PHYSICS

How Quixotic Is SLAC's Quest To Detect "Crazy Particle"?

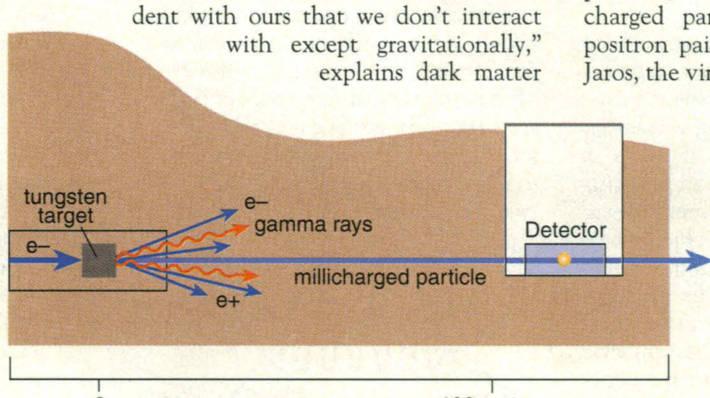
On the cult television hit *The X-Files*, FBI Agent Fox Mulder investigates reports of everything from attacks by vampires to visits from UFOs. Living by the motto "The truth is out there," Mulder will not accept offhand dismissals; he carefully attempts to disprove or corroborate each report, no matter how bizarre or improbable. And—at least in the fictional world of a TV series—such persistence sometimes has a dramatic payoff.

Physicist John Jaros thinks that spirit has a place in the real world. He and colleagues at the Stanford Linear Accelerator Center (SLAC) are now conducting a search for what Jaros jokingly calls a "crazy particle": a subatomic morsel carrying only the merest wisp of electric charge. For the last few months, Jaros, Willy Langeveld, Allen Odian, Alyssa Prinz, and their team have been watching for these so-called millicharged particles in subatomic debris produced as high-energy electrons slam into an inch-thick slab of tungsten. Jaros admits that the team has only the slimmest chance of finding anything, but he notes that millicharged particles aren't ruled out by established theories in physics. And he and others believe the implications of millicharged particles, should they exist, are noteworthy enough to justify the search.

"If you found one of these things, it would be as exciting as a massive neutrino," says physicist Sacha Davidson of the University of California, Berkeley, Center for Particle Astrophysics, referring to the recent announcement that the elusive subatomic particle known as the neutrino might have mass (*Science*, 10 February, p. 789). Like massive neutrinos, millicharged particles might be a clue to the universe's "dark matter"—the invisible matter that seems to exert a gravitational pull on the rest of the universe but has eluded vigorous efforts to track it down.

If the search does pay off, it would not be the first time physicists have had to revise their views on electric charge. The charges of an individual electron or proton were once seen as indivisible, but that mindset changed in the 1960s when theorists began arguing that protons and neutrons consist of quarks, particles carrying charge—either positive or negative—in quantities one-third or two-thirds that of the electron. And there's no clear reason why charges can't come in still smaller packages, say some physicists. "Electrical charge is quantized, but we don't know why it's quantized. Who says new particles would have familiar charges?" asks David Bailey, a University of Toronto experimental physicist.

What is more, theory has provided physicists with a few threads of hope that millicharged particles exist. The most discussed one is the idea—seemingly outlandish but proposed by a number of theorists over the years—that our universe is mirrored by another. Consisting of particles completely different from our own, this so-called shadow universe would be "another universe coincident with ours that we don't interact with except gravitationally," explains dark matter researcher David Caldwell of the University of California, Santa Barbara. This shadow realm would provide the dark matter whose gravity helps shape our own universe.



Vigil for a phantom. Any millicharged particle generated when electrons slam into a tungsten target should pass effortlessly through 100 meters of rock to a detector, where it might spark a single proton.

On rare occasions these two universes might intersect in another way, according to a theory devised by University of Toronto physicist Bob Holdom in 1986. Through a complex chain of events, some of our own universe's electric charge could rub off onto shadow particles, giving them a tiny fraction of a normal electron charge. In principle, this tiny borrowed charge would open the shadow particles to detection.

Fanciful as this sounds, says Jaros, Holdom's notion does not violate any known law of physics. In 1990, however, Russian physicists M. I. Dobroliubov and Alex Ignatiev and, a bit later, Davidson, Bailey, and Bruce Campbell of the University of Alberta in Canada pointed out that existing data rule out new particles with a charge greater than a thousandth of the electron's. Working independently, the two groups calculated that such particles would have revealed themselves in previous accelerator experiments or dark matter searches.

Particles with charges smaller than a millionth of an electron's could also be ruled out, the two groups concluded, because they would have had noticeable astrophysical and cosmological consequences. For instance, says Davidson, the core of a white dwarf star would probably create millicharged particles. If their charge was much smaller than a millionth of an electron's, she explains, the particles would escape the star so readily that they would rob it of energy and end its life more quickly than observations suggest.

Between a thousandth and a millionth of the charge of the electron, however, lies unexplored territory. To probe it, the Russian physicists suggested the scheme Jaros and his colleagues are now exploiting at SLAC. As energetic electrons bombard the tungsten target, they radiate short-lived "virtual" photons, which immediately convert into charged particles—most often, electron-positron pairs. But on rare occasions, says Jaros, the virtual photons should spawn particles with smaller charges, if any exist.

In the SLAC setup, magnets siphon off the positrons and other strongly charged particles for use in other experiments, but any millicharged particles should continue undeterred in a straight line. Last year, the SLAC researchers installed a detector to watch for them, positioned behind hundreds of feet of sandstone that would filter out other subatomic debris. Consisting of a cooled block of plastic scintillator, the detector might register the arrival of a millicharged particle by generating a single detectable photon.

Jaros and his colleagues were able to sell the unusual project to SLAC management because its cost—some $250,000—is modest (for high-energy physics), and the project can be carried out without interfering with SLAC's normal production of positrons. They started the search last fall and plan to continue until the end of March. So far, the SLAC team has seen no light flashes they can attribute to millicharged particles, although Jaros cautions that the group has only completed preliminary analyses of the data.

Nevertheless, they and some of their colleagues think this quest for improbable particles has been time and money well spent. "I've had more fun on this than I've had in years," comments Odian. Adds Bailey, "You should always do a crazy experiment every so often; otherwise you might miss important things." Fox Mulder would approve.

–John Travis