Argonne NATIONAL LABORATORY

News Release

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For immediate release

Distant black holes may be source of high-energy cosmic rays

ARGONNE, Ill. (Nov. 9, 2007) – Breakthrough astrophysics research may have established the hitherto mysterious source of exceptionally high-energy cosmic ray emissions, according to recently published research that culminates a project developed by a scientist at the U.S. Department of Energy's (DOE) Argonne National Laboratory.

This extraordinary result is a product of DOE's investment in high-energy physics research, giving scientists the resources they need to explore the interactions between matter, energy, time and space.

Argonne senior physicist Harold Spinka, in collaboration with more than 300 scientists from around the world affiliated with the Pierre Auger Observatory in western Argentina, determined a correlation between emanations of sufficiently energetic cosmic rays with a particular class of extrastellar objects, known as active galactic nuclei (AGNs). Scientists believe that AGNs are massive black holes in the center of distant galaxies that devour matter while ejecting plasma streams composed of high-energy particles.

"We have taken a big step forward in solving the mystery of the nature and origin of the highest-energy cosmic rays," said Nobel Prize winner and University of Chicago professor emeritus James Cronin, who founded the Pierre Auger Observatory with Alan Watson of the University of Leeds. "The age of cosmic-ray astronomy has arrived. In the next few years, our data will permit us to identify the exact sources of these cosmic rays and how they accelerate these particles."

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After observing and recording approximately two years' worth of cosmic rays hitting the earth, the Pierre Auger team noticed that the cosmic rays – a misnomer for energetic atomic particles, mainly protons -- with energies in excess of 60 EeV (60 exa-electron volts, or 10^{18} electron volts) tended to emanate from locations near known AGNs.

Most cosmic rays that strike the Earth originate from within our own Milky Way galaxy, where they emanate from supernovae, black holes or neutron stars. However, these cosmic rays have a substantially lower energy than those under investigation in the Pierre Auger study. Researchers knew that they could not attribute the production of those rays to any phenomenon or body within our own galaxy, and until now research to identify an extra-galactic source had yielded little more than hypotheses.

Astronomers had difficulty pinpointing the sources of especially energetic cosmic rays because they hit the Earth so infrequently, in contrast to the lower-energy cosmic radiation that continually bombards the Earth. During more than two years of observation, the Pierre Auger scientists detected only 28 cosmic rays that matched their stringent criteria. They excluded extragalactic cosmic rays with energies lower than 40 to 60 EeV, because the trajectories of these particles are so badly bent by deep-space magnetic fields that scientists cannot determine their origin; they also did not look at cosmic rays that had traveled more than 300 million light years due to concerns that interactions with cosmic background radiation during such a long journey would have significantly reduced their energy.

"The concern is that if you look too far back in time and space, it becomes harder to figure out a correlation," Spinka said.

Since 2004, the observatory, which contains a telescope array the size of Rhode Island, has detected only 80 cosmic rays with energies greater than 40 EeV. Of the 28 of these that had energies greater than approximately 60 EeV and originated within about 250 million light-years of Earth, 20 were located close to known AGNs. Six of the remaining eight cosmic rays come from directions where the source may be obscured by other matter in our galaxy.

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According to Spinka, astronomers have worked hard to complete the catalog of all the AGNs in the observable universe, and he believes that cosmic rays may offer clues as to where others might be. "I think that many astronomers will indeed go back and look at the areas of space to which we traced the cosmic rays, because it's definitely possible we might have missed something," he said.

Cosmic ray observations provide astronomers with another way of examining celestial features outside of the Milky Way, Spinka said. "Up until now there has been no way of doing astronomy for objects outside our galaxy except by using various wavelengths of light. This paper represents the first time that we've been able to use charged particles to observe these faraway objects."

The Pierre Auger Observatory is being built by a team of more than 370 scientists and engineers from 17 countries. "The collaboration is a true international partnership in which no country contributed more than 25 percent of the $54 million construction cost," said Danilo Zavrtanik of the University of Nova Gorica and chair of the Auger Collaboration Board.

The paper, "Correlation of the Highest Energy Cosmic Rays with Nearby Extragalactic Objects," appears in the November 9 issue of *Science*. A press release from the Auger Observatory can be found at http://www.auger.org/news/PRagn/AGN_correlation.html.

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