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## **SOLAR FLARE**

**Ken Tapping, 29<sup>th</sup> May, 2018**

The Sun has many times demonstrated its power to disrupt our power, communication and transportation infrastructure, and to cause problems for many aspects of our lives. The power outages in March 1989 are an example. As time passes we are finding more things the Sun can do.

The Sun is a big ball of mainly hydrogen gas about 1.5 million kilometres in diameter. In the core, where the temperatures are in the 10-20 million degree range, nuclear fusion is taking place, where hydrogen is being converted to helium, and in the process producing the energy that makes the Sun shine. The energy output is equivalent to the total annihilation of 400 million tonnes of hydrogen per second. To help illustrate how enormous an energy output it is, a ten billion-watt power station is converting one millionth of a kilogramme of material into energy per second.

However, this is not the whole story. The Sun is a ball of gas, and not a solid object. Its equatorial latitudes rotate faster than the polar latitudes, and the core probably rotates faster still. In addition material near the core gets hot, and rises to the surface by convection, where it radiates its energy to space and then submerges again. The churning material generates electric currents, which in turn create magnetic fields. These combine with the hot material to form jelly-like plasma magnetic flux ropes permeating the interior of the Sun.

Sometimes a magnetic flux rope gets caught by the convection and dragged to the surface, where it erupts up through it, forming giant loops. The magnetic fields are so strong they interfere with the transfer of energy; making it "cooler", 3,000 C rather than the 6,000 C of the surrounding surface, so that it looks darker – a sunspot. The magnetic fields spread out, and then dive back down.

As the magnetic fields continually rearrange and more magnetic fields come up, the loops get twisted, crowded and stretched. Just as in the case of a stretched and twisted elastic band, lots of energy gets stored in the stressed magnetic

fields. These distortions lead to increasing electric currents. There is a limit to how much current these loops can take. If this limit is not reached, the stresses may gradually relax over days. However, if the limit is exceeded anywhere in the magnetic structure, all that stored energy may be released, catastrophically.

Somewhere in the structure, the magnetic field tears, locally releasing the stress. This generates more stress in the surrounding material so the tearing grows and spreads. Imagine the snapping of an overly-stressed elastic band. The broken magnetic field lines then reconnect into a low-stress configuration, and all that stored energy is released, equivalent to millions of 100-megaton hydrogen bombs let off at once. The result is bursts of X-rays, which cause communication blackouts, high-energy particles which fry satellite electronics and endanger astronauts, and bursts of radio emission. In many cases a large mass, maybe 1.5 billion tonnes of solar material is ejected off into space at up to 3,000 km/sec. This is a coronal mass ejection or CME. If one of those is shot in our direction, it takes between 24 and 48 hours to reach us, and when it hits the Earth's protective magnetic field, we get magnetic storms, power outages and other disruptions.

We also get displays of aurora. Back in the days when we were not dependent upon our complex infrastructure, we just got to enjoy the aurora. Today, our street lights make it difficult to appreciate the night sky. However, a big magnetic storm will give us a bright aurora and also shut off the lights so we can more easily enjoy its beauty.

After sunset Venus is spectacular in the west and Jupiter almost as spectacular in the southeast. Saturn, fainter and golden coloured, rises around midnight and Mars, much fainter and reddish, about 1 am. The Moon will be Full on the 29<sup>th</sup>.

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