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Fastball-Strength Cosmic Rays Traced to Black Holes
First detailed mapping of high-energy cosmic rays points to galactic black holes as their source
Researchers have made a key breakthrough in a decades-old cosmic mystery by potentially identifying the source of ultrahigh-energy cosmic rays, rare but immensely powerful subatomic particles that strike our atmosphere each with the force of a fastpitch baseball. A study published in Science finds that these rays pierce the atmosphere not from any which way but rather in the direction of nearby active galactic nuclei (AGNs), bright galactic cores that researchers believe are powered by supermassive black holes guzzling mass quantities of matter.
The discovery comes from a network of more than 1,400 ground-based particle detectors and two-dozen telescopes covering 1,200 square miles (3,000 square kilometers) of the western Argentine plains, an area nearly the size of Rhode Island. Yet to be completed, the Pierre Auger Cosmic Ray Observatory South has nonetheless become the first experiment to piece together the trajectories of rare high-energy cosmic rays, first discovered in 1962.
"Nature has been very generous with us," says astrophysicist Antoine Letessier-Selvon of the University of Paris 6 and 7, part of a 160-person data analysis subgroup within the nearly 400-member Auger collaboration.
Cosmic rays are protons or atomic nuclei that travel through space at near light speed. When they strike Earth's atmosphere, they detonate in a burst of lighter particles, or air shower, extending up to 15 square miles (40 square kilometers). The highest energy cosmic rays pack a punch of more than 1020 electron volts (referred to as 100 exa-electrons volts, or EeV), which is 100 million times the energy produced by the largest particle accelerators and roughly equivalent to that of a well-thrown baseball.

"It is extremely difficult to understand how particles are accelerated that high," Letessier-Selvon says. Researchers say only a few sources were conceivable, including speculative remnants of the big bang or vast hiccups of matter in the early universe as well as AGNs, which were at least known to exist.

Complicating the problem, high-energy cosmic rays strike Earth at an average rate of about once per square kilometer per century, hence the sprawling Auger Observatory, which will contain 1,600 particle detectors when finished. (Auger North, to be located in the U.S., is planned for observations in the Northern Hemisphere.)

On the plus side, whereas lower energy cosmic rays become jumbled like billiard balls on their journeys, the highest energy rays fly relatively straight and true. By observing air showers from multiple vantage points, Auger instruments triangulated the flight paths of nearly a million cosmic ray showers since January 2004, the group reports.

A record 77 of the rays were the high-energy variety, registering 40 EeV, the threshold at which they begin to scatter off of the cosmic microwave background radiation. Of these, the 27 most energetic– exceeding 57 EeV– were tightly matched with parts of the sky that included AGNs lying within a few hundred million light-years of Earth.

"We're now convinced that they're not produced in the galaxy," Letessier-Selvon says. The exact source remains uncertain, he explains, because the team had to estimate the bending of the charged rays in the Milky Way's magnetic field, which

should come into sharper focus as the observatory detects more events.

"It's pretty suggestive of a particular origin of these cosmic rays," namely AGNs, says astrophysicist Roger Blandford of Stanford University, who was not part of the collaboration, adding that massive, spinning black holes had always been to him "the least implausible source."

To power the rays, Blandford says, an AGN's central black hole would have to produce a massive electric field very far from itself, because otherwise the cauldron of photons around the hole would scatter the cosmic rays and blunt their energy.

He adds researchers would never have guessed that black holes might have such powers if not for high-energy cosmic rays. "Nature does tricks we didn't know were possible," he says. "But it is happening and it's marvelous." Auger should eventually pinpoint the rays' origins definitely, he says. "They have the capacity to answer these questions beyond all reasonable doubt."