The Solar FAQ

Education Resources

Quick Links

Solar Data Browsing
RHESSI Science Nuggets
RHESSI Browser
RHESSI Flare List
GOES 6 hr, 1,3,7 day plots
Solar Monitor
SolarSoft Latest Events
SDO Images
Fermi Solar
Flare Predictions (Bradford)
SDAC
Max Millennium
RHESSI Wiki

The Solar FAQ

Are all solar flares of the same intensity?

Solar flares are not all the same intensity. In fact, there are many more low-intensity flares than high-intensity flares. The number of flares increases with decreasing intensity right on down to the limit of the sensitivity of the instruments that have been used to detect them.

How often do solar flares occur at solar minimum and at solar maximum, on a day-to-day basis?

This depends upon the flare intensity. The statistics of flares that were detected from 1980 through 1989 with the Hard X-Ray Burst Spectrometer on the Solar Maximum Mission show that flares occurred at an average rate of about one per day at solar minimum. At solar maximum the average rate was as high as 20 per day (averaged over a 6 month interval). So the rate at solar maximum is roughly a factor of ten greater than at solar minimum. It is important to realize, however, that the flare rate is very irregular. There can be long periods of time at solar minimum when no detectable flares occur. Then a large active region can form and produce many flares in just a few days.

What is the duration of a solar flare - minutes? hours? days?

The duration of a solar flare in the energetic hard x-rays is seconds to minutes (this is called the impulsive phase of the flare). The evolution of the less energetic soft x-rays from a flare is more gradual. This emission can last from minutes to hours.

What is the velocity of plasma from a solar flare as it heads toward Earth?

Geomagnetic storms are observed to be primarily if not entirely associated with large ejections of mass from the Sun called coronal mass ejections. Coronal mass ejections (CMEs) were originally thought to be driven by solar flares. It is now known that CMEs may occur without any observable flare associated with them. Likewise, many flares occur with no associated CME. Therefore, phenomena associated with geomagnetic storms such as power grid failures, many satellite failures, and the aurora are most closely associated with CMEs rather than flares. On the other hand, interruptions in radio communications and expansion of the Earth's atmosphere, resulting in increased drag on satellites in low Earth orbit, are associated with radiation from flares. The electromagnetic radiation from flares travels at the speed of light and reaches the Earth in eight minutes. CMEs, on the other hand, travel at speeds from 100 to 1000 kilometers per second and take several days to reach the Earth. The relative importance of studying CMEs versus flares for the purpose of predicting many phenomena at the Earth is presently a subject of much controversy.

One solar flare crippled the communications satellite Anik E1 permanently and temporarily interfered with other satellites - why weren't all affected equally?

The best way to protect sensitive components from energetic particles and, in some cases, radiation is to shield them. (Also, special "hardened" electronic components are used in space.) Shielding adds weight to the satellite and, therefore, increases its cost. The sensitive components on Anik E1 were presumably not shielded well enough to withstand the large storm that occurred. The effects of the storm are not the same at all locations. It may be that Anik was damaged while other satellites were not because it just happened to be in a location where the effects of the storm were particularly intense. The Anik satellites are in high, geosynchronous orbits that expose them to the Earth's radiation belts. But other satellites are in similar orbits.

Where can I find some information pertaining to the effect of solar flares on power transmission lines and the amount of power that could be expected to develop on the lines based on past flares?

Two articles on this topic by John G. Kappenman are Geomagnetic Storms & Impacts on Power Systems: Lessons Learned from Solar Cycle 22 and Outlook for Solar Cycle 23 and Geomagnetic Storms Can Threaten Electric Power Grid. Also see Power Failure in Canada During 1989 from the IPS Radio & Space Services and A Primer on the Space Environment from the NOAA Space Environment Center.

What's the lifespan profile of sunspots?

The lifespan of a sunspot can be anywhere from less than an hour for a small spot to as long as several months.

I've seen reference to a formal naming system for sunspots. Where can this be found?

There is no naming or numbering system for sunspots. There is a system for numbering active regions, however. An active region can contain one or more spots. The National Oceanic and Atmospheric Administration (NOAA) numbers active regions consecutively as they are observed on the Sun. According to David Speich at NOAA, an active region must be observed by two observatories before it is given a number (a region may be numbered before its presence is confirmed by another observatory if a flare is observed to occur in it, however). The present numbering system started on January 5, 1972, and has been consecutive since then. An example of an active region "name" is "AR5128" (AR for Active Region) or "NOAA Region 5128". Since we only see active regions when they are on the side of the Sun facing the Earth, and the Sun rotates approximately once every 27 days (the

equator rotates faster than the poles), the same active region may be seen more than once (if it lasts long enough). In this case the region will be given a new number. Hence, a long-lived active region may get several numbers.

On June 14, 2002, active region number 10000 was reached. For practical, computational reasons, active region numbers continue to have only four digits. Therefore, the sequence of numbers is 9998, 9999, 0000, 0001, and so on. Active region number 10030, for example, is AR0030. This region will often simply be referred to as region number 30, with 10030 implied.

Do solar flares have an effect on the weather?

There is no known relationship between individual solar flares and weather. There is, however, evidence for a relationship between the solar activity cycle and global climate. The best known case is the correlation of a long period of solar inactivity called the Maunder Minimum (1645-1715) with the lowest temperatures recorded during the "Little Ice Age" that occurred from 1500 to 1850. Almost no spots were observed on the Sun during this period. There is evidence for the correlation of other periods of low solar activity with cooler temperatures on Earth as well.

The temperature above the north pole in the stratosphere (about 10 km above the surface of the earth) appears to be correlated with the 11 year sunspot cycle. The stratospheric temperature above the pole is relatively warm or cool when the Sun is active, depending upon which way stratospheric winds are blowing above the equator. There are also other climatic effects that appear to be associated with the sunspot cycle.

The physical mechanism responsible for these apparent correlations is not known. Until such a mechanism is found, the existence of a direct relationship between the solar cycle and climate will not be generally accepted. If you are interested in learning more about this, check out the article "The Sun-Climate Question: Is there a Real Connection?" by George C. Reid.

How are solar flares caused exactly? Can any elements such as metals or chemicals cause solar flares to erupt on the Sun's surface? If so, what kind of elements or chemicals?

Solar flares are thought to result from the build up and explosive release of magnetic energy in the solar atmosphere. The outer layer of the Sun is convective, meaning that the gas rolls up and down like in a pot of boiling water. This ionized gas (plasma) drags the Sun's magnetic field with it, twisting it and strengthening it. In some regions the magnetic field becomes particularly strong and breaks out into the solar atmosphere as discrete, loop-like structures. In active regions where flares occur, these structures either interact or become internally unstable, giving a flare. The signs of a flare are gas rapidly heated to high temperatures, electrons and ions accelerated to high energies, and bulk mass motions. The energy in the magnetic field is thought to be converted into these things through a process called magnetic reconnection, in which oppositely directed magnetic field lines "break" and connect to each other and part of their energy is transferred to the gas in the solar atmosphere. This is the basic picture. Some aspects of it may not be entirely correct and many of the details are not yet understood.

No particular metal or chemical is believed to cause a solar flare. Rather, the flare results from the local interaction of the solar magnetic field with the gas in the outer layer of the Sun and the solar atmosphere.

Can flares erupt on any star's surface, or just the Sun's?

Flares do erupt on the surface of other stars. Most stars are in fact too far away for flares having the brightness of those that occur on the Sun to be observed. However, there are certain stars, called flare stars, that produce flares that are much more energetic than solar flares. There are also certain pairs of stars (close binary stars) that apparently flare as a result of their interaction. We can learn a lot about our Sun and the general processes that drive flares by comparing the similarities and differences in these different stars and star systems.

I am trying to find an historical record of sunspot activity. Do you have such a record or could you direct me to another possible source?

Sunspot numbers are available from the NOAA National Geophysical Data Center. You can find information containing yearly mean sunspot numbers from 1700 to the present, monthly mean sunspot numbers from 1749 to the present, and daily counts from 1980 to the present.

Note that these sunspot numbers are not simply counts of the number of spots on the Sun. They are a weighted sum of the number of sunspot groups and the number of individual spots counted on the Sun each day.

Is there a Web site where current solar activity can be acquired?

Daily information about solar flare activity and a forecast of solar activity can be found at the NOAA "Today's Space Weather" Web page. The 3-day plot of x-ray flux is particularly useful for quickly seeing if a flare has occurred.

Do flares have a measured effect on the ionosphere?

Solar flares do have an effect on the ionosphere. The evolution of the x-ray emission from a flare is mimicked in the ionosphere as a Sudden Ionospheric Disturbance (SID). This particularly affects radio communications at frequencies below around 30 MHz that depend upon the reflection of the signal off the ionosphere for long distance communications. A good place to learn more about this is the Australian Ionospheric Prediction Service's (IPS) "Interesting Facts and Educational Material" Web page.

I am doing a research project on detecting solar flares with a long wave radio. If you could please help me out in any way, or suggest a different way of detecting flares that is not too expensive, I will be grateful.

I can suggest several possibilities. Here are two books that include information about solar radio receivers that an amateur could build:

Beck, R., Hilbrecht, H., Reinsch, K., and Volker, P., Solar Astronomy Handbook. Willmann-Bell, Inc. (Richmond, VA) ISBN 0-943396-47-6 (1995).

Taylor, Peter O., Observing the Sun. Cambridge University Press, ISBN 0-521- 40110-0 (1991).

Also, you should check out the Society of Amateur Radio Astronomers Web site. This site contains a page of additional references. The experienced amateur radio astronomers who belong to this Society can provide motivation and invaluable practical information for such a project.

Which specific types of ions or particles are emitted from a solar flare.

There is an active field of space research dedicated to studying the composition of ions from the Sun in general, and specifically from solar flares. The simple answer to your question is that the types of particles detected in space from solar flares reflect the composition of the solar corona. The corona is mostly hydrogen, so a lot of energetic protons and electrons are observed. Since the protons are heavier and more energetic than the electrons, they are of particular concern because of the damage they can do to astronauts and to electronic equipment. The next most abundant element is helium, which is observed along with its isotope helium-3. Heavier ions such as carbon, oxygen, silicon, iron, and many others are present at a much lower level. The relative abundance and charge state of these ions provide important clues to the processes that energize them.

If you have access to journals and are prepared to deal with a technical paper, I suggest that you look at a paper titled "Composition of Energetic Particles from Solar Flares" by Garrard and Stone in the journal Advances in Space Research (Volume 14, No. 10, pp. 589-598, 1994). This will give you an introduction to this area of research and provide references to other papers on the subject.

How does the sun burn? Is there oxygen in space? Isn't that needed for fire?

The burning in a fire is a chemical reaction, requiring oxygen. If such a chemical reaction were responsible for the heat of the Sun, the Sun would have lasted for less than 100 million years. We know, however, that the Sun must be several billion years old. Therefore, a greater source of energy is required.

We now know that the Sun is powered by nuclear fusion reactions taking place at the center of the glowing ball of gas that we observe from the Earth. Unlike the Earth's atmosphere, most of the gas in the universe is hydrogen. The Sun's energy primarily comes from the fusion of hydrogen into helium. The glow we see from the Sun's surface is from gas that is kept hot by heat from these fusion reactions at the Sun's center. The temperature of the gas at the surface of the Sun is about 6000 degrees. The temperature at the center of the Sun is 16 million degrees!

So, although the Sun is very hot, there is no fire in or on the Sun in the sense of a chemical wood fire or candle flame here on Earth that requires oxygen to burn.

The amount of oxygen in space is tiny compared to the amount of hydrogen (more than 1000 hydrogen atoms for each atom of oxygen). Nevertheless, oxygen is still the third-most abundant element and was necessary for the water and, ultimately, life on Earth. The precise amount of oxygen in the Sun is currently being debated and revised, and this has important consequences for the precise modeling of the Sun's interior.