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Cosmic ray detector confirms hints of dark matter

Space station-based instrument records high amount of antimatter seen in earlier experiments

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DARK MATTER HUNTER

The Alpha Magnetic Spectrometer sits aboard the International Space Station some 400 kilometers above Earth's surface. New results from the detector confirm previous antimatter observations.

NASA

A $2-billion experiment on the International Space Station has released the first data from its unprecedented census of the charged subatomic particles whizzing by Earth. Although the results, presented April 3 at a seminar at CERN in Geneva, largely confirm previous observations, researchers hope they will lead to discovering the identity of dark matter, an invisible form of matter that outweighs normal matter in the universe by more than 5 to 1.

The Alpha Magnetic Spectrometer is the latest and most ambitious attempt to uncover the identity of dark matter by looking for cosmic rays, which are charged subatomic particles cruising through space. Theoretical physicists have proposed that dark matter could be made up of exotic particles that can slam into and annihilate each other, creating detectable cosmic rays such as electrons and their antimatter partners, positrons.

This first batch of AMS results, published April 3 in *Physical Review Letters*, encompasses about 25 billion particles detected over the course of a year and a half, including 6.8 million measurements of the electrons and positrons that could come from dark matter. AMS improved the precision of earlier data, detected particles at higher energies than previous instruments and found that the particles arrive in equal amounts from all directions.

But none of the new data give clues to the positrons' source, said Katherine Freese, a theoretical astrophysicist at the University of Michigan in Ann Arbor. The trajectories of these charged particles can change as they move through magnetic fields, she said, making it difficult to determine where the particles began their journey. Her bet is that rapidly spinning stars called pulsars produce positrons and fling them across the galaxy using extremely strong magnetic fields. "It will take a while to sort this out," she said.

In the mid-1990s, physicists got a first peek at cosmic rays that could have resulted from dark matter annihilation. The High Energy Antimatter Telescope, a cosmic ray detector attached to a high-altitude balloon, found an unexpectedly high number of positrons, a result that seemed to jibe with the idea that dark matter annihilation creates these charged particles. In the last five years two space-based detectors, PAMELA, for the Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics, and the Fermi Gamma-ray Space Telescope, have found even more decisive evidence of excess positrons.

Unfortunately for dark matter hunters, the specifics of the probes' observations do not match up well with theories that predict cosmic rays resulting from dark matter annihilation. Along with electrons and positrons, dark matter annihilation should produce other signals like extra antiprotons (protons' antimatter siblings), gamma rays and radio waves. But detectors have found no evidence of any of those signals.

Researchers hope that AMS can bring clarity to this debate because of its leg up on other cosmic ray detectors. Among other strengths, its perch aboard the International Space Station means it can sample the full spectrum of cosmic rays above Earth's atmosphere, avoiding molecules in the air that prevent most cosmic rays from ever reaching the ground. AMS also sports a strong magnet and precise sensors that allow researchers to easily distinguish between particles that behave similarly, such as protons and positrons.

Samuel Ting, a Nobel laureate from MIT who leads the AMS experiment, is optimistic about the project's chances. "I think there is no question we are going to solve this problem" of the positrons' origin, he said. One clue comes from studying the abundance of positrons at very high energies, which AMS is the first to explore. In general, the number of positrons increases as their energies rise, but the new AMS data shows that at a certain point, that increase tails off.

If the number of positrons at high energies suddenly plummets, Ting said, it would suggest dark matter as a source. He said it would take at least several more months for AMS to detect enough of these high-energy particles to come to a definitive conclusion. Piergiorgio Picozza, spokesman for the PAMELA mission, eagerly awaits that announcement, saying it may bring "pleasant surprises," he said. "We have to wait and to hope."

Adam Falkowski, a particle physicist at the National Center for Scientific Research in Paris, is more pessimistic: "There's absolutely no way that measurements of the positron spectrum may give us a robust evidence for dark matter, not now, and not anytime soon," he wrote on his blog.

For Ting, these results have been a long time coming. He first proposed the idea of a space-based cosmic ray detector in 1994. He kept the project alive through lobbying NASA officials and Congress during years of delays, cost overruns and the 2003 explosion of the space shuttle Columbia. Ultimately his 8,500-kilogram magnum opus made it to the International Space Station aboard the penultimate shuttle flight in May 2011.

Dark matter detection is just one of many goals for AMS. After billions more particle detections, the instrument may find antimatter nuclei that somehow survived the first few moments after the Big Bang when most of their counterparts collided with regular matter and got destroyed. Other possibilities include pinning down the source of cosmic rays within the Milky Way and finding other exotic types of matter.

http://www.sciencenews.org/view/generic/id/349352/description/Cosmic_ray_detector_confirms_hints_of_dark_matter