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Earth & Space Science News

NEW PLANS FOR OCEAN DRILLING

A Human-Created Barrier to "Killer Electrons"

Investments in Scientific Research Drive Innovation

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Human Radio Transmissions Create Barrier to "Killer Electrons"

Scientists have discovered that radio transmissions from Earth have helped to build a shield-like "impenetrable barrier" in space that scatters high-energy electrons and prevents them from coming closer to our planet.

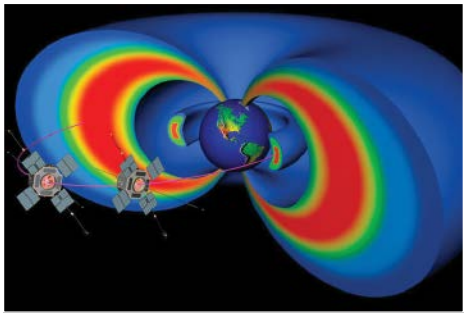
Since the 1950s, humans have communicated—particularly with submarines deep in the ocean—using very low frequency (VLF) radio transmissions at lower frequencies than your favorite sports cast or talk show. After a fortuitous solar storm on 17 March 2015, scientists discovered that it may be these very transmissions that create a protective "VLF bubble" (http://bit.ly/Space-Barrier) that blocks high-energy "killer electrons." These electrons, which can damage satellites, as well as future travelers to the Moon or Mars, zip around the Earth within doughnut-shaped regions of space called the Van Allen radiation belts.

"To us it was an amazing insight" that came from NASA's Van Allen probes. These probes continuously take measurements of the two "doughnuts" of high-energy particles that encircle the Earth, said Daniel Baker, director of the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics on 14 December at the 2015 AGU Fall Meeting in San Francisco, Calif. (see http://bit.ly/barrier-talk).

"Because powerful VLF transmitters have been operating since before the dawn of the space era, it is possible that we have never observed the radiation belts in their pristine, unperturbed state," said John Foster, a scientist at the Massachusetts Institute of Technology's Haystack Observatory and lead author on the new research.

A Cosmic Electric Fence

Baker and his colleagues discovered the impenetrable barrier—which lies at the inner edge of the outer Van Allen radiation belt—in 2014 but only closely investigated natural causes. The impenetrable barrier is set up when high-energy particles from the Sun hurtle toward Earth during a solar storm. When such a storm occurs, the edge of Earth's plasmasphere—an amorphous cloud of plasma surrounding the Earth—erodes closer to the planet. When the researchers first discovered the barrier, they suspected that the plasmasphere had something to do with its development—but they weren't sure of the underlying mechanism.



NASA

Two doughnut-shaped regions of high-energy particles make up the Van Allen radiation belts. Scientists discovered that very low frequency radio transmissions from Earth may help to create an "impenetrable barrier" at the inner edge of the outer belt that keeps the belt's "killer electrons" away from Earth.

Last year, with VLF transmissions in mind, the scientists analyzed data from the Van Allen probes after the March 2015 solar storm and found that when the outer Van Allen radiation belt was recovering from the solar onslaught, the edge of the VLF bubble matched up exactly at the same distance as the impenetrable barrier, about 12,000 kilometers from Earth.

"We've got a satellite that measures all the things at the same time," Foster said. "It sees the outer edge of the VLF transmitter bubble."

The researchers found that the solar storm actually pushed the edge of the plasmasphere inside the VLF bubble, allowing the VLF waves to interact with high-energy electrons within the Van Allen belt, kicking them out of the belt. These electrons are then lost within the Earth's atmosphere, where they lose their highly energetic "killer" characteristic by spreading their energy among a vast number of other particles at lower altitudes, Foster said.

This impenetrable barrier limits "the earthward, inward extent of these high-energy killer electrons during the very time period when their acceleration, when their energization—which is part of a geomagnetic storm—is taking place," Foster said.

But this mechanism is observed only during a solar storm, when the plasmasphere is eroded, he noted.

Think of the impenetrable barrier as an electric fence around Earth. Any intruder who tries to climb the fence gets an electric shock—but the rest of the time, the fence sits idle. Our cosmic electric fence repels highly energetic electrons when they get pushed in by an outburst from the Sun. In this way, scientists don't "see" the effects of the impenetrable barrier until something "provokes" it.

"During the time period when it can be helpful"—such as during a solar storm, which has the potential to knock out communications on Earth—"it's actually there," Foster said.

Future Warfare Defense?

The U.S. Air Force has been studying the Van Allen radiation belts since they were discovered in the 1950s and once conducted experiments by detonating nuclear bombs in this region to create artificial radiation belts for potential wartime purposes. Now that scientists have discovered the protective bubble of VLF transmissions, Foster said, they can perhaps start investigating how this mechanism could be harnessed deliberately, for defense purposes.

"In any kind of a war, one tactic could be to launch a nuclear weapon into space over your enemy's territory and explode it," Foster said, which would render the enemy essentially blind, as the electromagnetic radiation would knock out all their communication satellites. But if there was a way to get rid of an artificial radiation belt quickly—by using VLF transmissions—the military would want to know about it.

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This research shows that "you can really use ground-based systems to get rid of these electrons pretty quickly," instead of trying to go into space with powerful wave emitters to defend from a potential attack, Baker said.

But that's all for a day when scientists better understand the interactions between VLF transmissions and the radiation belts—for now, Foster says that understanding this impenetrable barrier is important for protecting our satellites from the naturally occurring, high-energy particles in space.

In fact, Baker dreams that one day during a solar storm, the VLF transmitters could be turned off—just to see what would happen.

By **JoAnna Wendel,** Staff Writer