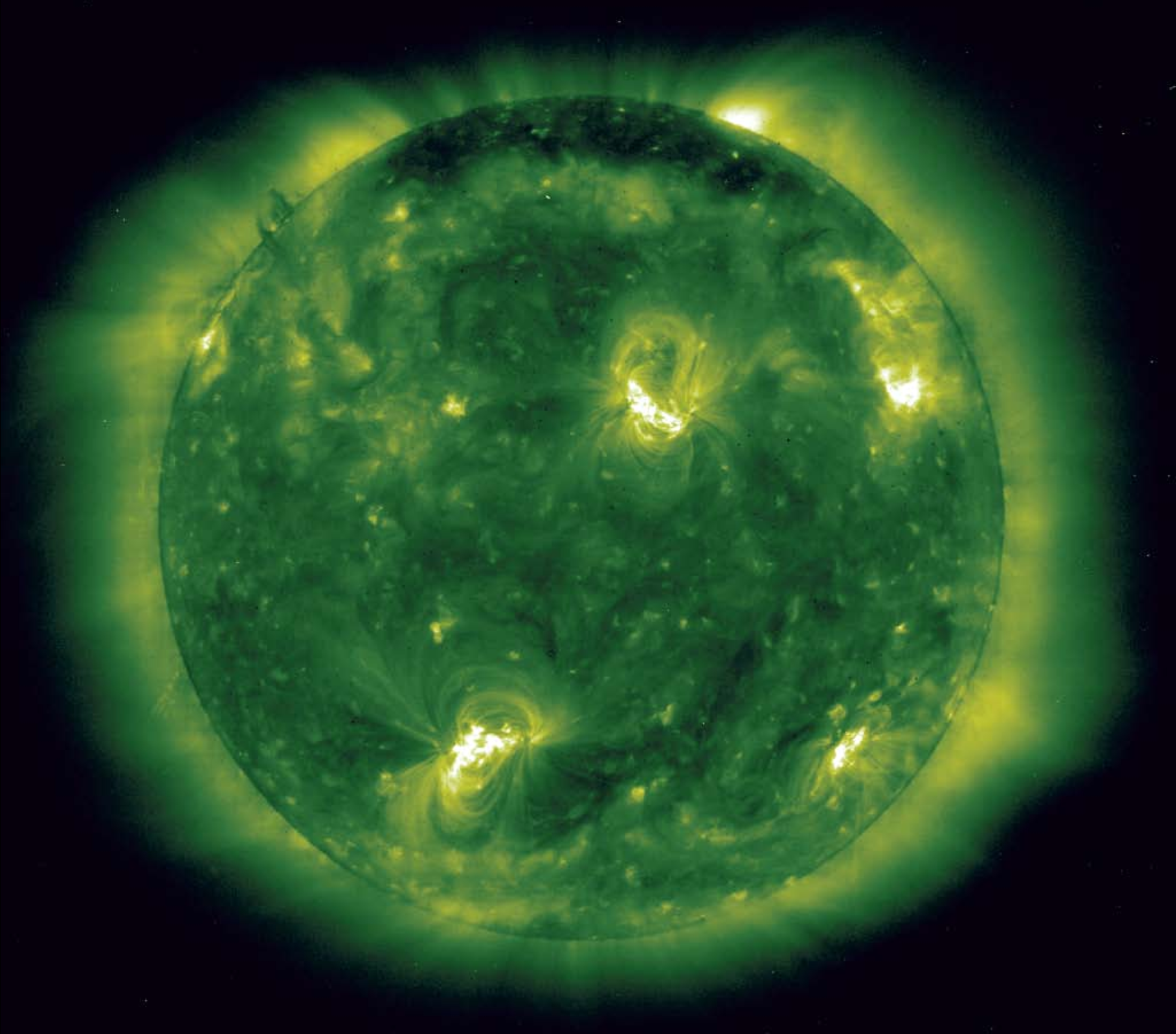
Year of the Sun

Lucie Green



The Sun's corona, seen by the SOHO satellite. This photo was taken using ultraviolet light, so the green colour is artificial.

Space science and technology are an integral part of our lives today. Astronauts have established a permanent presence in orbit, and we communicate and navigate effortlessly via the use of satellites. However, 50 years ago it was a different story.

In 1957 scientists knew very little about the solar system and the planet they lived on. The Sun, the eight planets, comets and asteroids were known to exist, but they were thought of as isolated and unconnected bodies. To further their understanding of the Earth and its place in the solar system, over 60 000 scientists came together to combine their efforts and finances. 1957 was named as International Geophysical Year. Scientists wanted to answer big questions and this required lots of people, money and importantly instruments in space. Contributing to this effort, the first satellites were launched in 1957.

Key words

solar system

spacecraft

telecommunications

power generation

ESA/NASA

In 2007 we are celebrating 50 years of space science with a new initiative that once again draws together scientists from around the world. This time it is the Sun, rather than the Earth, which is taking centre stage. The plans are more ambitious as scientists are working together to understand fundamental processes which take place throughout the entire solar system.

On February 19th 2007 International Heliophysical Year (IHY) was launched to provide a focus for this research. The name doesn't exactly roll off the tongue, but the word *helio* derives from the ancient Greek name for the Sun *helios*. In simple terms, IHY is about the science of the solar system, and in particular the effects the Sun has on the planets.

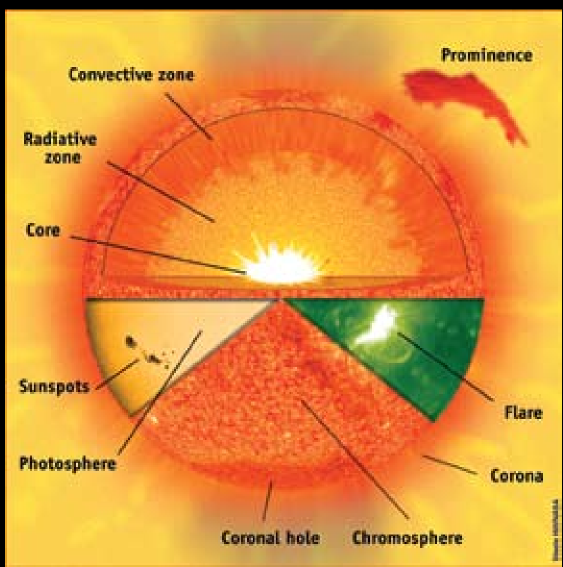
Box 1
International Heliophysical Year

International Heliophysical Year has been launched to celebrate 50 years of space science and to learn more about our Solar System. The scientific aims are:

- **to understand how the planets are affected by the Sun**
- **to learn more about the fundamental physics of the Solar System**
- **to study how the heliosphere interacts with the region beyond called the interstellar medium**

Our changing Sun

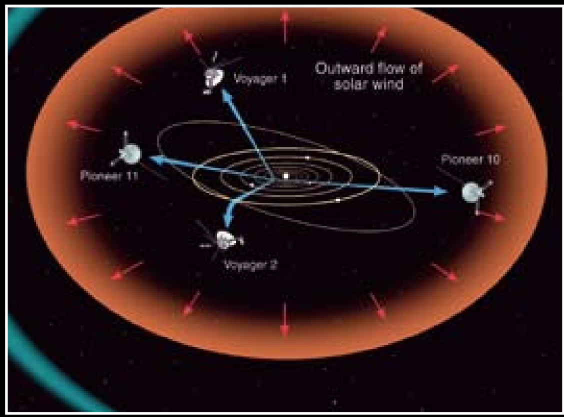
The Sun is a dynamic object. From the Earth we see the Sun's surface, called the photosphere. It is on the photosphere that we see changing black patches called sunspots. Placing our telescopes in space gives us a clear view of the higher layers of the Sun's atmosphere, first the chromosphere and then the corona.



ESA/NASA

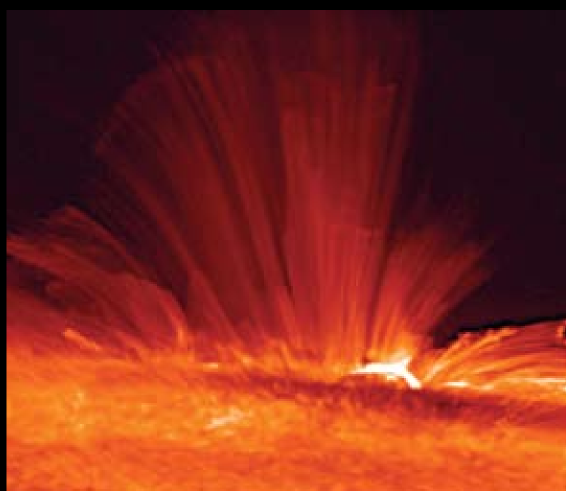
The structure of the Sun

The Sun produces a gusty wind that streams out continuously into the solar system. This solar wind is made up largely of protons and electrons; at the point where it slows down and perhaps even turns back on itself, we have the edge of the solar system. In fact, the solar wind can be thought of as creating a bubble in space and this bubble is known as the heliosphere. The edge of the heliosphere is thought to be over 12 billion km from the Sun.



The heliosphere, showing the vast extent of the Sun's influence.

The Sun is also a magnetic object and its atmosphere is filled with giant magnetic structures which arch up from the photosphere. These magnetic fields are more concentrated in regions arching from sunspots. Just like compressing a spring or twisting a rubber band, these magnetic fields can get distorted and energy starts to build up. Under the right conditions this energy is released, producing a huge explosion that is called a solar flare. Solar flares manifest themselves in many ways and their symptoms last from minutes to hours. They heat up gases in the solar atmosphere to 100 million degrees and they produce radiation across the electromagnetic spectrum from radio waves to gamma rays. They also send a beam of particles (mainly electrons and protons) like a light-house beam out into the solar system.



JAXA/NASA/PPARC

This image, made by the Hinode solar observatory, shows the Sun's chromosphere with its magnetic field rising vertically from a sunspot.

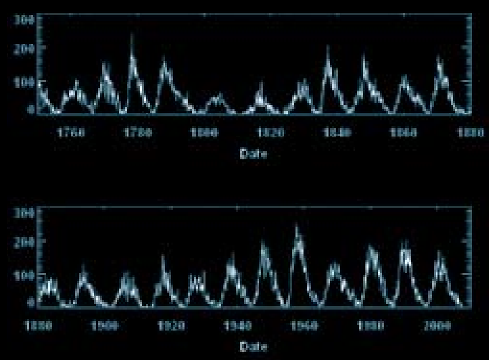
Space hazard

The very energetic particles released by solar flares can pose a problem to astronauts; in particular, it is the protons from the solar flares which are the most dangerous. Humans on the Earth are protected by the atmosphere, but the higher up you go, the less protection you have. If you are an astronaut on the Moon or on your way to Mars you have no natural protection at all! Instead it must be built into spacesuits and the spacecraft. The high energy particles from solar flares can penetrate the human body and lead to radiation sickness and even cancer, in extreme cases. The situation is similar to receiving radiation from a nuclear bomb.

Solar flares also directly affect the ionosphere, the upper-most part of the Earth's atmosphere. The particles in the ionosphere are torn apart by the X-rays and ultra-violet radiation coming from the Sun. During a solar flare the amount of X-rays and UV emitted increases by many thousands and the day-side of the ionosphere becomes more heavily ionised. High frequency radio waves normally bounce off the ionosphere to provide communications over long distances, around the curvature of the Earth. During a solar flare the increased ionisation means that radio waves are absorbed by the ionosphere. This leads to a blackout in the high frequency radio range which can last from minutes to hours and so can seriously disrupt communications using this frequency range. Mariners and aviators who are travelling on the day side of the Earth may be affected; for example, flights that go over the poles rely on HF radio communications for a large part of the route. Blackouts can last for many hours. In 2001 (just after a solar maximum) 25 flights were diverted during a 23 day period as a result of solar flare alerts.

Solar activity, including solar flares and the number of sunspots, follows a cycle. Over 11 years the Sun goes from being very quiet with very few sunspots, to being very active, and back to quiet again. In 2007 we are currently at a minimum in solar activity but the Sun is still an interesting object to study even at this time.

In 1989, 6 million Canadians lost their power



The number of sunspots visible on the Sun's face clearly follows a cycle.

when a magnetic storm took place. In this case a coronal mass ejection (CME) was responsible, rather than a solar flare. CMEs are huge bubbles of solar magnetic field and hot gases which erupt into space at speeds of thousand of kilometres per second. The CME hit the Earth's magnetic field and interacted with it. Immense currents were generated around and through the Earth. These currents find the path of least resistance and in this case it was the power lines of the Hydro-Quebec power grid! The overload of current brought the system down.

The Sun from space

Scientists today view the Sun and the Earth as forming a connected and dynamic system, and the effects mentioned above are just two of many ways that we feel the influence of the Sun. During IHY around twelve space missions will be studying this connected system, with scientists in international teams analysing the data. Two of the most important solar missions being used during IHY are called STEREO and Hinode. STEREO is a NASA mission which UK scientists are contributing to. It is a unique mission that uses a pair of spacecraft, one behind the Earth in its orbit, and one ahead. Just as two eyes can give us a sense of depth and perspective, the two STEREO spacecraft will be able to build up 3-D images of the Sun's magnetic arches. The Hinode mission is a Japanese mission that UK scientists are contributing to. Hinode will also study the giant magnetic structures in the Sun's atmosphere and help us understand why solar flares happen.

Lucie Green has been observing the Sun since she was a student at Sussex University. Now she works at the Mullard Space Science Laboratory as well as giving talks about astronomy and space science on TV and radio, and in schools.

Look here!

For more information on IHY visit
www.sunearthplan.net
For more information on how the Sun affects the Earth visit www.windows.ucar.edu and click on 'space weather'.

Box 2 Did you know?

There are around 12 space missions studying the Sun and how the Sun affects the Earth during International Heliophysical Year.
The charged particles of the solar wind form an electrical current connecting the Sun and the Earth. Between one and ten million amps flows in the circuit!
The Sun's activity follows a cycle which lasts roughly 11 years. This cycle was first realised through watching how the number of sunspots on the Sun varies with time.

There were nine planets in the solar system until last year (2006), when Pluto was reclassified by International Astronomical Union – now it is classed as a dwarf planet.

The element helium (symbol He) gets its name from *Helios*, the Sun. The gas was discovered when the elements in the Sun were first identified by analysing the spectrum of sunlight.