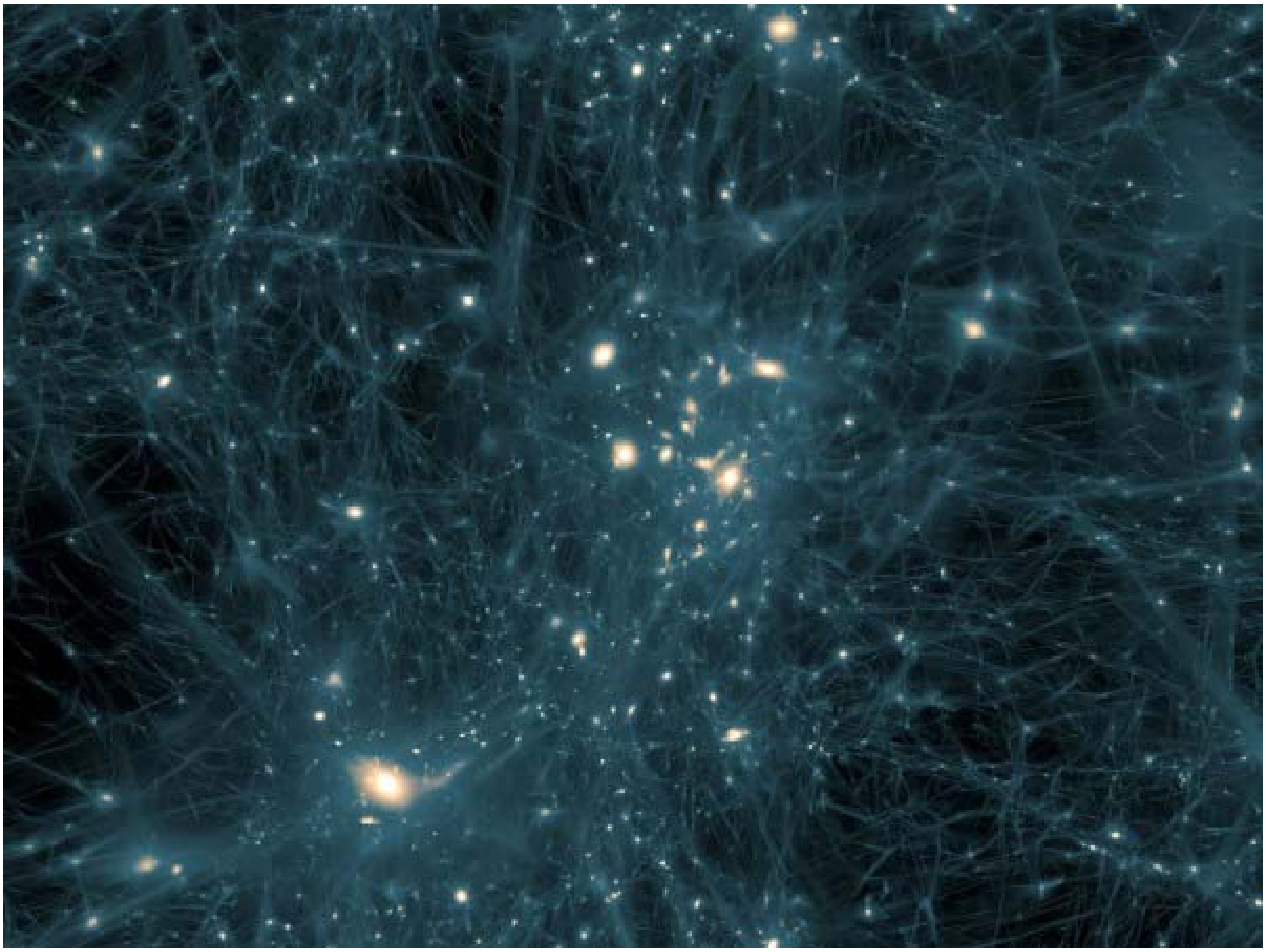

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SIMPs would resolve certain discrepancies between simulations of the distribution of dark matter, like this one, and the observed properties of the galaxies.

Dark matter: Out with the WIMPs, in with the SIMPs?

By Adrian Cho (/author/adrian-cho) | 30 October 2014 5:15 pm | 5 Comments (/physics/2014/10/dark-matter-out-wimps-simps#disqus_thread)

Like cops tracking the wrong person, physicists seeking to identify dark matter (http://news.sciencemag.org/physics/2014/10/decades-old-scientific-paper-may-hold-clues-dark-matter) —the mysterious stuff whose gravity appears to bind the galaxies—may have been stalking the wrong particle. In fact, a particle with some properties opposite to those of physicists' current favorite dark matter candidate—the weakly interacting massive particle, or WIMP (http://news.sciencemag.org/funding/2014/07/two-big-dark-matter-experiments-gain-u-s-support) —would do just as good a job at explaining the stuff, a quartet of theorists says. Hypothetical strongly interacting massive particles—or SIMPs—would also better account for some astrophysical observations, they argue.

"We've been searching for WIMPs for quite some time, but we haven't found them yet, so I think it's important to think outside the box," says Yonit Hochberg, a theorist at Lawrence Berkeley National Laboratory and the University of California (UC), Berkeley, and an author of the new paper.

Theorists dreamed up WIMPs 30 years ago to help explain why galaxies don’t just fly apart. The particles would have a mass between one and 1000 times that of a proton and, in addition to gravity, would interact with one another and with ordinary matter through only the weak nuclear force, one of two forces of nature that normally exert themselves only in the atomic nucleus.

The infant universe would have produced a huge number of WIMPs as subatomic particles crashed into one another. Some of those WIMPs would then disappear when two of them collided and annihilated each other to produce two ordinary particles. As the universe expanded, such collisions would become ever rarer and, given the strength of the weak force, just enough WIMPs would survive to provide the right amount of dark matter today—about five times that of ordinary matter. That coincidence, or "WIMP miracle," has made WIMPs a favorite of theorists, even if experimenters have yet to spot them (http://news.sciencemag.org/physics/2013/10/new-experiment-torpedoes-lightweight-dark-matter-particles) floating about.

However, Hochberg and colleagues argue that dark matter could also consist of lighter particles that have a mass somewhere around one-tenth that of the proton and interact with one another—but not ordinary matter—very strongly. Such SIMPs would pull on one another almost as strongly as the quarks in a proton, which cling to each other so fiercely that it's impossible to isolate a quark.

SIMPs can also provide just the right amount of dark matter, assuming the theorists add a couple of wrinkles. The SIMPs must disappear primarily through collisions in which three SIMPs go in and only two SIMPs come out. These events must be more common than ones in which two SIMPs annihilate each other to produce two ordinary particles. Moreover, the theorists argue, SIMPs must interact with ordinary matter, although much more weakly than WIMPs. That's because the three-to-two collisions would heat up the SIMPs if they could not interact and share heat with ordinary matter.

That may seem like a lot to ask, but those conditions are easy to meet so long as the SIMPs aren't too heavy, Hochberg says. So the WIMP miracle could easily be replaced with a SIMP miracle (http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.113.171301) , as the team reports this month in *Physical Review Letters*.

Moreover, the fact that SIMPs must interact with ordinary matter guarantees that, in principle, they should be detectable in some way, Hochberg says. Whereas physicists are now searching for signs of WIMPs colliding with massive atomic nuclei, researchers would probably have to look for SIMPs smacking into lighter electrons because the bantamweight particles would not pack enough punch to send a nucleus flying.

Compared with WIMPy dark matter, SIMPy dark matter would also have another desirable property. As the universe evolved, dark matter coalesced into clumps, or halos, in which the galaxies then formed. But computer simulations suggest that dark matter that doesn't interact with itself would form myriad little clumps that are very dense in the center. And little "dwarf galaxies" aren't as abundant and the centers of galaxies aren't as dense as the simulations suggest. But strongly interacting dark matter would smooth out the distribution of dark matter and solve those problems, Hochberg says. "This isn't some independent thing that we've just forced into the model," she says. "It just naturally happens."

The new analysis "has the flavor of the WIMP miracle, which is nice," says Jonathan Feng, a theorist at UC Irvine who was not involved in the work. Feng says he's been working on similar ideas and that the ability to reconcile the differences between dark matter simulations and the observed properties of galaxies makes strongly interacting dark matter attractive conceptually.

However, he cautions, it may be possible that, feeble as they may be, the interactions between dark and ordinary matter might smooth out the dark matter distribution on their own. And Feng says he has some doubts about the claim that SIMPs must interact with ordinary matter strongly enough to be detected. So the SIMP probably won't knock WIMP off its perch as the best guess for the dark matter particle just yet, Feng says: "At the moment, it's not as well motivated as the WIMP, but it's definitely worth exploring."

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