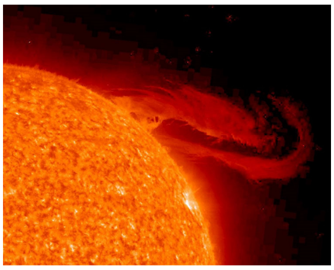
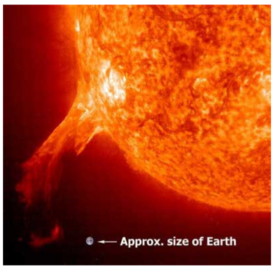
Sun - Part 25 - Solar flares





Solar flares

These are a sudden release of energy in the Sun's corona, visible as flashes of brightness erupting from above the Sun's surface. They usually occur within about 175,000 km of the photosphere and can last up to several hours and, exceptionally, as long as a day. Frequency of flare occurrence varies from several per day when the Sun is particularly active to less than one a week when it is quiet. Large flares are less frequent than smaller ones. Flare frequency shows a pattern which follows the 11-year solar cycle.

They emit radiation across the whole spectrum. Travelling at the speed of light, this can reach Earth in around eigh minutes. A flare also ejects clouds of electrons, ions and atoms through the corona into space. Only the most energetic are visible in white light. If a flare is directed towards Earth, its energetic particles, travelling up to 70% of the speed of light, can arrive within 15 minutes.

The first observation of a solar flare occurred in 1859. While observing sunspots through his optical telescope with a solar filter, the English astronomer Richard Carrington observed a very intense white light flare. The event was also independently observed by Richard Hodgson, an amateur astronomer. Carrington's observation was confirmed by a blip in the tracing of a nearby magnetometer. This blip is now known to have been caused by the effect of the flare's X-ray energetic particles on Earth's ionosphere. At the time, however, X-rays had not yet been discovered, nor the existence of the ionosphere recognised. What these two men observed was, in fact, the most powerful flare ever observed, to date, which is why it was so visible. The solar storm of 1859 is known as the Carrington event.

The flare left a trace in Greenland ice and, for many years, this was the only source of information on flares. In 1942, radar operator Stanley Hey unintentionally observed radiation which he interpreted as solar emission. Others found the same, but the discovery only went public in 1945 after World War 2 ended. Following the first radio astronomy solar observations, which began in 1843, later radio astronomers identified several features of solar activity including solar flares. Radio telescopes continue to be important for flare observation.

More recently, space telescopes became useful tools for observing solar flares. Located beyond the atmosphere, which absorbs wavelengths shorter than ultraviolet, they operate at X-ray wavelengths, where flares may be very bright. Flares are also observed from dedicated Earth-based solar telescopes.

Flares occur when accelerated charged particles, mainly electrons, interact with the plasma medium in active regions round sunspots, where intense magnetic fields penetrate the photosphere to link the corona to the Sun's interior. Acceleration of the charged particles is a result of magnetic reconnection, often in solar arcades (series of closely occurring loops of magnetic lines of force). Reconnection is a physical process in which highly stretched or twisted magnetic field rapidly relaxes into low-stress configurations. The process can leave unconnected areas of field, which initiates a sudden release of energy and particles as flares. This explains why flares typically erupt from active regions of the Sun where magnetic fields are much stronger, on average.

Although the cause of solar flares is understood, is is unclear how magnetic energy is transformed into particle kinetic energy, nor how particles are accelerated to such high energies. Also, like other features of solar activity, scientists are unable to forecast the occurrence of flares, although their association with sunspots can provide some opportunity, although only as probabilities.

Solar flares affect all layers of the solar atmosphere; photosphere, chromosphere and corona. The plasma medium is heated to tens of millions K while the electrons, protons and heavier ions are accelerated near to the speed of light. They produce radiation across all wavelengths of the electromagnetic spectrum, from gamma to radio. Most energy is spread over frequencies outside visual range, so the majority of flares are only observable with special instruments.

The same energy release producing flares can also produce larger coronal mass ejections (CME) and this is often the case. However, causal links between these and flares are not well established

Hazards Flares strongly influence local space weather. The solar wind carries their streams of highly energetic particles and can impact Earth's magnetosphere, causing geomagnetic storms and presenting radiation hazards to spacecraft and astronauts. If accompanied by CMEs, they can trigger storms powerful enough to disable satellites and knock out power grids. X-ray and ultraviolet radiation from flares can affect the ionosphere and disrupt long range radio communications. X-ray radiation can also heat the outer atmosphere, increasing drag on satellites and leading to orbital decay.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed rev, www.en.wikipedia.org