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The Great Cosmic-Ray Sniffer Reaches Orbit, on the Hunt for Dark Matter

By Michael D. Lemonick

For years, scientists have ridiculed NASA's claim that the International Space Station (or ISS) is a grand platform for groundbreaking research — and plenty of the science done there has just reinforced that attitude. Who can forget, for example, this classic opening sentence from a landmark 2006 paper in the *Journal of Experimental Biology*: "During space flights, tadpoles of the clawed toad *Xenopus laevis* occasionally develop upward bended tails (tail lordosis)"? If we hadn't spent tens of billions of dollars to construct the ISS, we might never have known that.

In fairness, though, the ISS can do science that's awe-inspiring rather than merely *ewww*-inspiring, and a 7.5-ton particle detector hauled aloft by the space shuttle *Endeavour* last week is poised to prove that point. Known as the Alpha Magnetic Spectrometer 2 (AMS-2), it will try to unravel a pair of long-standing mysteries, each of which is literally cosmic in its implications. The first: How much antimatter is out there in the depths of space? And th second: What is the mysterious, invisible dark matter that makes up a quarter of the known universe? (See pictures of five nations' space programs.)

The answer to both could be wrapped inside cosmic rays — electrically charged subatomic particles that zip through the galaxy like interstellar bullets. They're created in all sorts of places — in solar flares, in the exploding stars known as supernovas, in pulsars and more — and then whipped out into space by powerful magnetic fields. If you can catch a ray, you can determine what kind of particles it's made of — electrons, protons, whatever — and how much energy it carries. Knowing that, you can, in theory, figure out where it came from. That's what AMS-2 — $2 billion and nearly two decades in the making — will try to do, using powerful magnets to snag some rays and sensitive particle detectors to examine them.

Some of what AMS-2 scoops up will inevitably be made of antimatter, a suite of mirror-image particles (positrons, for example, which correspond to electrons, or antiprotons, the counterparts of protons) that occur naturally in small amounts throughout the universe. When a normal particle meets its antiparticle twin, they annihilate each other in a burst of energy and particle debris. (A controlled version of this phenomenon is how the *Starship*

Enterprise got Captain Kirk around the galaxy.)

The existence of antimatter is old news, however. The more important point is that every bit as much antimatter should have emerged from the Big Ban as ordinary matter, and most of it has gone missing. By taking a census of antimatter in cosmic rays, which is only possible from space, AMS-2 may be able to see if there's a large cache of these mirror particles hiding somewhere in the universe — maybe even entire antigalaxies filled with antistars and antiplanets. (See the top 50 space moments since Sputnik.)

Whether or not a mirror cosmos is out there, we've actually seen antimatter particles, and even manufactured them with particle accelerators. With dar matter, the evidence is still completely indirect. Astronomers see galaxies orbiting around one another and rotating impossibly fast — impossibly because at that speed they should fly apart gravitationally, unless there's some huge cloud of invisible matter holding them together. In fact, the dark matter must outweigh all of the matter we can see by a factor of six or more — and nobody has yet figured out what it's made of.

The best bet is that it's some sort of yet-undiscovered particle. One of the leading candidates, known as the neutralino, would itself be virtually undetectable. Bizarrely, though, neutralinos would be their own antiparticles: when they meet, they destroy one another. It's the fallout from these annihilations, speeding past the ISS in the form of antiprotons, that the new detector might be able to snag. (See "TIME's Complete Coverage: Space, Astronomy, NASA and More.")

It's also quite possible that AMS-2 won't solve either mystery, since in both cases the hoped-for detections depend on a series of "ifs" — if there's a lot o antimatter out there, if dark matter is what we think it is and if the AMS-2 performs as it's designed to perform. But failure would still be an important scientific result, since it could rule out some of the competing theories about both antimatter and dark matter. And from some scientists' perspectives, a least, learning anything significant at all about these two fundamental mysteries would count for more than anything we could possibly learn about how the tails of tadpoles bend.

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