Twist in dark matter tale hints at shadow Milky Way

› 13:06 11 April 2013 by **Lisa Grossman**
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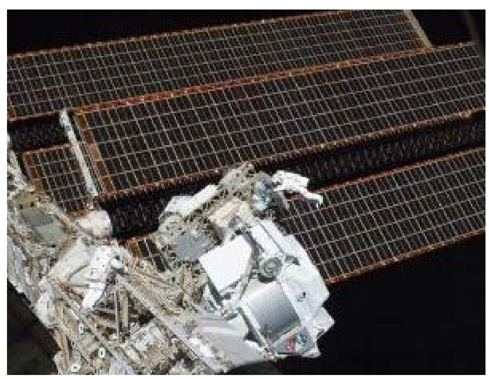

Space station looks for WIMPs *(Image: NASA)*

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THE HUNT for some of the most wanted stuff in the universe took a new twist this week with the first results from a high-profile, space-based dark matter detector. The results are inconclusive, but, if combined with recent theory, they hint at something exciting. Could the universe have a dark side, complete with its own force, a zoo of particles and even a shadow version of the Milky Way?

"There could be a mirror world where interesting things are going on," says James Bullock of the University of California at Irvine, who has been working on the idea of a "dark sector" for a while. "It means nature is much richer than we would otherwise know," he says.

The dark sector could help explain why we've failed to detect dark matter on Earth so far, but it would also demand a radical shift in our understanding of the stuff.

The way stars and galaxies move shows there is more mass present than we can see. To account for this, 80 per cent of the universe's matter must be dark. No wonder physicists are desperate to find it. The trouble is the stuff stubbornly refuses to interact with ordinary matter, except through gravity, so has not been conclusively detected.

The most favoured models say it is made up of a new, weakly interacting massive particle. These WIMPs collide in space, annihilating and decaying into ordinary particles, including electrons and their antimatter counterparts, positrons.

Since May 2011, the Alpha Magnetic Spectrometer has been sitting on the International Space Station, sifting through billions of charged cosmic rays for evidence of those annihilations. If it sees an excessive number of positrons relative to electrons at a certain energy, that might just be a compelling sign of dark matter.

On 3 April, AMS designer Samuel Ting of the Massachusetts Institute of Technology reported an expected rise in the ratio of positrons to electrons at energies between 10 and 350 gigaelectronvolts. Frustratingly though, the upturn is not yet sharp enough to attribute to dark matter collisions since the extra positrons could still come from more mundane sources like pulsars. "It's an indication, but by no means is it a proof," Ting says.

In the meantime, a further quirk in the results suggests that if the particles are dark matter, they may not be vanilla WIMPs.

The simplest models predict there should be only a certain amount of dark matter hanging around, and that WIMPs should rarely meet. But AMS has spotted too many positrons for that – so what could make WIMPs collide in space more often than expected?

In 2008, when the PAMELA satellite found a similar excess of positrons, Neal Weiner of New York University and colleagues suggested that WIMPs are drawn together under a force of their own. This new force increases their collision rate but would have escaped our gaze until now because it ignores ordinary matter entirely.

"The basic model is very simple – we know that there are forces in nature, so the idea that dark matter might have its own is pretty easy to consider," Weiner says. The fact that AMS, which makes much more precise measurements of the positron-electron ratio, still sees too many positrons, further invigorates this idea, he says. But the dark force models still need to describe how galaxies and clusters form and interact, which classic dark matter already explains very well.

Enter Lisa Randall of Harvard University and colleagues, who last month proposed a way around this by suggesting that there might be two different types of WIMP. Under their model, 85 per cent would be the classic, non-interacting kind, but 15 per cent would be separate particles that interact with each other via a new dark force, akin to the one proposed by Weiner. This removes some of the difficulties with introducing a new dark force while preserving the benefit of a "boost factor" in the rate of WIMP annihilation – via the 15 per cent of self-interacting WIMPs. It would also require a second new particle, a kind of dark photon.

Randall's model was created before the AMS result came out, to explain another whiff of dark matter. That signal, an excess of gamma rays seen by the Fermi satellite, also required a boost factor for it to be attributed to WIMP annihilation. That signal is now fading, but, somewhat serendipitously, Randall's model could be tweaked to fit with the AMS positron excess as well.

If her model is correct, the consequences would be pretty interesting. Observations of the orbits of stars around galaxies suggest that all galaxies, including the Milky Way, are surrounded by a spherical cloud of dark matter (see diagram). But if a fraction of dark matter particles interact with each other, they would combine into atom-like structures and eventually collapse into a spinning disc. This is how ordinary matter formed the Milky Way. The resulting shadow Milky Way could be spinning right along with the visible one, or it could end up tilted at a slight angle, she adds. Randall is also

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If it all sounds too radical, that may be a good thing: most direct detection experiments, which wait for an ordinary WIMP to collide with the nucleus of a heavy atom like germanium or xenon, have seen nothing (see "Going underground in search of dark matter strikes "), for example.

Even if AMS comes up similarly empty, as many expect, Randall's idea could still survive. To some, a dark force, though it brings complications, seems more natural than the traditional model of dark matter. "Anything beyond that is now considered exotic," says Bullock. "But why? Normal matter interacts with itself, so 20 per cent of matter is really complicated. It's funny that the other 80 per cent is thought to be uncomplicated," he adds.

Self-interacting dark matter may also be easier to detect than its aloof counterpart, so we may soon know who is right. Bullock and colleagues already attributed the dynamics of one galactic smash-up to a dark force keeping WIMPs closer to each other than expected. They are seeking more similar examples.

Randall's dark disc, meanwhile, would affect the movements of some stars in ways that the Gaia satellite, which launches in October, could spot. And because the disc rotates at about the same speed as the Milky Way, WIMPs might collect in the sun more often than you would expect, knocking into solar protons to produce neutrinos. The IceCube detector in Antarctica could detect those extra neutrinos – although in results released two weeks ago the detector reported no such signal.

Weiner describes dark matter hunters like a drunkard looking for keys under a lamp post – that's not where the boozer dropped them, just where the light is. "Changing the dark matter model enlarges the lamp post you're looking under," he says, upping our chances of finding WIMPs – and other things besides.

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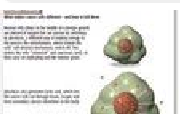

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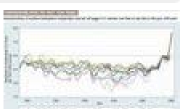

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