Mysteries of Earth's radiation belts uncovered by Van Allen Probes twin spacecraft

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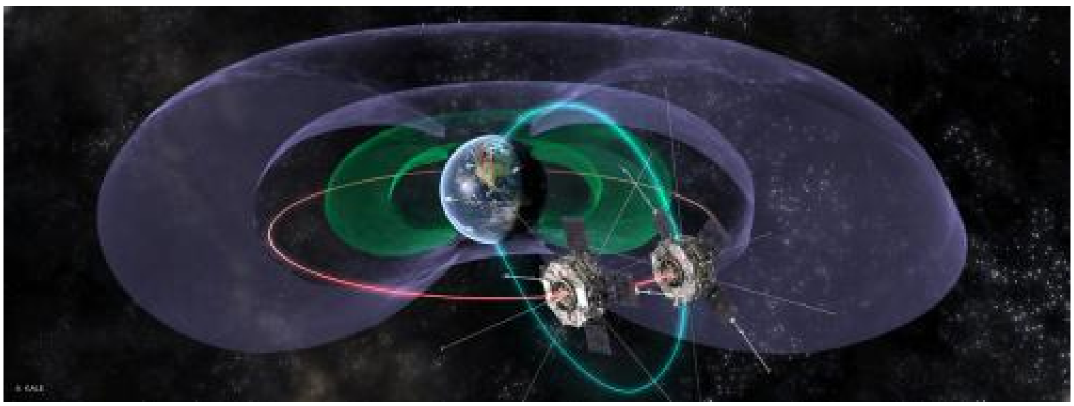

The twin Van Allen Probes were launched on August 30, 2012 into elliptical, near-equatorial orbits around the Earth. Remarkably, rather than seeing just the well-known two-belt structure, the mission found almost immediate evidence of the clear three-belt structure portrayed in green in this diagram. Image courtesy of Andy Kale, University of Alberta.

Just over a year since launch, NASA's Van Allen Probes mission continues to unravel longstanding mysteries of Earth's high-energy radiation belts that encircle our planet and pose hazards to orbiting satellites and astronauts.

Derived from measurements taken by a University of New Hampshire-led instrument on board the twin spacecraft, the latest discovery reveals that the high-energy particles populating the radiation belts can be accelerated to nearly the speed of light in conjunction with ultra-low frequency electromagnetic waves operating on a planetary scale.

This mode of action, as detailed in a paper recently published in the journal *Nature Communications*, is analogous to that of a cyclical particle accelerator like the Large Hadron Collider. However, in this case, the Earth's vast magnetic field, or magnetosphere, which contains the Van Allen belts, revs up drifting electrons to ever-higher speeds as they circle the planet from west to east.

The recent finding comes on the heels of a related discovery—also made by the UNH-led Energetic Particle, Composition, and Thermal Plasma (ECT) instrument suite—showing similar particle acceleration but on a microscopic rather than a planetary scale.

"The acceleration we first reported operates on the scale size of an electron's gyromotion—it is a really local process, maybe only a few hundred meters in size," notes Harlan Spence, director of the UNH Institute for the Study of Earth, Oceans, and Space, principal scientist for the ECT, and coauthor on the *Nature Communications* paper. "Now we're seeing this large-scale, global motion involving ultra low-frequency waves pulsing through Earth's magnetosphere and operating across vast distances up to hundreds of thousands of kilometers." And, Spence adds, in all likelihood both processes are occurring simultaneously to accelerate particles to relativistic speeds.

Understanding the complex dynamics of the particle acceleration will help scientists make better predictions of space weather conditions and, thus, offer better protections to orbiting satellites crucial to modern-day society.

Having twin spacecraft making simultaneous measurements in different regions of nearby space is a key part of the mission as it allows the scientists to look at data separated in both space and time.

"With the Van Allen Probes, I like to think there's no place for these particles to hide because each spacecraft is spinning and 'glimpses' the entire sky with its detector 'eyes', so we're essentially getting a 360-degree view in terms of direction, position, energy, and time," Spence says.

Adds Ian Mann of the University of Alberta and first author of the *Nature Communications* paper, "People have considered that this acceleration process might be present but we haven't been able to see it clearly until the Van Allen Probes."

What this provides is the ability to decipher actual changes in the surrounding region rather than encountering something that looks different but may simply be the result of a single-point measurement with a limited perspective.

With the discoveries, scientists are starting to unravel the different pieces of the puzzle for any particular particle event that changes the structure of the radiation belts. Ultimately they hope to be able to understand the dynamics well enough to actually predict how, collectively, all these different conditions working in tandem make the belts either move in or out, inflate, deflate, change energy, or lose or gain particles.

Says Spence, "What we hope for are those serendipitous occasions when nature has accentuated one process above all others, which allows the spacecraft to really see what's going on. We want to know how the whole system causes one phenomenon or process to dominate or have a lesser influence compared to another one, and we're gaining a much deeper understanding of that."

More information: www.nature.com/ncomms/2013/131 … full/ncomms3795.html

Provided by University of New Hampshire