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breaking

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Pursuit of dark matter progresses at AMS

A possible sign of dark matter will eventually become clear, according to promising signs from the Alpha Magnetic Spectrometer experiment.

By Kathryn Jepsen

New results from the Alpha Magnetic Spectrometer experiment show that a possible sign of dark matter is within scientists' reach.

Dark matter is a form of matter that neither emits nor absorbs light. Scientists think it is about five times as prevalent as regular matter, but so far have observed it only indirectly.

The AMS experiment, which is secured to the side of the International Space Station 250 miles above Earth, studies cosmic rays, high-energy particles in space. A small fraction of these particles may have their origin in the collisions of dark matter particles that permeate our galaxy. Thus it may be possible that dark matter can be detected through measurements of cosmic rays.

AMS scientists—based at the AMS control center at CERN research center in Europe and at collaborating institutions worldwide—compare the amount of matter and antimatter cosmic rays of different energies their detector picks up in space. AMS has collected information about 54 billion cosmic ray events, of which scientists have analyzed 41 billion.

Theorists predict that at higher and higher energies, the proportion of antimatter particles called positrons should drop in comparison to the proportion of electrons. AMS found this to be true.

However, in 2013 it also found that beyond a certain energy—8 billion electronvolts—the proportion of positrons begins to climb steeply.

“This means there’s something new there,” says AMS leader and Nobel Laureate Sam Ting of the Massachusetts Institute of Technology and CERN. “It’s totally unexpected.”

The excess was a clear sign of an additional source of positrons. That source might be an astronomical object we already know about, such as a pulsar. But the positrons could also be produced in collisions of particles of dark matter.

Today, Ting announced AMS had discovered the other end of this uptick in positrons—an indication that the experiment will eventually be able to discern what likely caused it.

“Scientists have been measuring this ratio since 1964,” says Jim Siegrist, associate director of the US Department of Energy’s Office of High-Energy Physics, which funded the construction of AMS. “This is the first time anyone has observed this turning point.”

The AMS experiment found that the proportion of positrons begins to drop off again at around 275 billion electronvolts.

The energy that comes out of a particle collision must be equal to the amount that goes into it, and mass is related to energy. The energies of positrons made in dark matter particle collisions would therefore be limited by the mass of dark matter particles. If dark matter particles of a certain mass are responsible for the excess positrons, those extra positrons should drop off rather suddenly at an energy corresponding to the dark matter particle mass.

If the numbers of positrons at higher energies do decrease suddenly, the rate at which they do it can give scientists more clues as to what kind of particles caused the increase in the first place. “Different particles give you different curves,” Ting says. “With more statistics in a few years, we will know how quickly it goes down.”

If they decrease gradually instead, it is more likely they were produced by something else, such as pulsars.

To gain a clearer picture, AMS scientists have begun to collect data about another matter-antimatter pair—protons and antiprotons—which pulsars do not produce.

The 7.5-ton AMS experiment was able to make these unprecedented measurements due to its location on the International Space Station, above the interference of Earth’s atmosphere.

“It’s really profound to me, the fact that we’re getting this fundamental data,” says NASA Chief Scientist Ellen Stofan, who recently visited the AMS control center. “Once we understand it, it could change how we see the universe.”

AMS scientists also announced today that the way that the positrons increased within the area of interest, between 8 and 257 GeV, was steady, with no sudden peaks. Such jolts could have indicated the cause of the positron proliferation were sources other than, or in addition to, dark matter.

In addition, AMS discovered that positrons and electrons act very differently at different energies, but that, when combined, the fluxes of the two together unexpectedly seem to fit into a single, straight slope.

“This just shows how little we know about space,” Ting says.

Fifteen countries from Europe, Asia and America participated in the construction of AMS. The collaboration works closely with a management team at NASA’s Johnson Space Center. NASA carried AMS to the International Space Station on the final mission of the space shuttle Endeavour in 2011.