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Ether returns to oust dark matter

From his office window, Glenn Starkman can see the site where Albert Michelson and Edward Morley carried out their famous 1887 experiment that ruled out the presence of an all-pervading "aether" in space, setting the stage for Einstein's special theory of relativity. So it seems ironic that Starkman, who is at Case Western Reserve University in Cleveland, Ohio, is now proposing a theory that would bring ether back into the reckoning. While this would defy Einstein, Starkman's ether would do away with the need for dark matter.

Nineteenth-century physicists believed that just as sound waves move through air, light waves must move through an all-pervading physical substance, which they called luminiferous ("light-bearing") ether. However, the Michelson-Morley experiment failed to find any signs of ether, and 18 years after that, Einstein's special relativity argued that light propagates through a vacuum. The idea of ether was abandoned – but not discarded altogether, it seems.

Starkman and colleagues Tom Zlosnik and Pedro Ferreira of the University of Oxford are now reincarnating the ether in a new form to solve the puzzle of dark matter, the mysterious substance that was proposed to explain why galaxies seem to contain much more mass than can be accounted for by visible matter. They posit an ether that is a field, rather than a substance, and which pervades space-time. "If you removed everything else in the universe, the ether would still be there," says Zlosnik. This ether field isn't to do with light, but rather is something that boosts the gravitational pull of stars and galaxies, making them seem heavier, says Starkman. It does this by increasing the flexibility of space-time itself . "We usually imagine space-time as a rubber sheet that's warped by a massive object," says Starkman. "The ether makes that rubber sheet more bendable in parts, so matter can seem to have a much bigger gravitational effect than you would expect from its weight." The team's calculations show that this ether-induced gravity boost would explain the observed high velocities of stars in galaxies, currently attributed to the presence of dark matter.

This is not the first time that physicists have suggested modifying gravity to do away with this unseen dark matter. The idea was originally proposed by Mordehai Milgrom while at Princeton University in the 1980s. He suggested that the inverse-square law of gravity only applies where the acceleration caused by the field is above a certain threshold, say a0. Below that value, the field dissipates more slowly, explaining the observed extra gravity. "It wasn't really a theory, it was a guess," says cosmologist Sean Carroll at the University of Chicago in Illinois.

Then in 2004 this idea of modified Newtonian dynamics (MOND) was reconciled with general relativity by Jacob Bekenstein at the Hebrew University in Jerusalem, Israel (New Scientist, 22 January 2005, p 10), making MOND a genuine contender in the eyes of some physicists. Bekenstein's work was brilliant, but fiendishly complicated, using many different and arbitrary fields and parameters," says Ferreira. "We felt that something so complicated couldn't be the final theory.

Now Starkman's team has reproduced Bekenstein's results using just one field - the new ether (www.arxiv.org/astro-ph/ 0607411). Even more tantalisingly, the calculations reveal a close relationship between the threshold acceleration a0 - which depends on the ether - and the rate at which the universe's expansion is accelerating. Astronomers have attributed this acceleration to something called dark energy, so in a sense the ether is related to this entity. That they have found this connection is a truly profound thing, says Bekenstein. The team is now investigating how the ether might cause the universe's expansion to speed up.

Andreas Albrecht, a cosmologist at the University of Calfornia, Davis, believes that this ether model is worth investigating further. "We've hit some really profound problems with cosmology ׀ with dark matter and dark energy," he says. "That tells us we have to rethink fundamental physics and try something new."

Both Bekenstein and Albrecht say Starkman's team must now carefully check whether the ether theory fits with the motions of planets within our solar system, which are known to a high degree of accuracy, and also explain what exactly this ether is. Ferreira agrees: "The onus is definitely on us to pin this theory down so it doesn't look like yet another fantastical explanation," he says.

However, physicists may be reluctant to resurrect any kind of ether because it contradicts special relativity by forming an absolute frame of reference . "Interestingly, this controversial aspect should make it easy to test for experimentally," says Carroll.

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