Space Station Experiment to Hunt Antimatter Galaxies

TECH WEDNESDAY

By Jeremy Hsu
Special to SPACE.com
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09:22 am ET

Antimatter galaxies and dark matter have long haunted physicists' theories, but no instrument in orbit has had the power to confirm or deny their existence. Now a $1.5 billion cosmic ray detector scheduled for launch in 2010 could usher in a new era for discovering all that's weird and wonderful about the universe.

Cosmic rays consist of high-energy particles that emerge from catastrophic events such as supernovas, and may also hold the clues to whether antimatter galaxies and dark matter truly exist. Detecting cosmic rays firsthand from the ground has proved difficult, because they collide with atoms in Earth's atmosphere and break up into a shower of secondary particles.

"Earth's atmosphere absorbs everything, so you cannot study primary cosmic rays until you go to space," said Samuel Ting, an MIT physicist who first proposed a large cosmic ray detector back in 1994.

Now just months from completion, the Alpha Magnetic Spectrometer (AMS) represents years of work by NASA and the Department of Energy to overcome the challenges of putting a superconducting magnet into space. It also holds the hopes of an international physics community that wants to finally tackle some of the longest-standing questions behind the universe.

The mission to launch the spectrometer was initially canceled by NASA in the wake of the 2003 Columbia tragedy. But NASA reinstated it after Congress approved funding for an extra shuttle flight to the International Space Station. That flight is slated to launch in either July or September 2010.

Bend it like a magnet

A large superconducting magnet allows AMS to analyze the charged particles of cosmic rays, given that the particle paths curve in the presence of magnetic fields. The charged particles then pass through a number of detectors that allow scientists to figure out whether the particles are protons or electrons, or even anti-electrons known as positrons that might signal the existence of dark matter.

Crunching the data from the sensors requires an onboard supercomputer that combines 650 computer units and uses 2.5 kilowatts of power — far more power than a satellite's solar panels can normally provide. That means AMS must find a home on the International Space Station, where the Canadian robot arm will help install the instrument on an outside truss.

But putting a magnet in space has long frustrated scientists because of the magnetic compass effect, Ting told *SPACE.com*. Just as the magnet in a compass rotates to point north due to Earth's magnetic field, the large AMS magnet would want to rotate along with the entire space station.

"The task of building a space-qualified superconducting magnet is a very, very hard one," said Ben Monreal, a physicist at the University of California in Santa Barbara. He worked on one of the AMS sensors as a grad student at MIT, but also observed how engineers at NASA and Space Cryomagnetics, Ltd. worked around the magnet problem.

Engineers ultimately used a set of racetrack coils that canceled out the dipole magnetic field outside AMS, and will prevent the instrument from giving space station residents a case of the dizzies.

Catching bigger fish than CERN

An Italian satellite called PAMELA launched in 2006 with the capability of detecting some antimatter particles such as positrons. But AMS has about 250 times the sensitivity of such existing instruments for detecting high-energy particles.

The AMS magnetic setup also resembles that of the Large Hadron Collider, or the most powerful particle accelerator in the world located at CERN in Switzerland. The underground particle accelerator sends protons zooming around a 17-mile-long circular track and smashes them together to create combined energies of 7 tera-electronvolts (TeV).

Still, that fades in comparison to cosmic ray particles that may have energies of 100 million TeV or more.

"The space station [AMS device] can detect particles of practically unlimited energy," Ting noted. Those include positrons that may suggest collisions between particles of dark matter thought to make up 90 percent of the universe.

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An artist's concept of the Alpha Magnetic Spectrometer installed on the International Space Station. Credit: NASA/MIT


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The Alpha Magnetic Spectrometer is intended to hunt for antimatter galaxies. Credit: NASA/MIT

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Finding evidence of anti-helium or heavier antimatter elements could also provide strong proof of antimatter galaxies, given that the heavier elements would only emerge from stars in an antimatter galaxy. AMS would cover any possible antimatter galaxies out to about 1,000 megaparsecs, or about the edge of the observable universe.

Bumpy space odyssey

The 15,000 pound cosmic ray detector remains just months away from delivery to NASA's Kennedy Space Center in Florida, where it can prep for a 2010 launch to the space station aboard one of the last space shuttle flights. But physicists can still recall the long battle to move AMS forward to this point.

One of the bleaker moments came after NASA lost the space shuttle Columbia in a 2003 tragedy. The space agency told physicists that no room existed for AMS aboard remaining shuttle flights, at least until more recent schedule reshufflings that added shuttle flights.

"It's been up and down," Monreal recalled. "I can think of three or four cycles where it looked [like] it was completely dead, and then things looked up."

Ting and other physicists have already begun working around the clock to ensure that everything checks out with the cosmic ray detector. They also plan to monitor AMS 24 hours a day, seven days a week after launch using a control room and working in shifts. The plan, they hope, will help to hit scientific pay dirt when the instrument begins analyzing the heavens.

"Certainly for me, it's the most difficult experiment I've ever done," Ting said. "That's why we want to take the time to get it right."

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MartianSam1 wrote: posted 02 September 2009, 9:48 am ET

There is one more key issue here to opening up the solar system for human exploration - actually two issues.

It will give a far more in-depth analysis of cosmic rays than ever before - a primary radiation threat to humans on long missions.

The same group who designed this also have a larger version designed that can bend cosmic rays away from a crew capsule, enabling human missions anywhere in deep space for any duration. Granted, the coil is large and the capsule is small, but it's far less massive or thick than the 4 meter thick water layer that would otherwise be needed. With an Ares V, a highly workable crew hab that could protect astronauts from any cosmic ray hazard is easily launched. Having AMS on ISS is a working prototype that could be "space rated" and proven while helping to characterize the threat.

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Rascal_sage wrote: posted 02 September 2009, 12:09 pm ET

"Antimatter galaxies and dark matter have long haunted physicists' theories, but no instrument in orbit has had the power to confirm or deny their existence. Now a $1.5 billion cosmic ray detector scheduled for launch in 2010 could usher in a new era for discovering all that's weird and wonderful about the universe."

Emphasis on "could." No promises that $1.5 billion will confirm or deny anything.

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KEB wrote: posted 02 September 2009, 12:14 pm ET

This is very, very exciting! I can hardly wait! The most important experiment on the ISS ever.

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AsmGuru62 wrote: posted 02 September 2009, 12:21 pm ET

"known as positrons that might signal the existence of dark matter."

That's a typo. Should be "anti-matter".

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Rado wrote: posted 02 September 2009, 5:03 pm ET

This is the first time I hear they seriously consider existance of galaxies comprised of anti-matter. I mean, anti-matter is proven but finding entire galaxies of anti-matter in our Universe, I can hardly believe that. I'm a bit surprised they invested so much in a mission with such a goal, although it's not the only thing they want to achieve.

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Bill_Wright wrote: posted 02 September 2009, 7:45 pm ET

At least after $1.5B they finally decided to launch this thing. So many of the original experiments have been canceled after major bucks have been spent on them. Except for the real tragedies like loss of life, these cancellations have been secondary tragedies.
-- Bill

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mindopener9 wrote: posted 02 September 2009, 8:19 pm ET

I think it is a great step forward in Cosmic Ray science, providing scientists can determine what they're actually observing, with a degree of accuracy and there are no engineering or equipment glitches. On the other hand, the space station EVA specialists can always do repair and maintenance work, per the mission designers instructions. The anti-matter galaxies and dark matter conjectures are a clever way to interest the public. Cosmic Rays are still a long way from being understood, totally, so any conjectures based on early discoveries must be taken with a few grains of salt.

And I, too, hadn't really heard of whole galaxies of anti-matter, outside of Sci-Fi, before this. Wishful thinking, if you ask me, but then, I should have been from Missouri. I'm not all that keen on organized religion, either.

But there are plenty of targets, out there for this new observatory to investigate, just by locating them in the sky, so we know for sure where to train the rest of our instruments. This could be very interesting.....

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bobodirt1 wrote: posted 02 September 2009, 9:18 pm ET

The existence of an antimatter galaxy seems improbable. Matter dominates all we know of this galaxy. Where in the universe would you hide an antimatter galaxy so that it does not contact matter? How vicious would an explosive collision of an antimatter galaxy with a matter galaxy be? Wow. I think this is the start of a new sci fi novel, not the subject of serious study.

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Bill_Wright wrote: posted 03 September 2009, 1:12 am ET

I have been fortunate to have worked on algorithms used in Magnetic Resonance Imagers (MRI). I worked on a family of machines that ended up benefiting my own family through some of the advanced diagnostic techniques available. There is no better feeling than going to work and realizing that thousands of people will benefit from what you do that day. It also keeps you on your toes as one bad line of code can cause a mis-diagnosis that could cause heartbreak. Sorry, got off target.

One of the areas that I got to see on "field trips" was how they prepared rooms prior to installing an MRI. They have been doing this since at least the mid-1980's, when I got involved in this field. Hospitals then were full of CRTs and other equipment that could be severely impacted by magnetic fields. It seems to me that it should have almost been a no-brainer in prepping an area on the ISS for this detector as there are not only numerous small vendors that do this, but some hospitals just use their own electricians and maintenance staff to prep a room for an MRI. Obviously, they don't have to do this with a space suit on but it should have been easy enough to build the shield here on Earth and break it down in such a way that our cosmo- and astro-nauts could easily re-assemble it in space.

On a side note, as the Large Hadron Collider (LHC) won't reach full power until next year, if ever, wouldn't it be great if the Higgs Boson was discovered on the ISS? It would really validate the ISS as a serious physics research site (although a bit harder to get to than France and Switzerland). As this detector will encounter particles with much higher energies, although less frequently than the LHC, I am sure that many discoveries will come as we pass through higher and higher energies. Even if it works perfectly, the LHC will never reach energies above 14TeV, while there is no upper boundary that I know of for sub-atomic particles in space. We need to keep the ISS in LEO forever, or at least until we build the next generation (ISS2?). There is no real reason we can't add a nearby solar farm or a nuclear generator to keep adding power to this platform.

We spend less than $20B per year on civilian space programs while we have given about $1T to failing banks, failing car companies, and failing brokerage houses. People who work in these industries must have skills that could be used in project management, statistical analysis, computer support, maintenance, etc. It would be so easy to re-train them for 21st Century jobs than simply subsidizing them in their current jobs. Space is definitely the ignored child when it comes to budget allocation. Why are we acting like smokers and letting Congress push us off into a corner? When will someone start collecting money and getting petitions filled to do some serious lobbying for building up our space program?

Bill

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adastra3141 wrote: posted 03 September 2009, 8:58 am ET

Excellent article and great comments. AMS does indeed sound like a very exciting experiment - I'm surprised I never heard of it before now.
And we DO need to get off our collective butts and get some space rated nuclear power sources beyond the limited RTGs. The Navy has a little bitty, 13 person crew, nuclear sub for exploration. Surely, if we can do that we can build nuclear powered space ships. Have to work on a power transfer system though. Magnetic coupling instead of a steam engine to generate electricity.
Something like VASIMR makes so much more sense than chemical propulsion for beyond lunar exploration.

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