Dark matter may be hiding in a hidden sector

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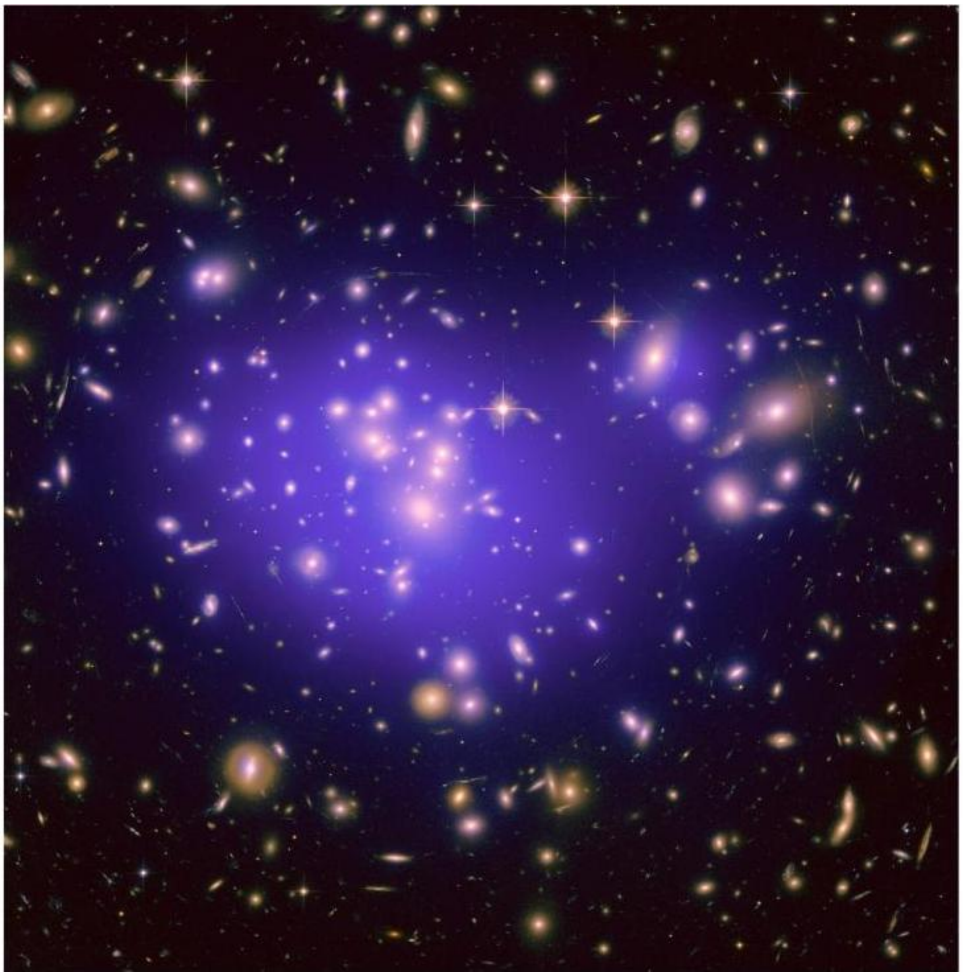

This image shows the galaxy cluster Abell 1689, with the mass distribution of the dark matter in the gravitational lens overlaid (in purple). The mass in this lens is made up partly of normal (baryonic) matter and partly of dark matter. Credit: NASA, ESA, E. Jullo (JPL/LAM), P. Natarajan (Yale) and J-P. Kneib (LAM).

(Phys.org)—Currently, one of the strongest candidates for dark matter is weakly interacting massive particles, or WIMPS, although so far this hypothetical particle has not yet been directly detected. Now in a new study, physicists have proposed that dark matter is not a WIMP, and further, it is not any particle that is so far known or theorized to exist.

Instead, the physicists argue that dark matter is made of particles from one of the many "hidden sectors" that are thought to exist outside of the "visible sector" that encompasses our entire visible world. The team of researchers, Bobby Acharya, Sebastian Ellis, Gordon Kane, Brent Nelson, and Malcolm Perry, from institutions in the UK, Italy, and the US, has published their study in a recent issue of *Physical Review Letters.*

Hidden sectors are so-named because particles in these sectors don't feel the strong and electroweak forces like those in the visible sector do, which greatly reduces their interaction with the visible sector. So hidden sector particles could be all around us—we just currently have no way to detect them.

In the proposed scenario, dark matter consists of particles in the hidden sector that communicate through a portal from the hidden sector to the visible sector, and in this way exert the gravitational effects that scientists have long observed.

While such an idea may sound far-fetched, hidden sectors and portals have long been components of string theory and M-theory—two theories that seek to explain particle physics at its most fundamental level.

The main support for the new claim boils down to a question of stability. In general, heavier particles decay into lighter particles. So lighter particles, being more stable, are much more likely candidates for dark matter. This is where the long-standing support for WIMPs comes from, since WIMPs are the lightest supersymmetric particle, and therefore, until now, considered to be stable.

However, since approximately 100 hidden sectors are thought to exist, but only one visible sector, the scientists argue in the new study that some hidden sector likely contains a particle that is even lighter than WIMPs.

The scientists show that WIMPs could theoretically decay into one or more lighter hidden sector particles, which could in turn decay into even lighter hidden sector particles. So the lightest supersymmetric particle in the visible sector wouldn't be stable enough to be dark matter. Instead, according to this argument, some currently unknown hidden sector particle would be a much more likely dark matter candidate.

"The greatest significance of our work is that it forces theorists to rethink the paradigm of what is called WIMP dark matter," Ellis, a physicist at the University of Michigan, told *Phys.org*. "WIMPs have been the most popular candidates for what constitutes dark matter for over 30 years. A WIMP is a particle a bit like the Higgs or Z-boson that are electrically neutral, heavy particles which participate in the weak nuclear interactions, but unlike the Higgs or Z-boson, WIMP dark matter would be stable on cosmological scales. WIMP dark matter has most commonly been discussed within the context of supersymmetry (SUSY).

"For 30 years, theorists have thought that in SUSY models, the lightest SUSY particle was a good dark matter candidate due to its stability. However, in our paper we argue that if you take the Standard Model of particle physics as residing in a greater, string/M-theory framework, then supersymmetric WIMPs are probably not a good dark matter candidate, because we show that they are typically unstable.

"The string landscape encompasses a vast number of possible low-energy theories. However, we found that nearly all of the landscape would exhibit this feature of WIMP instability. Such a conclusion means that if we are to think seriously of embedding our visible universe in a string theory, we have to seriously consider the natural possibility that dark matter resides in a hidden sector, or we are forced into a very untypical corner of the string landscape."

If dark matter does turn out to be a hidden sector particle, it would explain why WIMPs have been so difficult to detect in particle colliders. In order to detect a WIMP, scientists will have to modify their search and look in different places.

"If dark matter comes from a hidden sector, it poses a serious issue of how to detect it, other than through its gravitational interactions," Ellis said. "String/M-theory can provide so-called 'portals' which connect these hidden sectors to our visible sector, thus potentially leading to a means of searching for hidden sector dark matter. Also, if dark matter is 'proven' experimentally to be in a hidden sector, it would fit very naturally with typical models of the universe that arise in string and M-theory."

In the future, the scientists plan to further investigate the exact signature of a WIMP decaying into a hidden sector particle, which would guide future experiments.

"We are currently finalizing a follow-up paper where we consider typical string/M-theory hidden sector constructions which could give good candidates for dark matter," Ellis said. "Most importantly, we find there are such candidates. The typical signature of such constructions is that when SUSY particles are produced in a collider, the WIMP will decay promptly into the hidden sector and other visible particles. Thus one would expect the typical collider signature for SUSY, namely missing energy, but accompanied by more particles than in a typical SUSY event."

More information: Bobby S. Acharya, Sebastian A. R. Ellis, Gordon L. Kane, Brent D. Nelson, and Malcolm J. Perry . "Lightest Visible-Sector Supersymmetric Particle is Likely to be Unstable." *Physical Review Letters*. DOI: 10.1103/PhysRevLett.117.181802
Also at arXiv:1604.05320 [hep-ph]