Scientific breakthrough will help protect astronauts and spacecraft

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A breakthrough by a team of British, US and French scientists will help protect astronauts, spacecraft and satellites from radiation hazards experienced in space.
Reporting in the journal *Nature* this week, the team describe how their study of rare and unusual space storms provided a unique opportunity to test conflicting theories about the behaviour of high energy particles in the Van Allen radiation belts* - a volatile region 12000 miles (19,000 km) above the Earth.

Lead author, Dr Richard Horne of the British Antarctic Survey (BAS) says "Solar storms can increase radiation in the Van Allen belts to levels that pose a threat to spacecraft. As modern society relies increasingly on satellites for business, communications, and security, it is important to understand the environment that spacecraft operate in so that we can help protect our space investment.

"For a long time scientists have been trying to explain why the number of charged particles inside the belts vary so much. Our major breakthrough came when we observed two rare space storms that occurred almost back-to-back in October and November 2003. During the storms part of the Van Allen radiation belt was drained of electrons and then reformed much closer to the Earth in a region usually thought to be relatively safe for satellites.

"When the radiation belts reformed they did not increase according to a long-held theory of particle acceleration. Instead, by using scientific

instruments in Antarctica and on the CLUSTER mission satellites, we showed that very low frequency radio waves caused the particle acceleration and intensified the belts.

"This new information will help spacecraft operators and space weather forecasters who must predict when satellites and missions are most at risk from radiation events allowing them to take measures to protect instruments and systems from damage, and astronauts from risks to their health."

* Van Allen radiation belts

The Van Allen radiation belts were the foremost discovery of the space age after being detected by the first US satellite Explorer I, which was launched during the International Geophysical Year of 1957-58. They are composed of energetic charged particles trapped inside the Earth's magnetic field, which surrounds the Earth like a ring doughnut. They vary according to solar activity. Other planets with magnetic fields, such as Jupiter and Saturn, also have radiation belts. At present it is not known how the radiation belts at the other planets are formed, but the wave acceleration theory presented here could apply.

The 'old' theory

Until now it was believed that the electrons within the belts were accelerated by radial diffusion. This can be explained by thinking of the Earth's magnetic field as elastic bands. If the bands are plucked, they wobble. If they wobble at the same rate as the particles drifting around the Earth then the particles can be driven across the magnetic field and accelerated. This process is known as radial diffusion and is driven by solar activity. The new research presented here shows that this theory is now inadequate.

Space storms

Antarctica is our 'window on space'. Magnetic space storms damage spacecraft, disrupt power supplies, communications & navigation systems and alter satellite orbits. BAS scientists are attempting to predict Space Weather through a better understanding of the complex process that take place when the Earth and Sun's magnetic fields meet. BAS scientists use several different technologies to measure variations in the Earth's magnetic field. Data from these studies are used in mathematical models to test theoretical ideas. This research makes a major contribution to international global research programmes that involve spacecraft and networks of ground-based scientific instruments.

Whistler mode chorus waves

During magnetic storms very low frequency radio waves (in the audio range below 20 kHz) are generated in space by low energy electrons. The waves can be guided along the magnetic field down to the ground in the polar regions. Under some conditions the waves can accelerate a small number of electrons to very high energies and trap them in space. These are the particles that damage spacecraft. But under other conditions they can drain the radiation belts by dumping energetic particles down into the upper atmosphere and change its chemistry as a result.

Source: British Antarctic Survey