the sunspot image in the upper right corner of the page. Or go to the SOHO Latest Images page and click on the MDI Continuum image at http://soho.nascom.nasa.gov/data/realtime-images.html.

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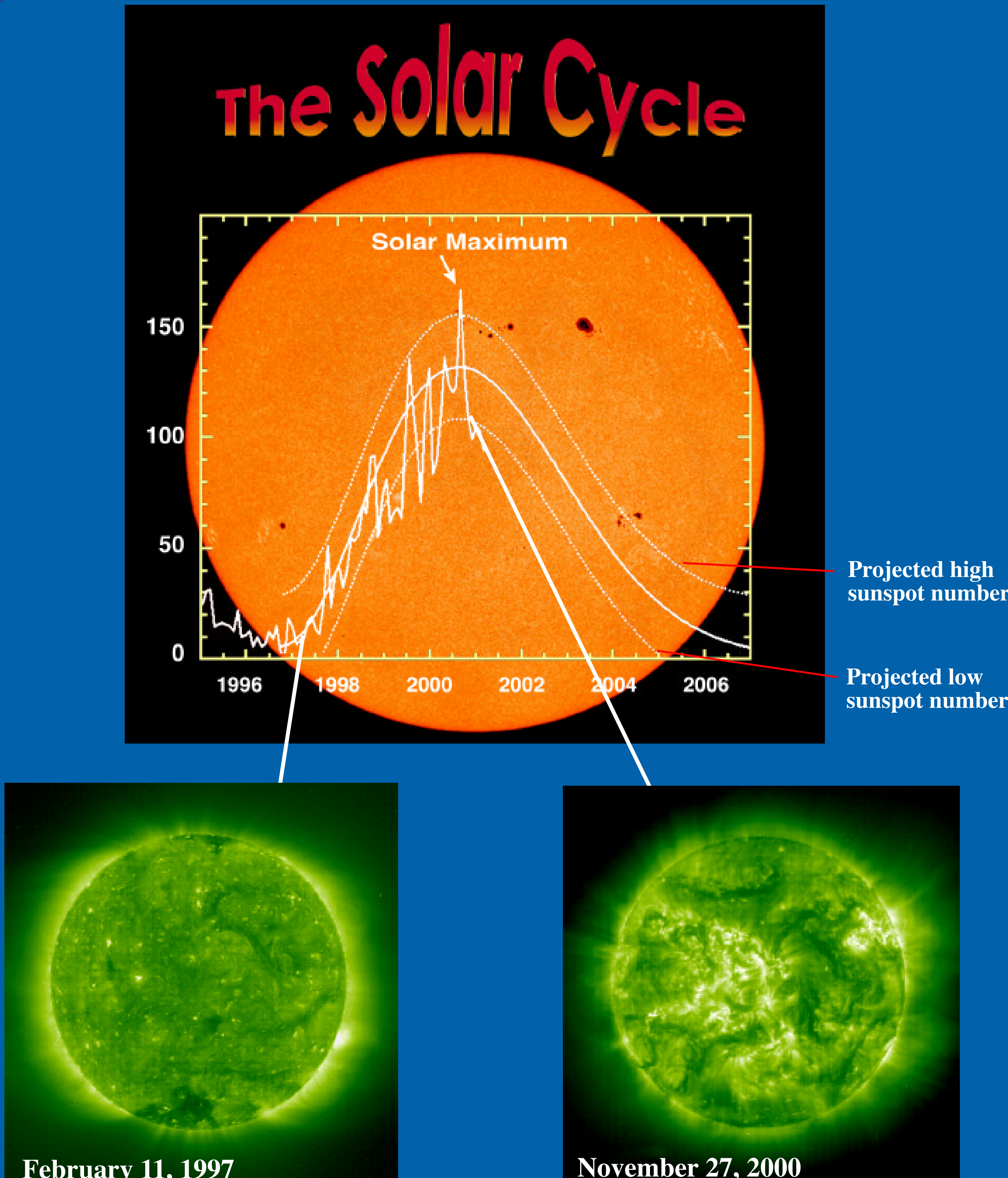


Plot of the Sun's 11 year cycle shows the number of sunspots recorded to date and projected – compare the level of solar activity in these two ultraviolet images

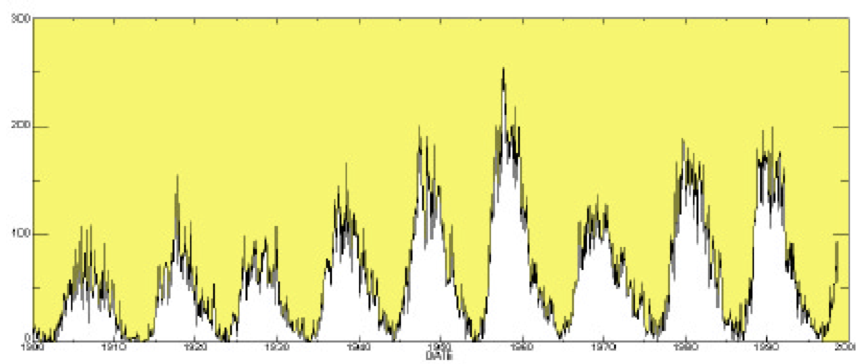
Plot of the Sun’s 11 year cycle shows the number of sunspots recorded to date and as projected –

compare the level of solar activity in these two ultraviolet images

The number of sunspots on the Sun is not constant. In addition to the obvious variation caused by the Sun's rotation (sunspots disappear from view and then re-appear), over time new sunspot groups form and old ones decay and fade away. When viewed over short periods of time, this variation in the number of sunspots might appear to be random. However, observations over many years reveal that the number of sunspots varies in a cyclic manner, usually described as the 11 year cycle (in actuality, the period has been closer to 10.5 years this century). While the cycle has been relatively uniform this century, there have been large variations. From about 1645 to 1715, a period known as the Maunder Minimum, apparently few sunspots were present on the Sun. And the Earth’s temperatures were significantly colder.

A comparison of the two extreme ultraviolet images in the corona (at about 1 million degrees K.) shows the rise in the number and size of active regions that indicate the expected rise in solar activity.

Essentially all aspects of the Sun and solar activity are influenced by the solar cycle. Because solar activity (such as coronal mass ejections) is more frequent at solar maximum, geomagnetic activity here at Earth also follows the solar cycle. Why is there a solar cycle? No one knows the answer to this question.



A chart showing the number of sunspots since 1900

For an updated chart of the solar cycle, go to
http://www.sel.noaa.gov/SolarCycle/

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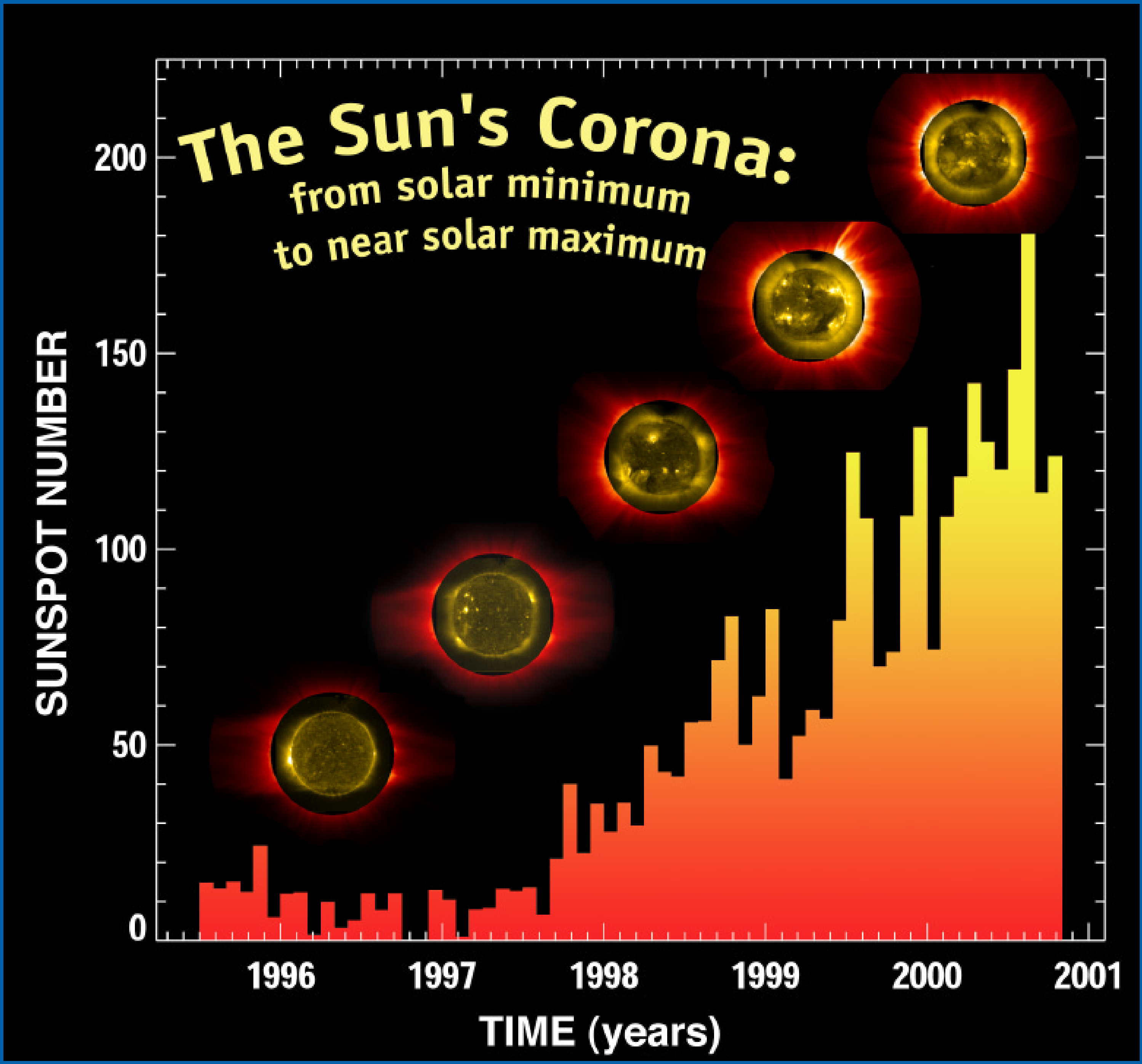

Credit: Smithsonian Astrophysical Observatory; ESA & NASA

Ultraviolet images of the Sun's corona show how it changes over the solar cycle –

the 11-year cycle can be tracked by counting sunspots

Ultraviolet images of the Sun’s corona show how it changes over the solar cycle –

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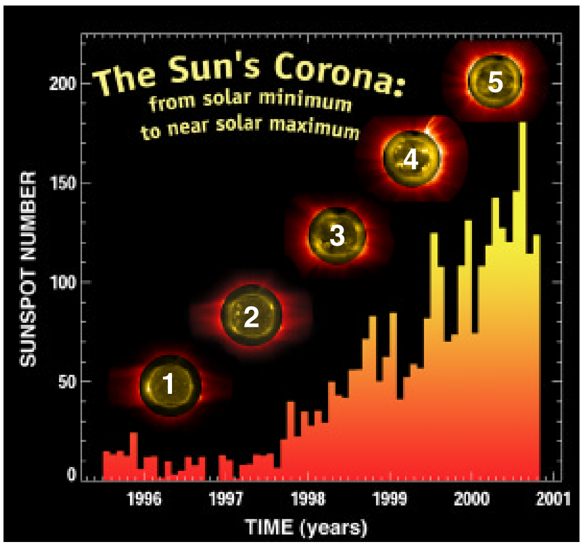
These composite images show how the ultraviolet corona changes with the rising phase of solar cycle 23, covering over four years of SOHO’s operation. The solar images show quantitative changes in the solar corona as seen by two of SOHO’s instruments: the Ultraviolet Coronagraph Spectrometer (UVCS) and the Extreme ultraviolet Imaging Telescope (EIT). The UVCS images (outer corona) show the emission from ionized oxygen atoms that have five missing electrons. The EIT images (inner corona) show the emission from ionized iron atoms that have 14 missing electrons. The brightness scales for the images increase from black through red or yellow to white. The chart below the SOHO images shows the monthly sunspot number for the current 11-year solar cycle starting from its minimum in 1996 to near its maximum.



1) & 2) At the solar minimum, large coronal holes exist above both poles of the Sun. Most of the ultraviolet emission is in elongated streamers near the equator.

4) During the rising phase of the cycle, more active regions (bright areas) appear on the disk; and the extended corona becames brighter and more complex. A coronal mass ejection (CME) is seen lifting off at the 1 o’clock position.

5) Near solar maximum, the corona is more symmetrical around the Sun and more active regions can be seen on the disk.

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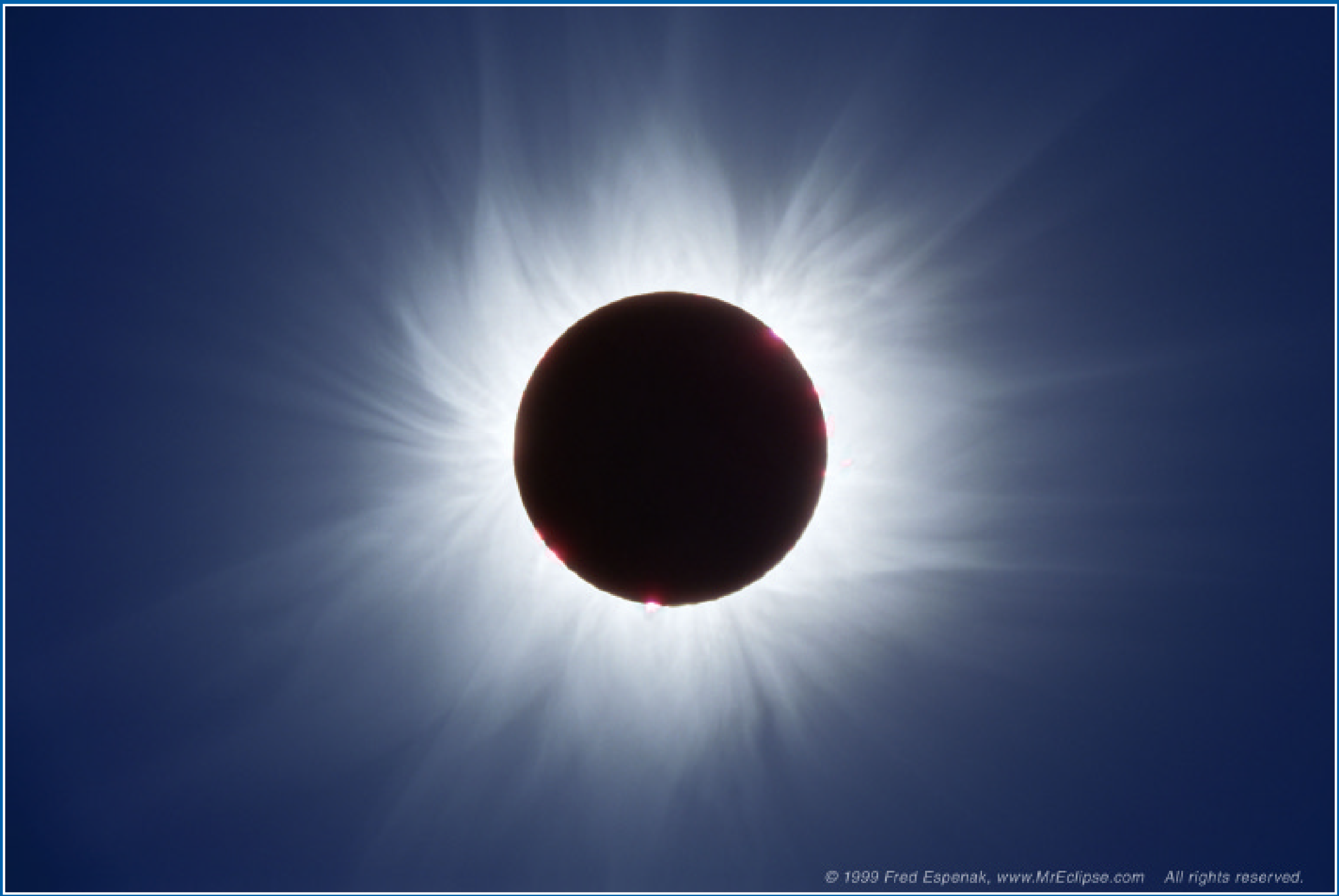
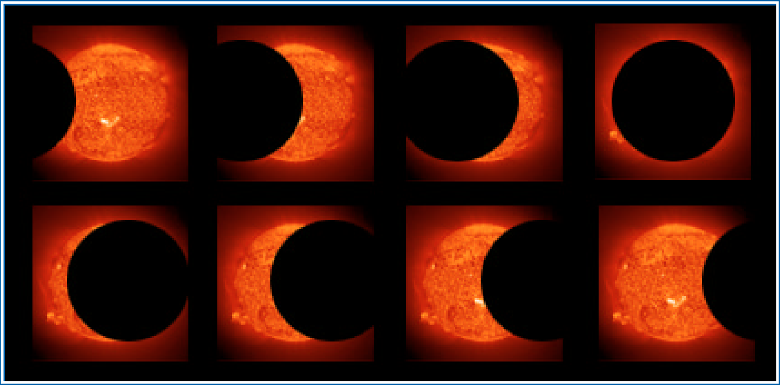


A total eclipse of the Sun in 1999



A series of illustrations shows the progress of an eclipse, which lasts less than three hours

The bright spots that appear as the Sun emerges from an eclipse are called Bailey's beads

Besides capturing the public's interest, eclipses give scientists the chance to study the Sun's corona

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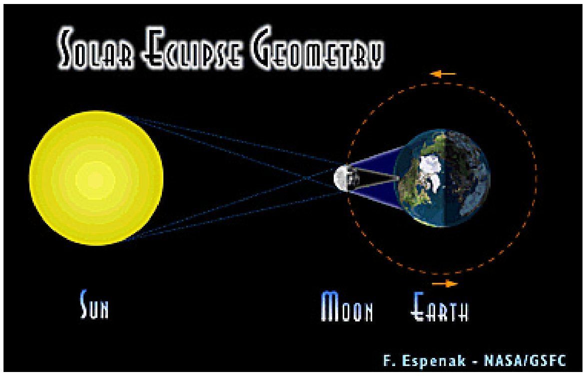
The Sun is so bright that it effectively hides anything nearby with brilliant sunlight. When the moon blocks out the Sun's light from an area of the Earth during a total solar eclipse (which happens roughly every 18 months), scientists rush for a chance to gaze for a couple of minutes at the glowing gas and dust that make up the sun's atmosphere, or corona (see below, left).

The Earth and moon shine only by the reflected light of the Sun, and both cast a shadow into space away from the Sun. This shadow consists of a cone-shaped area of complete darkness, the umbra (about 81 miles in diameter), and a larger area of partial darkness that surrounds the umbra, the penumbra. If you are lucky enough to be in the area when the umbra passes over, you will see a total eclipse that lasts for only a few minutes at best. An eclipse, from the beginning to the end, lasts less than three hours. The next total eclipse visible in the United States will be in 2017.



The basics of a solar eclipse

An excellent resource for more informatipn about eclipses can be found at
http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html

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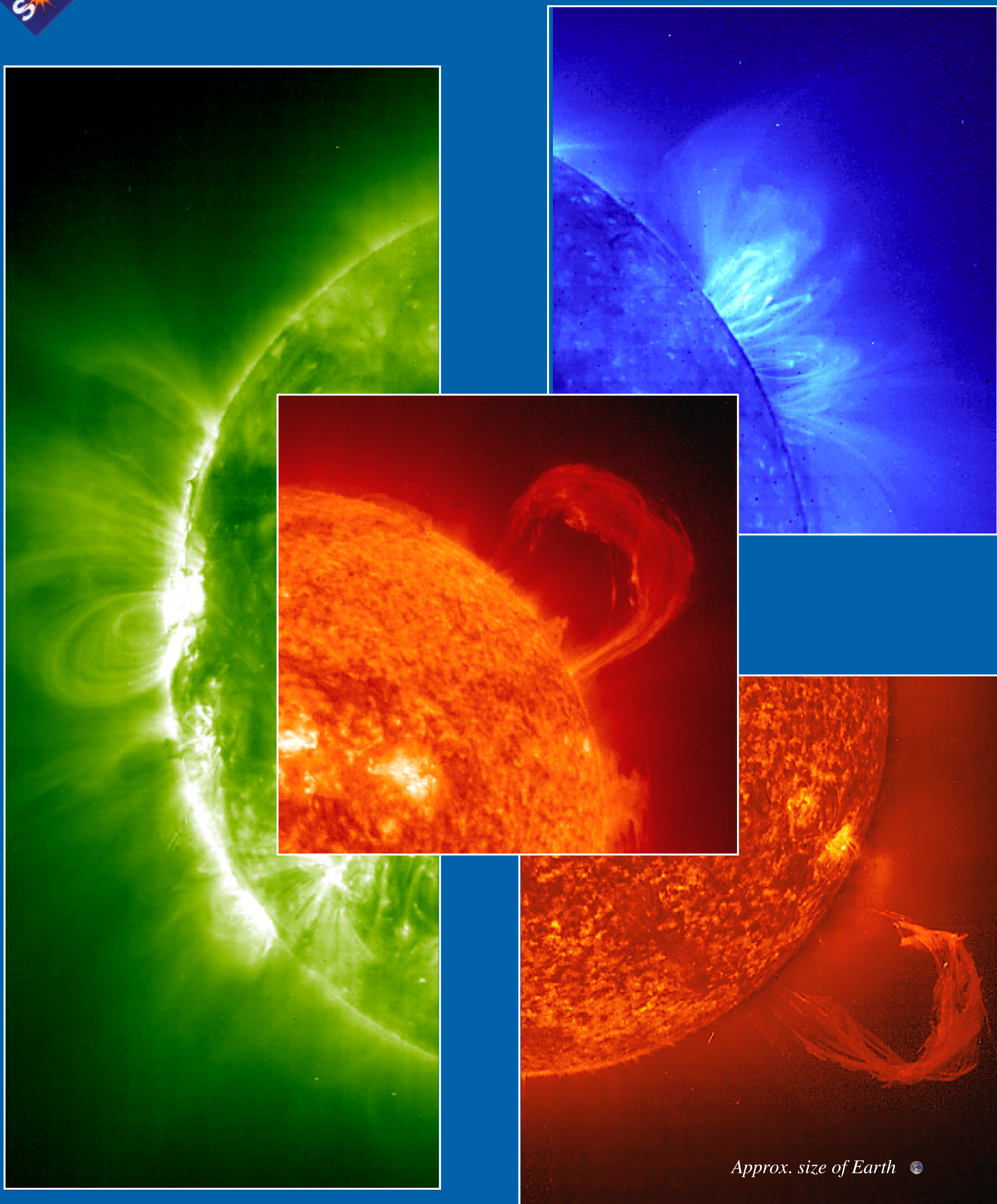

Magnetic loops and prominences are often seen projecting from the Sun

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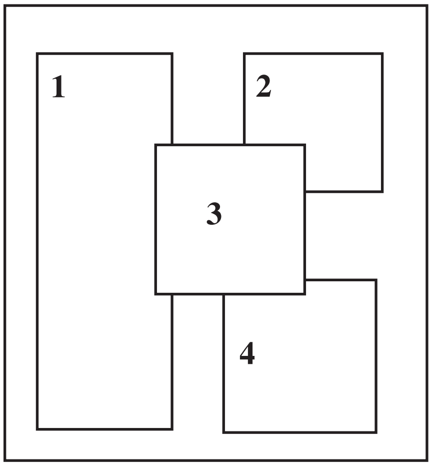
Prominences and loops are observed frequently by SOHO. The highly energized plasma in these features is held in by strong magnetic fields. When the fields finally become unstable and erupt, the plasma breaks away from the Sun's surface at speeds up to millions of kilometers an hour.



1) This 2001 image of about 1.5-million degrees Kelvin gas in the Sun's thin, outer atmosphere (corona) was taken by the Extreme ultraviolet Imaging Telescope (EIT) which detects ionized iron here at 195Å. The loops of energized particles clearly follow magnetic field lines around active regions.

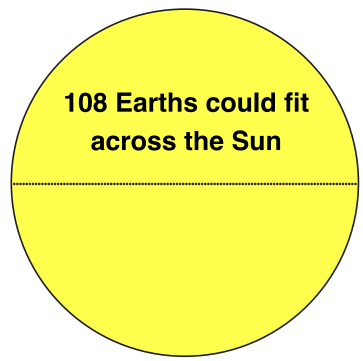
2) Charged material from the Sun can be seen looping out and back from an active region in this 1998 EIT image of 1-million degrees Kelvin gas at 171Å.

3) Taken by the EIT instrument at 304Å, this image shows the Sun releasing an impressive eruptive prominence (September 14, 1999). Material here is ionized helium at abpout 60,000 degrees C.

4) Also from the EIT instrument at 304Å, this arcing, eruptive prominence was taken on March 5, 1998.

Size? To present another visual reference for the Sun's size, we drew 108 Earth's side-by-side (right) across the surface of the Sun. And you could fit a million Earth's inside the Sun. The Sun accounts for almost 99% of the mass in our solar system.

To view other promincne images, go to
http://sohowww.nascom.nasa.gov/bestofsoho/



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esa NASA

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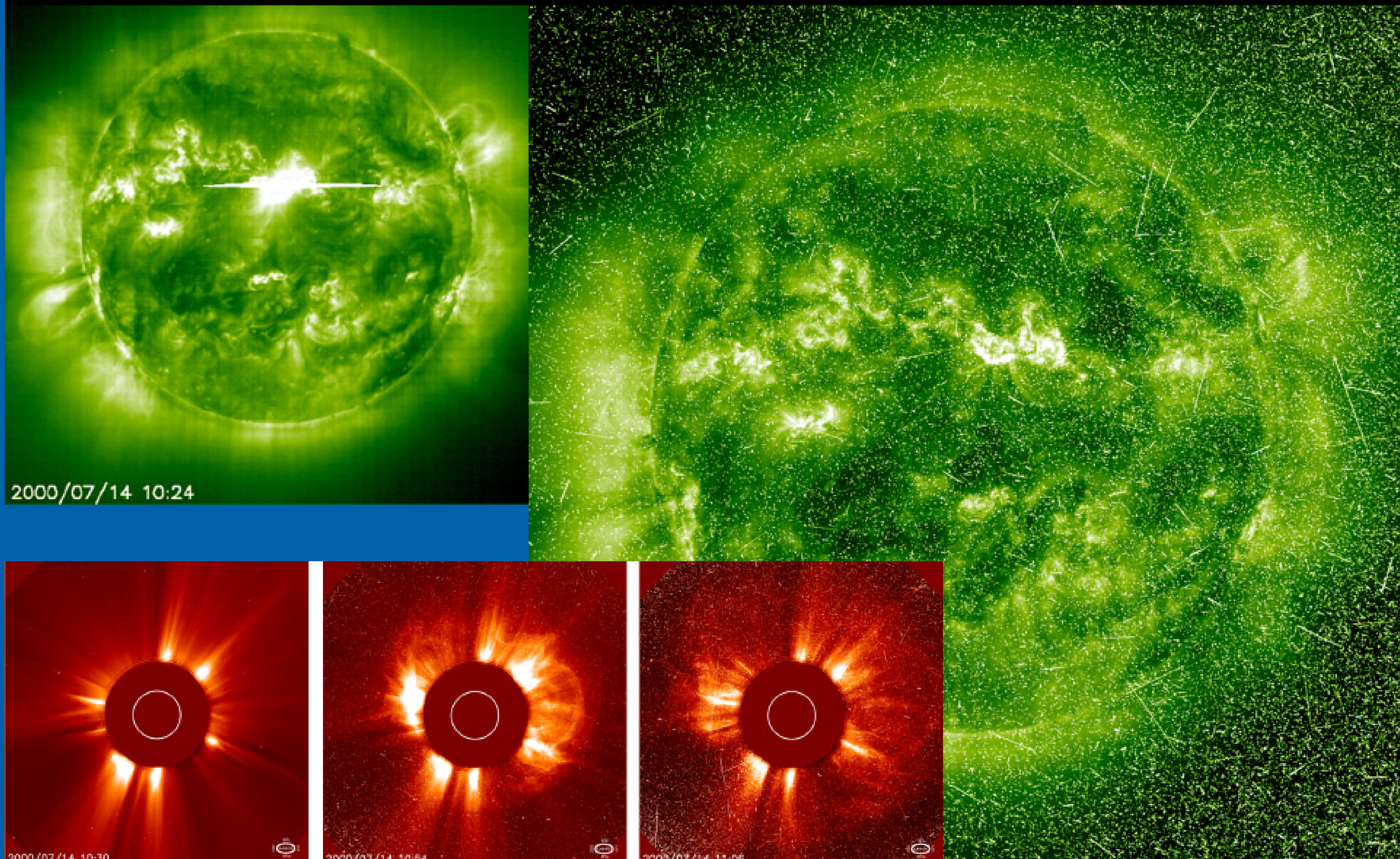
A solar flare erupts and in 20 minutes high-energy protons speckle SOHO's detector



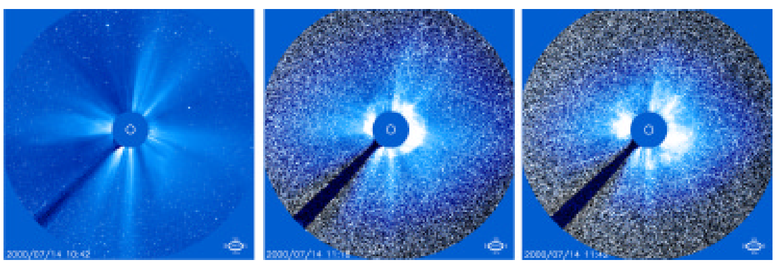
A large solar flare and coronal mass ejection shoot billions of tons of particles towards Earth

A large solar flare and coronal mass ejection shoot a billion tons of particles towards Earth

This sequence of composite images taken by SOHO's EIT195Å (green) and Large Angle Spectroscopic Coronograph (LASCO) C2 instrument (red) shows billions of tons of particles blasting into space associated with a solar flare and coronal mass ejection (CME) on July 14, 2000. The flare's blast (white flash) was caused by magnetic forces that launched the protons outward at half the speed of light. The C2 sequence shown here covers only 40 minutes, yet by the second frame the high-energy protons (seen as white streaks and dots) are already pounding the SOHO instruments, positioned 92 million miles from the Sun. These protons have the potential to harm spacecraft, but the Earth's magnetosphere protects us on Earth from harmful effects. Flares also propel X-rays and gamma ray radiation into space which could be hazardous to astronauts.

It is believed that the Sun's magnetic fields tend to restrain each other and force the buildup of tremendous energy, like twisting rubber bands, so much that they eventually snap. At some point, the magnetic lines of force merge and cancel in a process known as magnetic reconnection, causing the previously confined plasma to be released and forcefully escape from the Sun.

In the LASCO sequences, the white circle on the image indicates the size and position of the Sun. A disk blocks the Sun so that the instruments can capture activity in the corona.



A similar series with a broader view shows this CME (seen as a white cloud) rapidly expanding from the Sun even as very fast moving, high energy protons pelt the LASCO instrument within 20 minutes of the flare.

To view video clips and large still images of this event, go to
http://sohowww.nascom.nasa.gov/2000_07_14/

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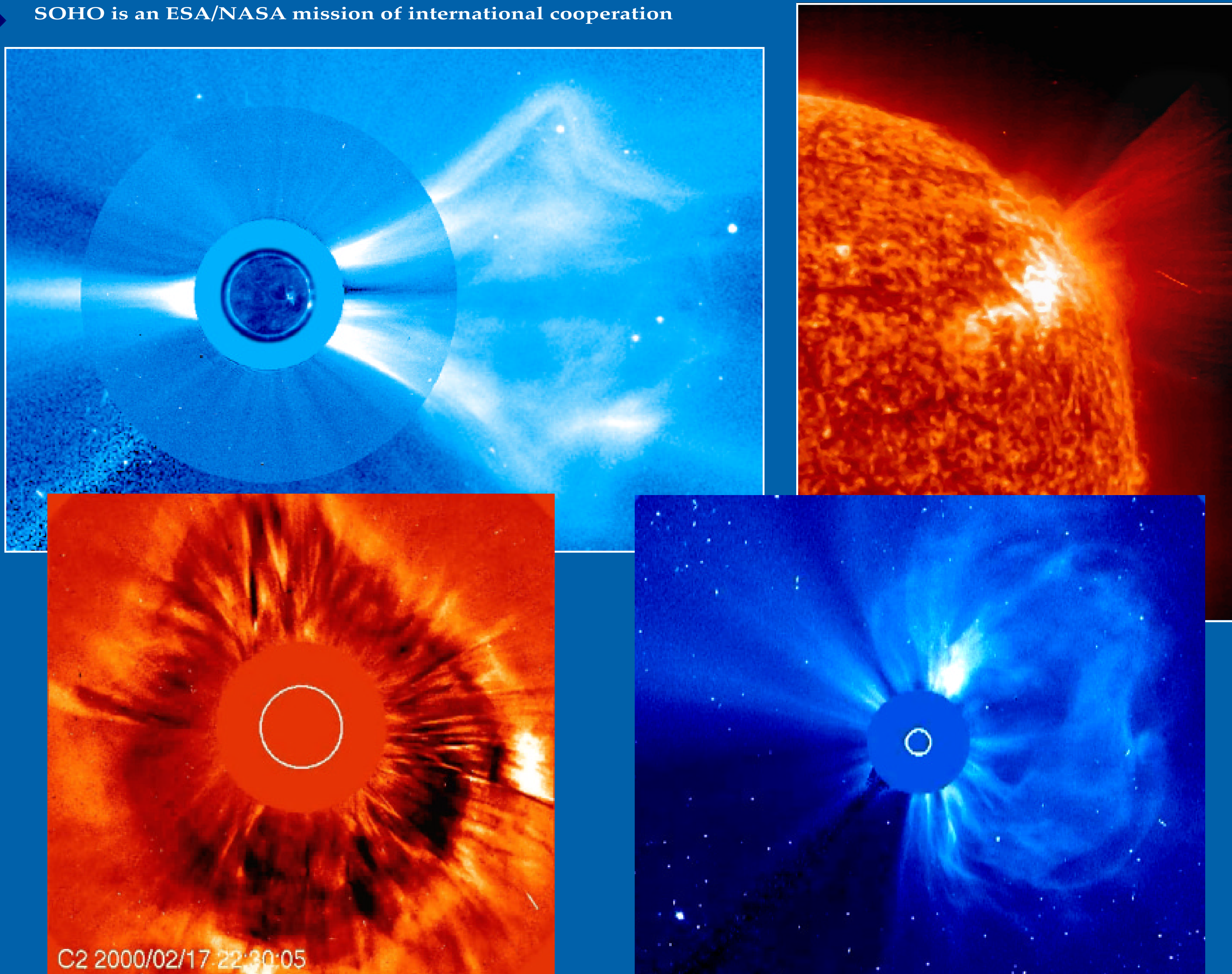

Blasts of particles explode into space following coronal mass ejections from the Sun's surface

Blasts of particles explode into space following coronal mass ejections from the Sun's surface

This group of images was generated by several of SOHO's instruments. They all clearly show the Sun hurtling particles into space during a coronal mass ejection or CME.

A CME cloud is composed of **billion of tons** of charged particles shooting out at hundreds of kilometers per second. A CME cloud, as it moves through space, is preceded by a shock wave of matter being pushed ahead of it as if it were a snowplow pushing snow (in this case, solar particles). By the time it reaches Earth from one to four days later, it has spread out to some 50 million km wide. When its energy interacts with our magnetosphere, it can cause problems with power plants, navigational instruments and communication systems, satellite functions and position, as well as generate beautiful auroral lights. CME's occur quite frequently on the Sun, but most are not directed towards the Earth.

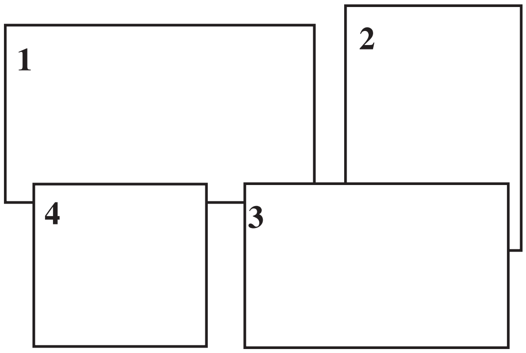

Photo credit: Jan Curtis

Aurora, here captured in the Alaskan sky, are often caused by CME blasts

1) Composite image of two of SOHO's Large Angle Spectroscopic Coronograph (LASCO) instruments showing a "hangar-shaped" blast of particles from a CME. An EIT image of the Sun's surface has been inserted where the Sun would be located.

2) An Extreme ultraviolet Imaging Telescope (EIT) close-up image of a particle blast just as it bursts out from the Sun's surface.

3) This blast from November, 2000 suggests the huge size of a billowing CME cloud.

4) In this LASCO C2 image the outer edges of the blast extend into a halo around the Sun, just as a basketball seems to enlarge as it nears you. The blast from February, 2000 was Earth-directed.

To view video clips of these events (updated daily), go to
http://sohowww.nascom.nasa.gov/data/realtime/mpeg/
and select the LASCO C2 or C3 links

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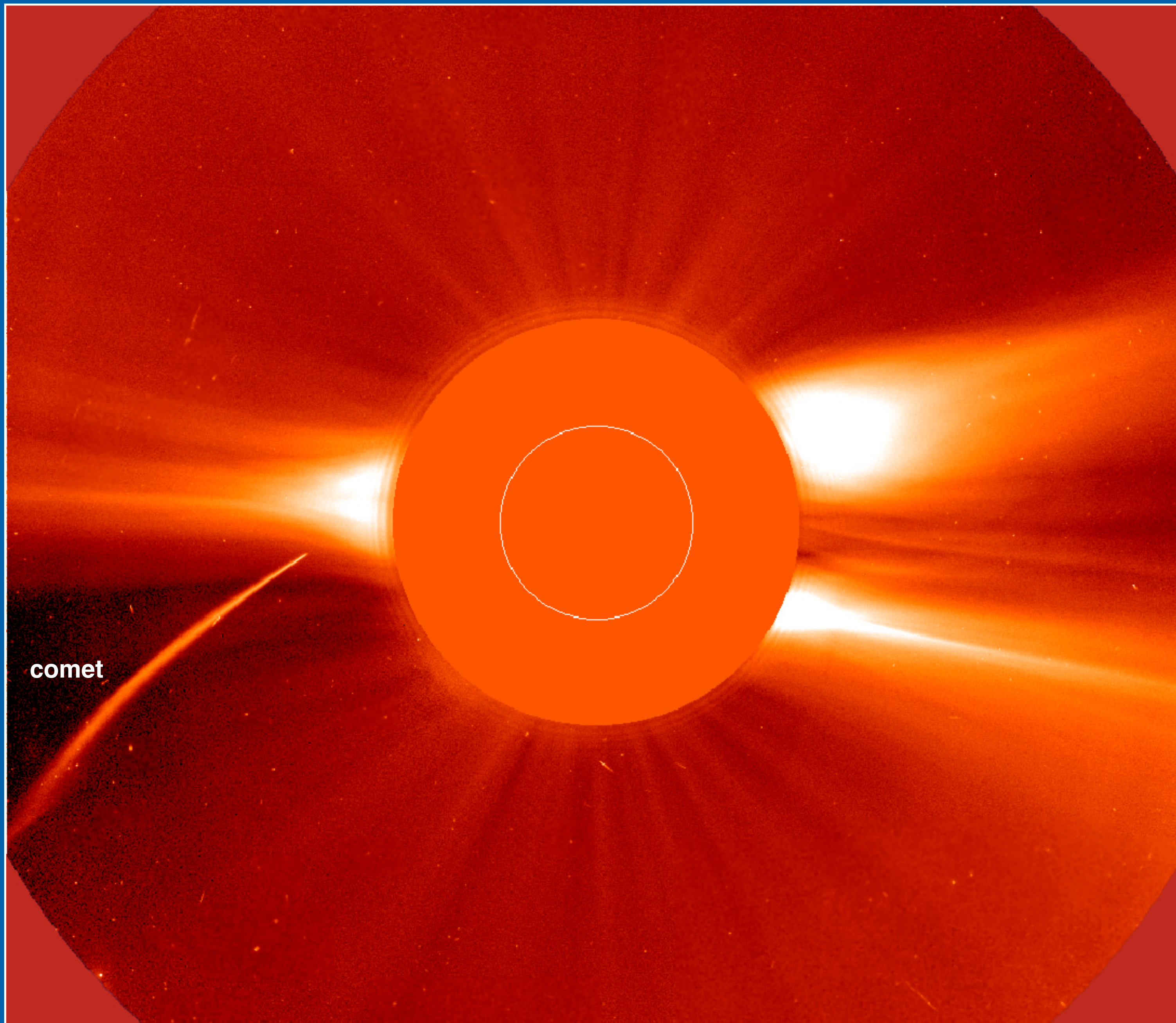


A "sun-grazing" comet about to be burned up by the Sun's heat

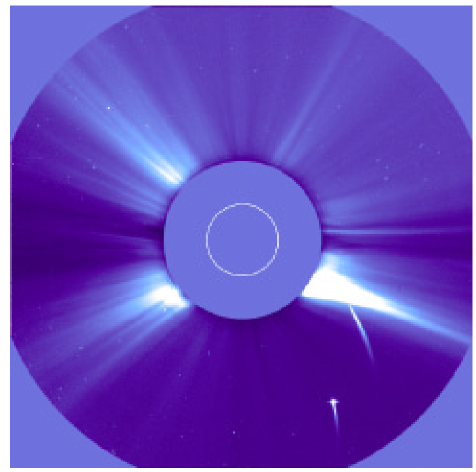
A “sun-grazing” comet about to be burned up by the Sun’s heat

This stunning image taken by one of SOHO’s coronograph instruments on December 23, 1996, shows a streaking comet as it heads towards the Sun. The size of the Sun is indicated by the white circle in the center of the red disk. The red disk in front of the telescope blocks out the Sun and some of the area around it. This reduces its brightness and allows the instrument to better observe the faint corona extending from the Sun. Comets, composed of ice and dust, characteristically have particles streaming out behind them. Comets can be found zooming around space quite frequently. This one, however, was heated as it neared the Sun until it was totally vaporized. SOHO has discovered almost 300 “sun-grazing” comets.

A comet and its long tail

The bright areas to the right of the Sun are actually regions of particles streaming away from the Sun as part of the solar wind. The image is actually taken in black and white. The red color is consistently added to make this kind of image more attractive and easily identified.

At right the two comets, their tails streaming away from the Sun, got much closer to the Sun over the next several hours and then disappeared.



On June 2, 1998 two comets were seen arching towards the Sun in tandem.

To see images and video clips of “sun-grazing comets,” go to
http://sohowww.nascom.nasa.gov/2000_08_21/

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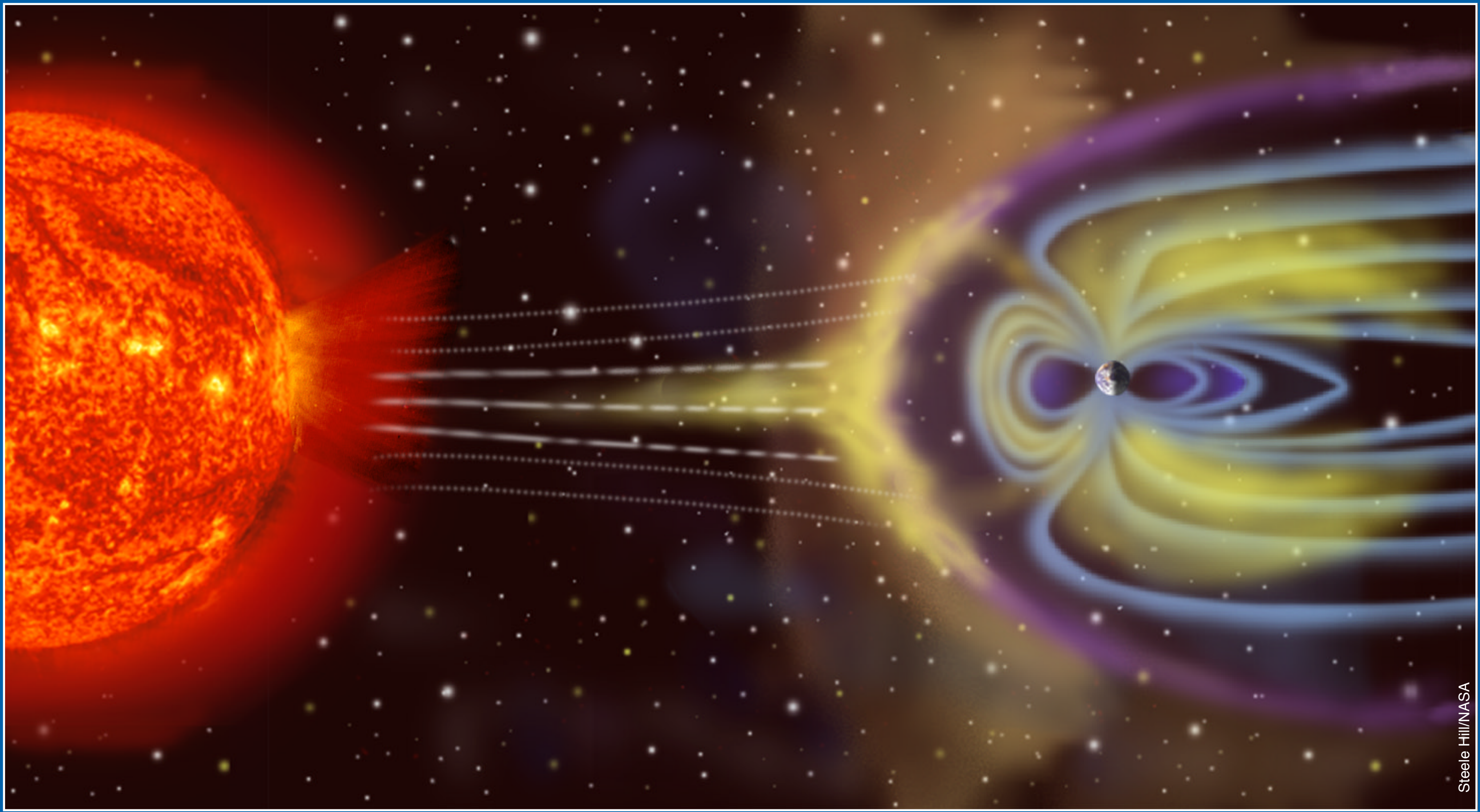


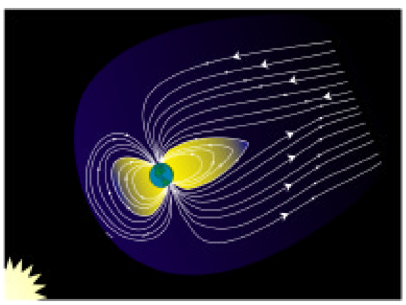
The Sun's magnetic field and releases of plasma directly affect Earth and the rest of the solar system. The solar wind shapes the Earth's magnetosphere and magnetic storms (illustrated here as approaching Earth) can disrupt communications and navigational equipment, damage satellites, and even cause blackouts.

The Sun’s powerful magnetic forces directly affect the Earth and the rest of the solar system

Events on the Sun can trigger changes in Earth's environment, particularly in the regions of the atmosphere known as the ionosphere and the magnetosphere. For one thing, the solar wind (the stream of gas that blows continuously outward from the Sun through the Solar System) shapes the Earth’s magnetosphere so that it is compressed on the side facing the Sun and is much elongated away from the Sun. Like the wind here on Earth, the solar wind blows soft and hard, sometimes leading to magnetic storms in the magnetosphere. The solar wind is essentially the hot solar corona expanding into interplanetary and interstellar space, flowing outward from the Sun at speeds as high as millions of kilometers per hour.

During a geomagnetic storm, portions of the solar wind's energy is transferred to the Earth’s magnetosphere, causing Earth's magnetic field to change rapidly in direction and intensity. Magnetic storms, such as the coronal mass ejection illustrated here, can interfere with radio, television, and telephone signals, upset the navigation systems of ships and airplanes, and cause blackouts. Also, Sun-induced storms can damage satellites and spacecraft or force them to re-enter the atmosphere prematurely.

By closely observing the Sun and the energy and material it blows at Earth, scientists may someday be able to anticipate changes in Earth's environment. Aside from disturbing our electronic equipment, the Sun and the solar wind seem to play a role in long-term climate changes on Earth.



The illustration at far left shows a normal magnetosphere. When the particles from a CME impact the Earth’s magnetosphere (second illustration), the front side flattens and the far side elongates. Some particles enter the magnetosphere along the front field lines to the poles, but most are drawn in on the far side.

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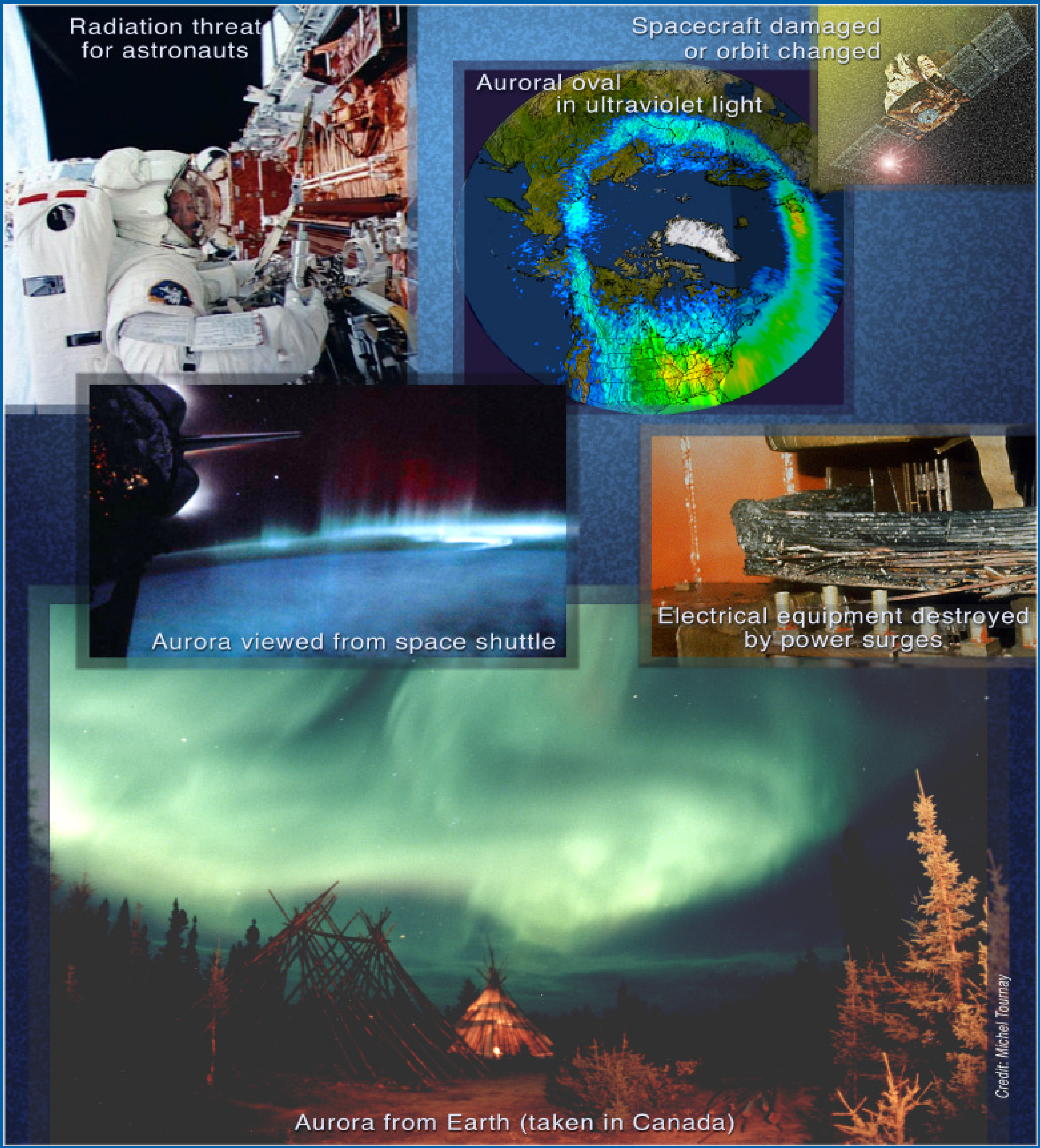

Some effects from solar storms

Some effects from solar storms

Events on the Sun can trigger changes in Earth's environment, particularly in the regions of the atmosphere known as the ionosphere and the magnetosphere. Bright auroras are a merely visible sign that the balance of electrical and magnetic energy in Earth's magnetosphere has been upset.

What are aurora? Excited particles inside the magnetosphere can plunge into the upper atmosphere, where they collide with oxygen and nitrogen. These collisions cause the oxygen and nitrogen to become electrically excited and to emit light (much like fluorescent lights). The result is a dazzling dance of green, blue, white, and red light in the night sky, also known as aurora borealis and aurora australis ("Northern and Southern lights"). Auroras can appear as colorful, wispy curtains of light ruffling in the night sky, or sometimes as diffuse, flickering bands.

There are less benevolent effects of the connection between Sun and Earth. For satellites, CMEs and magnetic storms can be perilous. For instance, a series of flares and coronal mass ejections in March 1989 produced a powerful magnetic storm. After the particles and energy from the Sun struck the Earth, more than 1500 satellites fell several miles of altitude in their orbits due to increased drag. The increased flow of electricity in Earth's space also can cause electrical charge to build up on the surface of a spacecraft and damage its circuits. More recently, Japan lost its ASCA satellite during a strong solar storm in July, 2000.

Magnetic storms also play havoc with radio signals, which are bounced off Earth's ionosphere (the outermost layer of our atmosphere, made up mostly of plasma) as a sort of natural relay station. In the extreme, magnetic storms can completely wipe out radio communication around Earth's North and South Poles for hours to days.

On the ground, magnetic storms can affect the strength of Earth's magnetic fields which can produce surges in power lines and strong electrical currents in gas and oil pipelines. In power lines, the extra electricity can burn out transformers and cause brownouts and blackouts. During the March 1989 storm, a transformer burned up at a power plant in New Jersey, and a whole system was blown out at a power station in Quebec, leaving 6 million people without electricity for hours, some for days.

Since so much modern information is relayed by satellites and other advanced technology—from automated teller machines and television broadcast signals to the Global Positioning System—these storms pose a natural and technological hazard to us on Earth. But the major human health hazard is faced by astronauts. Certain storms emit dangerous radiation (including gamma ray and x-ray) that can cause illness and even death for astronauts unprotected by shielding.

For a short article and some video clips on the effects of space weather, go to
http://www-istp.gsfc.nasa.gov/istp/outreach/cmeposter/blackout.html.
To learn more about today's current space weather, check at
http://www.sec.noaa.gov/

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NASA Resources for Educators

NASA's Central Operation of Resources for Educators (CORE) was established for the national and international distribution of NASA-produced educational materials in audiovisual format. Educators can obtain a catalogue and an order form by one of the following methods:

- NASA CORE
  Lorain County Joint Vocational School
  15181 Route 58 South
  Oberlin, OH 44074
- Phone (440) 774-1051, Ext. 249 or 293
- Fax (440) 774-2144
- E-mail *nasaco@leeca.esu.k12.oh.us*
- Home Page: *http://spacelink.nasa.gov/CORE*

Educator Resource Center Network

To make additional information available to the education community, the NASA Education Division has created the NASA Educator Resource Center (ERC) network. ERCs contain a wealth of information for educators: publications, reference books, slide sets, audio cassettes, videotapes, telelecture programs, computer programs, lesson plans, and teacher guides with activities. Educators may preview, copy, or receive NASA materials at these sites. Because each NASA Field Center has its own areas of expertise, no two ERCs are exactly alike. Phone calls are welcome if you are unable to visit the ERC that serves your geographic area. A list of the centers and the regions they serve includes:

AK, AZ, CA, HI, ID, MT, NV, OR, UT, WA, WY
NASA Educator Resource Center
Mail Stop 253-2
NASA Ames Research Center
Moffett Field, CA 94035-1000
Phone: (650) 604-3574

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Educator Resource Laboratory
Mail Code 130.3
NASA Goddard Space Flight Center
Greenbelt, MD 20771-0001
Phone: (301) 286-8570

CO, KS, NE, NM, ND, OK, SD, TX
JSC Educator Resource Center
Space Center Houston
NASA Johnson Space Center
1601 NASA Road One
Houston, TX 77058-3696
Phone: (281) 483-8696

FL, GA, PR, VI
NASA Educator Resource Laboratory
Mail Code ERL
NASA Kennedy Space Center
Kennedy Space Center, FL 32899-0001
Phone: (407) 867-4090

KY, NC, SC, VA, WV
Virginia Air and Space Museum
NASA Educator Resource Center for
NASA Langley Research Center
600 Settler's Landing Road
Hampton, VA 23669-4033
Phone: (757) 727-0900 x 757

IL, IN, MI, MN, OH, WI
NASA Educator Resource Center
Mail Stop 8-1
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, OH 44135-3191
Phone: (216) 433-2017

AL, AR, IA, LA, MO,TN
U.S. Space and Rocket Center
NASA Educator Resource Center for
NASA Marshall Space Flight Center
P.O. Box 070015
Huntsville, AL 35807-7015
Phone: (256) 544-5812

MS
NASA Educator Resource Center
Building 1200
NASA John C. Stennis Space Center
Stennis Space Center, MS 39529-6000
Phone: (228) 688-3338

NASA Educator Resource Center
JPL Educational Outreach
Mail Stop 601-107
NASA Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109-8099
Phone: (818) 354-6916

CA cities near the center
NASA Educator Resource Center for
NASA Dryden Flight Research Center
45108 N. 3rd Street East
Lancaster, CA 93535
Phone: (805) 948-7347

VA and MD's Eastern Shores
NASA Educator Resource Lab
Education Complex - Visitor Center
Building J-1
NASA Wallops Flight Facility
Wallops Island, VA 23337-5099
Phone: (757) 824-2297 / 2298

Regional Educator Resource Centers (RERCs) offer more educators access to NASA educational materials. NASA has formed partnerships with universities, museums, and other educational institutions to serve as RERCs in many states. A complete list of RERCs is available through CORE, or electronically via NASA Spacelink at *http://spacelink.nasa.gov*

NASA On-line Resources for Educators NASA's Education Home Page serves as a cyber-gateway to information regarding educational programs and services offered by NASA for educators and students across the United States. This high-level directory of information provides specific details and points of contact for all of NASA's educational efforts and Field Center offices.

Educators and students utilizing this site will have access to a comprehensive overview of NASA's educational programs and services, along with a searchable program inventory that has cataloged NASA's educational programs. NASA's on-line resources specifically designed for the educational community are highlighted, as well as home pages offered by NASA's four areas of research and development (including the Aeronautics and Space Transportation, Earth Science, Human Exploration and Development of Space, and Space Science Enterprises).

Access these resources through the NASA Education Home Page: *http://www.hq.nasa.gov/education*

NASA Television (NTV) NASA Television (NTV) features Space Shuttle mission coverage, live special events, interactive educational live shows, electronic field trips, aviation and space news, and historical NASA footage. Programming includes a Video (News) File from noon to 1pm, a NASA Gallery File from 1-2pm, and an Education File from 2-3pm. This sequence is repeated at 3pm, 6pm, and 9pm, Monday through Friday. The Education File features programming for teachers and students on science, mathematics, and technology, including *NASA. . . On the Cutting Edge*, a series of educational live shows.

These interactive live shows let viewers electronically explore the NASA Centers and laboratories or anywhere scientists, astronauts, and researchers are using cutting-edge aerospace technology. The series is free to registered educational institutions. The live shows and all other NTV programming may be taped for later use.

NTV is transmitted on the GE-2 Satellite, Transponder 9C at 85 degrees West longitude, vertical polarization, with a frequency of 3880.0 megahertz (MHz) and audio of 6.8 MHz-or through collaborating distance learning networks and local cable providers. For more information on NASA Television, contact: NASA Headquarters, Code P-2, NASA TV, Washington, DC 20546-0001 — Phone: (202) 358-3572
NTV Home Page: *http://www.hq.nasa.gov/ntv.html*

How to Access NASA's Education Materials and Services, EP-1998-03-345-HQ This brochure serves as a guide to accessing a variety of NASA materials and services for educators. Copies are available through the ERC network, or electronically via NASA Spacelink at *http://spacelink.nasa.gov*