A fog of x-ray emitting gas fills the center of our galaxy, where physicists have sought a dark-matter signal.

PARTICLE PHYSICS

# Have physicists seen the dying flash of dark matter?

## Dark particle decays could explain tantalizing x-ray signal seen in multiple galaxies, including our own Milky Way

*By* **Edwin Cartlidge**

Dark matter, by definition, can't be seen directly—except perhaps when it dies. For years, scientists have scanned the skies for signals given off by the decay or mutual annihilation of these elusive particles, which make up fully 80% of the matter in the universe. They've seen nothing definitive, but physicists are now reporting a new candidate: a peak in x-ray emission at an energy of 3.5 thousand electron volts (keV).

After many inconclusive claims, this one may be testable, they and other researchers say, by an upcoming satellite mission. "The 3.5-keV x-ray signal has a real chance of being definitively confirmed as dark matter in a few years, unlike other putative signals currently on the market," says Jonathan Feng, a particle theorist at the University of California (UC), Irvine. If it is from dark matter, the signal will give physicists their first direct handle on what the elusive stuff might consist of.

To date, theorists' leading dark matter candidate has been so-called weakly interacting massive particles (WIMPs)—hypothetical massive particles that don't interact with light and other electromagnetism but do respond to gravity and the weak nuclear force. Laboratory experiments haven't spotted WIMPs, however, and the gamma rays that some scientists believe could be coming from the annihilation of WIMPS in the centers of galaxies might simply be the radiation given off by more prosaic sources, such as hot gas.

Particle physicist Alexey Boyarsky of Leiden University in the Netherlands and colleagues went after a different quarry: x-ray signals from the decay of hypothetical particles that would be much lighter than WIMPS. They scoured data from the European Space Agency's XMM-Newton orbiting x-ray observatory for signs of particles weighing a few keV—a millionth of the mass of WIMPs. The group started its search in 2005, and last year they finally got lucky, finding the 3.5-keV peak in the x-ray spectrum from both the Milky Way's nearest neighbor, the Andromeda Galaxy, and the Perseus galaxy cluster. Another group—physicist Esra Bulbul of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, and colleagues—also reported finding an emission line at about 3.5 keV in the combined spectra from 73 galaxy clusters.

Now, in a paper accepted for publication in *Physical Review Letters*, Boyarsky's group reports a similar peak in x-rays from the core of the Milky Way. The intensity of the peak lies in the right range to be produced by dark matter reactions, the researchers say: It implies a density of dark matter higher than a lower limit inferred from measurements of galaxy clusters, but lower than a ceiling calculated from studies of the Milky Way's outer regions. "The signal passes a very nontrivial consistency check," Boyarsky says.

Some other researchers are skeptical. Physicist Ondrej Urban of the Kavli Institute for Particle Astrophysics and Cosmology at Stanford University in Palo Alto, California, and his colleagues say they don't see any real evidence of the 3.5-keV signal in spectra of four galaxy clusters, including Perseus, from the NASA/Japanese space agency Suzaku x-ray satellite. And physicists Tesla Jeltema and Stefano Profumo of UC Santa Cruz say that even if the 3.5-keV line is real, it could easily come from something less exotic than dark matter: the x-rays given off when ions of potassium and other elements blasted into space by supernovae collide, exciting their remaining electrons.

To try and settle the matter, Boyarsky and his colleagues have booked observing time on XMM-Newton, which will let them study the x-ray spectrum of a dwarf galaxy thought to harbor lots of dark matter but very little normal matter. "If we see the signal there, it would be very hard to interpret it in terms of normal astrophysics," he says. "That would constitute very solid proof of dark matter." The ultimate test, however, could come from a new x-ray satellite called ASTRO-H, which Japan plans to launch next year. ASTRO-H will be able to plot the shape of the 3.5-keV peak in much more detail than current satellites can, Feng says. A relatively broad line, he explains, would imply that the x-rays are due to dark matter, because the emissions from the fast-moving particles are expected to be Doppler-shifted. A narrower line, in contrast, would point to normal matter as the source.

If dark matter is the cause, physicists will still need to pin down its identity. Feng says the energy and intensity of the 3.5-keV line are "just as would be expected" from sterile neutrinos: hypothetical ultraelusive cousins of ordinary neutrinos that would give off x-rays when decaying into normal neutrinos.

Cosmologist Kevork Abazajian at UC Irvine says that sterile neutrinos are plausible but that other hypothetical particles could also produce the signal. He says that ground-based measurements of β-decay—the same radioactive process that yielded the first hints that neutrinos exist—could settle whether keV-scale sterile neutrinos really exist, and whether astronomers may be seeing their dying light. ■

*Edwin Cartlidge is a science writer in Rome.*

PHOTO: NASA/UMASS/D.WANG ET AL.