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Perspective

What is Exactly a Solar Flare?

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ABOUT THE STUDY

A solar flare is an intense eruption of an electromagnetic wave within the Sun's atmosphere. Flares occur in active regions and are often, but not always, accompanied by coronal mass ejections, solar particle events, and other solar phenomena. Solar flares have an effect on all layers of the solar atmosphere (photosphere, chromosphere, and corona). The plasma medium is heated to millions of kelvins, whereas electrons, protons, and heavier ions are accelerated to near the speed of light. Flares produce radiation across the electromagnetic spectrum at all wavelengths, from radio waves to gamma rays. Most of the energy is spread over frequencies outside the visual range; the majority of the flares isn't visible to the eye and should be observed with special instruments. Flares occur in active regions typically around sunspots, wherever intense magnetic fields penetrate the photosphere to link the corona to the solar interior.

Flares occur when accelerated charged particles, primarily electrons, interact with the plasma medium. Evidence suggests that the phenomenon of magnetic reconnection results in this extreme acceleration of charged particles. On the Sun, magnetic reconnection could happen on solar arcades-a series of closely occurring loops following magnetic lines of force. These lines of force quickly reconnect into a lower arcade of loops leaving a helix of magnetic field unconnected to the rest of the arcade. The sudden release of energy during this reconnection is the origin of particle acceleration. The unconnected magnetic spiral field and also the material that it contains may violently expand outward forming a coronal mass ejection. This also explains why solar flares generally erupt from active regions on the Sun wherever magnetic fields are much stronger.

Although there's a general agreement on the source of a flare's energy, the mechanisms involved are still not well understood. It isn't clear how the magnetic energy is transformed into the kinetic energy of the particles, nor is it noted how some particles can be accelerated. There are some inconsistencies regarding the entire number of accelerated particles that generally appear to be greater than the entire number in the coronal loop. Scientists are unable to forecast flares.

Solar flares cause no direct danger to humans on the Earth's surface. The harmful radiation emitted by flares, primarily X-rays, is absorbed by the daylight side of Earth's atmosphere and doesn't reach the Earth's surface. However, this absorption of high-energy radiation will temporarily increase the ionization of the upper atmosphere, which might interfere with short-wave radio communication and may temporarily heat and expand the Earth's outer atmosphere. This expansion can cause increased drag on satellites in low Earth orbit and may result in orbital decay over time.

The radiation risks posed by solar flares are a significant concern in discussions of a human mission to Mars, the Moon, or other planets. Energetic protons can pass through the human body, causing biochemical harm, presenting a hazard to astronauts during interplanetary travel. Some reasonably physical or magnetic shielding would be needed to shield the astronauts. Most proton storms take at least two hours from the time of visual detection to reach Earth's orbit. A solar flare on January 20, 2005, released the highest concentration of protons ever directly measured, which would have given astronauts on the moon little time to reach shelter.

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