Galactic Center Found To Glow Unevenly

21 February 2006

An international team of more than 100 astrophysicists said they have detected very-high-energy gamma rays emanating from the huge gas clouds known to pervade the center of the Milky Way galaxy.

The team, using the High Energy Stereoscopic System telescopes in Namibia, said they expect the gamma rays to result from even more energetic cosmic-ray particles that permeate the entire galaxy and crash into the atmosphere. The extreme sensitivity of the HESS instruments in this energy range make possible precise measurements of the intensity and energies of the gamma rays, they said.

In the galaxy's central region, cosmic-ray particles typically are more energetic than those measured falling into Earth's atmosphere. Possible reasons why include the echo of a supernova that exploded some 10,000 years prior to the emergence of the clouds, or maybe even a burst of natural particle acceleration from the super massive black hole at the Milky Way's center.

In a recent issue of the journal Nature, the scientists reported that the giant clouds of hydrogen encompass an amount of gas equivalent to 50 million times the mass of the Sun, and the HESS gamma-ray telescopes revealed that the clouds are glowing with very-high-energy gamma rays.

One key issue in understanding cosmic rays is their distribution in space - whether they permeate the entire galaxy uniformly, or whether their density and energy distribution vary, depending on their location - such as their proximity to cosmic particle accelerators.

Direct measurements of cosmic rays can only taken within our solar system, located about 25,000 light-years from the galactic center, but a new observation technique allows astrophysicists to investigate cosmic rays originating from more distant locations, by detecting when a cosmic-ray particle collides with an interstellar gas particle, producing gamma rays.

The Milky Way's center contains examples of every type of exotic object known to astronomers, including remnants of supernova explosions and a super-massive black hole. It also contains huge quantities of interstellar gas, which tends to clump into clouds. If gamma rays are detected from the direction of such a gas cloud, scientists can infer the density of cosmic rays at the location of the cloud, because the energy intensity and distribution of these gamma rays parallels that of cosmic rays.

Scientists have used this technique at low energies - around 100 million electron volts (man-made accelerators reach energies up to 1,000,000 million electronvolts) - to map cosmic rays in the Milky Way. At really high energies - the true domain of cosmic-ray accelerators - no instrument had been sensitive enough to detect interstellar gas clouds shining in the range of very-high-energy gamma rays. Now, for the first time, the HESS telescopes have demonstrated the presence of cosmic rays in the galactic central region.

The HESS data show the density of cosmic rays exceeds that in the solar neighborhood by a significant factor, and the difference increases as the energy increases, implying the cosmic rays have been recently accelerated. The data suggest that the clouds have been illuminated by a nearby cosmic-ray accelerator, which was active for at least 10,000 years. Likely candidates include a gigantic stellar explosion that apparently went off near the heart of the galaxy, or the super-massive black hole at the galaxy's center.

"This is only the first step," said Jim Hinton, one of the scientists involved in the discovery. "We are of course continuing to point our telescopes at the center of the galaxy, and will work hard to pinpoint the exact acceleration site. I'm sure that there are further exciting discoveries to come."

The HESS system includes four 13-meter

telescopes and is considered the most sensitive detector of very-high-energy gamma rays. These are absorbed in the atmosphere, where they give a short-lived shower of particles. The HESS telescopes detect the faint, short flashes of bluish light the particles emit (named Cherenkov light, lasting a few billionths of a second), collecting the light with large mirrors that reflect onto extremely sensitive cameras.

Each image gives the position in the sky of a single gamma-ray photon, and the amount of light collected gives the energy of the initial gamma ray. Building up the images photon-by-photon allows HESS to create maps of astronomical objects as they appear in gamma rays.

The team includes scientists from Germany, France, the United Kingdom, the Czech Republic, Ireland, Armenia, South Africa and Namibia.