Proposed Particle Help Explains Odd Galactic Photons

July 25 2008, By Laura Mgrdichian

In 2002, a satellite called INTEGRAL was launched by the European Space Agency with an instrument on board to detect and measure gamma rays from space. Four years later, it yielded some intriguing data: An unusually high number of gamma-ray photons from the galactic center carried the same energy—a particular, significant energy—and nobody could figure out why.

The energy is 511 keV (kilo electron volts), and it happens to be the exact rest-mass energy of the positron, the electron anti-particle, which emits a 511 keV photon when it annihilates with an electron. The gamma rays, then, are a telltale sign of positrons in the galactic center. Where those positrons come from, however, is not so clear.

At one point, scientists thought the positrons might originate as electron-positron pairs often referred to as positronium, an "element" that exists for a very short time before the electron and positron annihilate. For positronium to be the source of the gamma rays, there would have to be lots of it, but the usual positron sources, such as black holes and supernovae, don't emit enough of them.

"Theorists have thought that the 511 keV line might be from dark matter annihilation located at the center of our galaxy, but all the well known standard dark-matter candidates, such as the lightest super-particle, could not fit the data," said astrophysicist Seong Chan Park to *PhysOrg.com.*

Park and colleagues Ji-Haeng Huh, Jihn E. Kim, and Jong-Chul Park are researchers at Seoul National University in Korea, and the group recently proposed an explanation that involves a new particle.

The group suggests that the positrons come from a "millicharged fermion," a very lightweight particle with a tiny electric charge. The suggestion isn't groundbreaking, as many physicists think that there may be some new physics—a new particle, specifically—underlying the gamma-ray production.

"Most preferred interpretations of the 511 keV gamma rays involve the introduction of new particles, and a millicharged fermion has been proposed before, as far back as 20 years ago, as a dark-matter candidate." said Park. "But in this work we have handled the urgent problem of interpreting the 511 keV anomaly using millicharge fermions, within certain physical constraints."

The proposed particle can produce positrons, which would emit 511 keV gamma-ray photons by decaying into positrons and electrons, which would annihilate and emit the photons. Alternatively, it could annihilate with its own antiparticle to yield an electron and positron that would then annihilate.

The millicharged fermion, if it exists, would have escaped detection at collider experiments because its electric charge is so minute, say Park and his colleagues. They also suggest the particle as a dark-matter candidate, possibly making up 10 percent of the dark matter in the universe.

"In the beginning, we worried if the idea of 'millicharged' dark matter might be inconsistent with any existing experimental data," says Park. "As it turns out, that it is not the case and there is room to fit all of them, which is interesting."

This research is described in the June 3, 2008, online edition of *Physical Review D.*

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