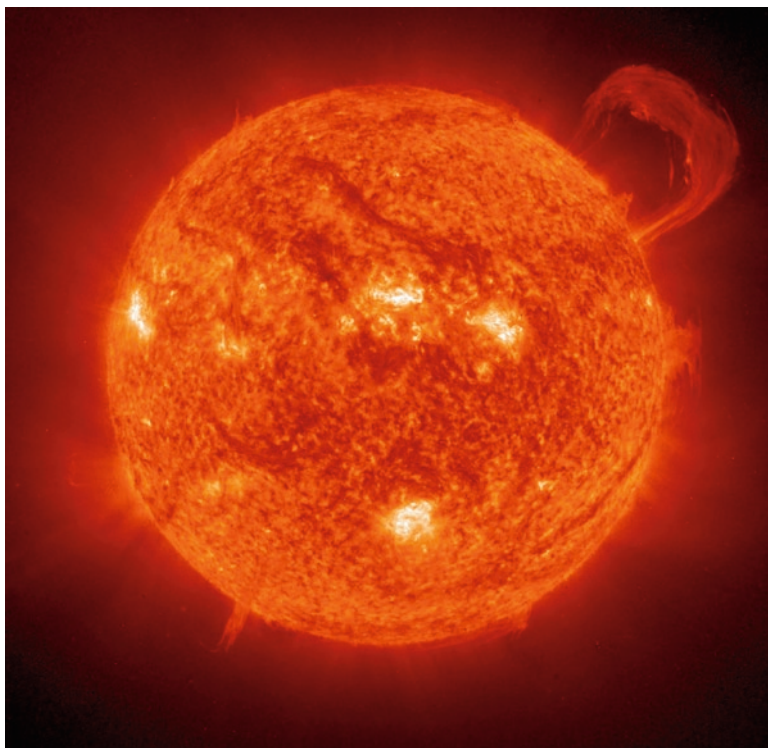


Chapter 2

The Turbulent Sun



The Sun (SOHO)

It had been some time since a programme had been devoted entirely to the Sun, and it seemed that one now would be appropriate. For this, I was joined by Professor John Brown (the Astronomer Royal for Scotland), Dr Lyndsay Fletcher of Glasgow university and (from La Palma in the Canary islands) Dr Goran Scharmer, who talked to Chris Lintott. In my garden, outside my observatory dome, were Keith Johnson, Alan Clitherow, Ninian Boyle and others, suitably equipped with telescopes. As usual, the Selsey weather was kind.

To us, the Sun is the most splendid object in the sky; it is all-important, and without it the Earth would not have been born. True, it is only a normal star – 1 of 100,000 million in our Galaxy – but it is the only star close enough to be studied in detail; it is a mere 93 million miles away, and light from it can reach us in only 8.6 min. Light from the nearest star beyond the Sun, Proxima Centauri, takes over 4 years to reach us. Represent the Earth–Sun distance by one inch, and Proxima will be over 4 miles away.

The Sun is large; its diameter is around 865,000 miles, and it could hold over a million bodies, the volume of the Earth. It is also very hot. At its surface the temperature is not less than 6,000°, and at its core a thermometer would register about 15 million degrees – assuming that a thermometer could survive there!

The Sun is a gaseous throughout. It is not burning in the conventional sense; a Sun made up of coal and radiating as fiercely as the Sun actually does would turn to ashes in a million years or so. But we know that the age of the Earth is 4,600,000,000 years, and the Sun is certainly older than that. According to modern theory, it was formed from a cloud of dust and gas inside a nebula 5,000 million years ago, and it will be another 5,000 million years before anything dramatic happens to it so that by cosmological standards, it is no more than middle-aged.

The core is the Sun's power house, where its energy is being created. It contains a vast amount of hydrogen, which is the most plentiful element in the universe (atoms, of hydrogen outnumber the numbers of all other elements combined). At the core, where the temperature and pressure are so high, the nuclei of hydrogen atoms are combining to make up nuclei of another element, helium. It takes four hydrogen nuclei to form one helium nucleus; every time this happens, a little energy is set free and a little mass is lost. It is this liberated energy that makes the Sun shine, and the mass-lost amounts to four million tons per second so that the Sun now "weighs" much less than it did when you began to read this page. However, please do not be alarmed – there is plenty of hydrogen fuel left. To quote Corporal Jones, "Don't panic!"

The Sun's bright surface is known as the photosphere. It is not as placid as it may seem; it shows granular structure, and very often there are dark patches known as sunspots. The spots are huge by terrestrial standards, but are not permanent; even large spots-groups seldom last for more than a few weeks or months. Neither is then in view continuously. The Sun is spinning on its axis, taking an average of 28 days to complete one turn so that a spot will be carried slowly across the disk until it passes over the limb. A fortnight or so later, it will reappear at the opposite limb, provided that it still exists. Spots generally appear in groups, though single spots are not uncommon; some spots are regular in shape, others irregular. A regular spot will have a dark central "Umbra", surrounded by a lighter "Penumbra". Many Umbrae may be contained in one penumbral mass; a typical group has two main spots, a leader and a follower.

Sunspots are essentially magnetic phenomena. Lines of magnetic force run below the solar surface; when they break through the photosphere they cool it down, and a sunspot is the result. In fact a spot is not really dark; It appears so only because it is around 2,000° cooler than its surroundings. If it could be seen shining on its own,

its surface brightness would be greater than that of an arc-lamp. Spots are usually associated with brilliant, high altitude clouds known as faculae (Latin, torches).

A word of warning here: Solar observing can be dangerous, and to look straight at the Sun through any telescope or binoculars will result in eye damage – perhaps blindness – unless careful precautions are taken. Fitting a dark filter over the telescope eyepiece is not recommended for the newcomer; filters may not give full protection and are liable to splinter without warning. Mylar filters can be used – but make sure you know exactly what you are doing. To use the telescope as a projector and send the Sun’s image on to a card held or fixed behind the eye piece is far better. In general, a refracting telescope is better than a reflector for solar work. Remember, too, that the Sun is still dangerous when it is low in the sky, veiled by haze, and looks deceptively mild and harmless. A moment’s carelessness may have tragic results, and, sadly, accidents of this kind have happened in the past. (Some small, cheap telescopes are sold together with dark “Sun caps” for direct viewing. If you have one of these caps, throw it away.)

Above the photosphere comes the layer known as the chromosphere, and above the chromosphere we come to the corona, made up of very tenuous gas. Normally, the chromosphere and the corona cannot be seen with the naked eye, or with a straightforward telescope; we have to wait for a total solar eclipse when the Moon passes directly in front of the Sun and obligingly blocks out the photosphere for a brief period (never as long as eight minutes and usually much less). Unfortunately, total eclipses are rare as seen from any particular location, and generally we have to depend upon instruments based upon the principal of the spectroscope. Consider flares, for example, which occur in the chromosphere, and are immensely energetic. Very few have been observed with ordinary telescopes; the first was seen in 1859 by one of the great pioneer solar observers, Richard Carrington. I have never seen one myself.

A flare begins in the lower chromosphere; it rises upwards, sending out charged particles that cross the 93,000,000-mile gap and reach the Earth, meeting the top of the atmosphere and causing the lovely aurorae or polar lights as well as causing magnetic storms and interfering with radio communication. Flares are usually (not always) associated with spot-groups, which means that they are commonest when the Sun is most active. Equipment now is less expensive than it used to be; for example, the serious solar observer will need a telescope design to cut out all light except that from, say, incandescent hydrogen. If you can afford £400, you can set up a proper solar observing station. This may sound a large sum – until you compare it with a new laptop or a couple of railway tickets between London and Glasgow! There are also phenomena such as Coronal Mass Ejections (CMEs), when huge quantities of gas are sent out, never to fall back into the Sun.

There is a reasonably well-defined solar cycle with a mean period of 11 years; at maximum, many spot-groups may be on view at the same time, while at minimum the disk may be clear for several consecutive days or even a week or two. The last maximum fell in 2001 so that the next is due in 2012, but we cannot be precise, because the cycle is not perfectly regular. Moreover there have been protracted minima in the past, for reasons which are not known; for example there were few

spots between 1645 and 1715, and this so-called Maunder Minimum (named after E.W. Maunder, who was one of the first to draw attention to it) also marked a cold spell nicknamed the Little Ice Age. In England, during the 1680s, the Thames froze every winter, and frost fairs were held on it; in Holland, canals also froze. There have been earlier cold spells, obviously less well documented, which also seemed to be linked with solar activity, and many evidences are accumulating that shows global warming and cooling is due to the Sun and not of human activity as Politically Correct politicians claim. (*En passant*, similar effects apply to Mars – and there are no Martian factories as yet!)

Today the Sun is under constant surveillance from Earth, and there are many solar observatories such as the Swedish station at La Palma. There are also satellites such as immensely successful Solar and Heliospheric Observatory (SOHO). New space missions and new methods of investigations are being planned, and we may hope that in the reasonably, near future we will solve some of the problems which still baffle us. There is a role here for amateur astronomers, but never forget the dangers; a cat may look at a king, but an observer must always be wary of looking directly at the Sun.



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