Dark dwarfs lurking at the center of our galaxy might hint at the nature of dark matter

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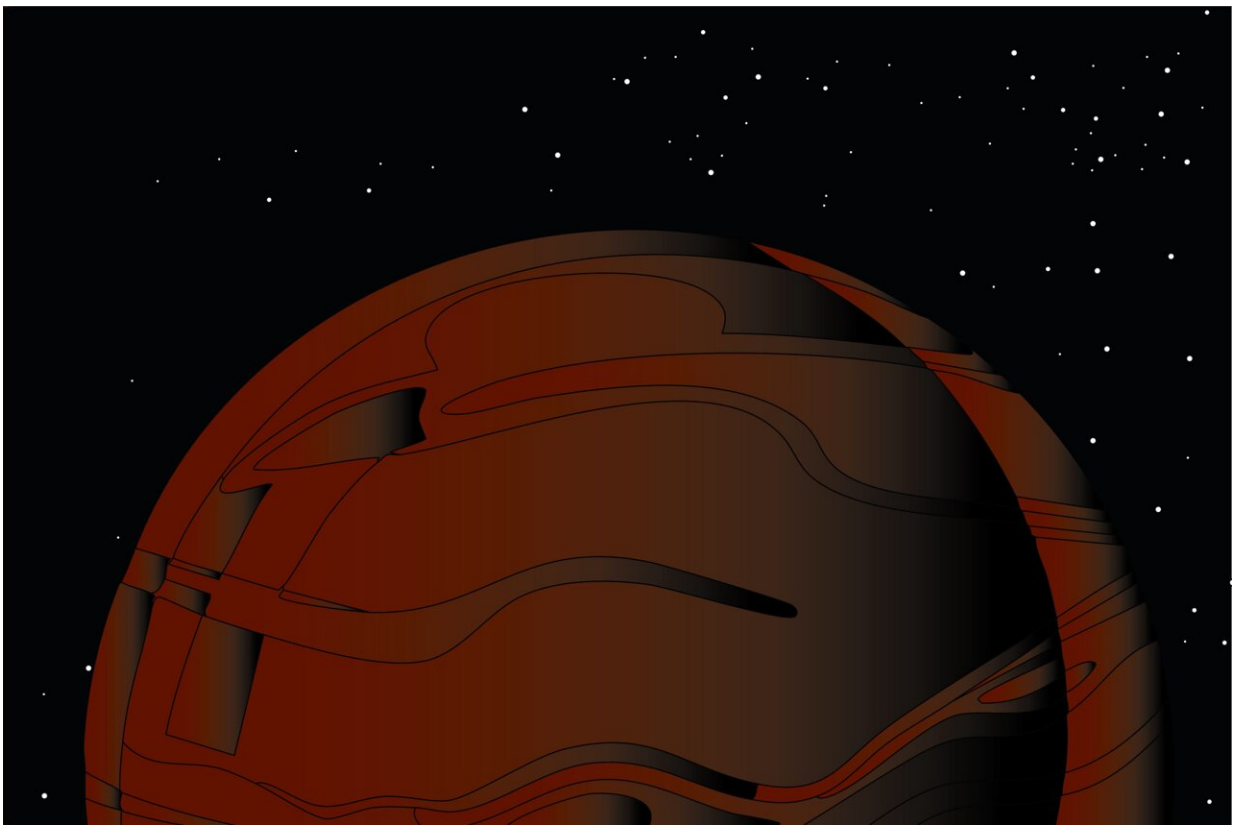

Artistic representation of a dark dwarf. Credit: Sissa Medialab

Celestial objects known as dark dwarfs may be hiding at the center of our galaxy and could offer key clues to uncover the nature of one of the

most mysterious and fundamental phenomena in contemporary cosmology: dark matter.

A paper published in the *Journal of Cosmology and Astroparticle Physics* by a team of researchers based in the UK and Hawaii describes these objects for the first time and proposes how to verify their existence using current observational tools such as the James Webb Space Telescope. The paper is titled "Dark Dwarfs: Dark Matter-Powered Sub-Stellar Objects Awaiting Discovery at the Galactic Center."

The Anglo-U.S. team behind the study named them dark dwarfs. Not because they are dark bodies—on the contrary—but because of their special link with dark matter, one of the most central topics in current cosmology and astrophysics research.

"We think that 25% of the universe is composed of a type of matter that doesn't emit light, making it invisible to our eyes and telescopes. We only detect it through its gravitational effects. That's why we call it dark matter," explains Jeremy Sakstein, Professor of Physics at the University of Hawai'i and one of the study's authors.

What we know today about dark matter is that it exists and how it behaves—but not yet what it actually is. Over the past 50 years, several hypotheses have been proposed, but none have yet gathered enough experimental evidence to prevail. Studies like the one by Sakstein and colleagues are important because they offer concrete tools to break this deadlock.

Among the most well-known dark matter candidates are the Weakly Interacting Massive Particles (WIMPs)—very massive particles that interact very weakly with ordinary matter: they pass through things unnoticed, don't emit light and don't respond to electromagnetic forces (so they don't reflect light and remain invisible), and reveal themselves

only through their gravitational effects. This type of dark matter would be necessary for dark dwarfs to exist.

"Dark matter interacts gravitationally, so it could be captured by stars and accumulate inside them. If that happens, it might also interact with itself and annihilate, releasing energy that heats the star," Sakstein explains.

Ordinary stars—like our sun—shine because nuclear fusion processes occur in their cores, generating large amounts of heat and energy. Fusion happens when a star's mass is large enough that gravitational forces compress matter toward the center with such intensity that they trigger reactions between atomic nuclei. This process releases a huge amount of energy, which we see as light. Dark dwarfs also emit light—but not because of nuclear fusion.

"Dark dwarfs are very low mass objects, about 8% of the sun's mass," Sakstein explains. Such a small mass is not sufficient to trigger fusion reactions.

For this reason, such objects—although very common in the universe—usually only emit a faint light (due to the energy produced by their relatively small gravitational contraction) and are known to scientists as brown dwarfs.

However, if brown dwarfs are located in regions where dark matter is particularly abundant—such as the center of our galaxy—they can transform into something else.

"These objects collect the dark matter that helps them become a dark dwarf. The more dark matter you have around, the more you can capture," Sakstein explains. "And, the more dark matter ends up inside the star, the more energy will be produced through its annihilation."

But all of this relies on a specific type of dark matter. "For dark dwarfs to exist, dark matter has to be made of WIMPs, or any heavy particle that interacts with itself so strongly to produce visible matter," Sakstein says.

Other candidates proposed to explain dark matter—such as axions, fuzzy ultralight particles, or sterile neutrinos—are all too light to produce the expected effect in these objects. Only massive particles, capable of interacting with each other and annihilating into visible energy, could power a dark dwarf.

This entire hypothesis, however, would have little value if there weren't a concrete way to identify a dark dwarf. For this reason, Sakstein and colleagues propose a distinctive marker. "There were a few markers, but we suggested Lithium-7 because it would really be a unique effect," the scientist explains.

Lithium-7 burns very easily and is quickly consumed in ordinary stars. "So if you were able to find an object which looked like a dark dwarf, you could look for the presence of this lithium because it wouldn't be there if it was a brown dwarf or a similar object."

Tools like the James Webb Space Telescope might already be able to detect extremely cold celestial objects like dark dwarfs. But, according to Sakstein, there's another possibility. "The other thing you could do is to look at a whole population of objects and ask, in a statistical manner, if it is better described by having a sub-population of dark dwarfs or not."

If in the coming years we manage to identify one or more dark dwarfs, how strong would that clue be in support of the hypothesis that dark matter is made of WIMPs?

"Reasonably strong. With light dark matter candidates, something like an axion, I don't think you'd be able to get something like a dark dwarf. They don't accumulate inside stars. If we manage to find a dark dwarf, it would provide compelling evidence that dark matter is heavy and interacts strongly with itself, but only weakly with the Standard Model. This includes classes of WIMPs, but it would include some other more exotic models as well," concludes Sakstein.

Observing a dark dwarf wouldn't conclusively tell us that dark matter is a WIMP, but it would mean that it is either a WIMP or something that, for all intents and purposes, behaves like a WIMP.

More information: Dark Dwarfs: Dark Matter-Powered Sub-Stellar Objects Awaiting Discovery at the Galactic Center, *Journal of Cosmology and Astroparticle Physics* (2025). On *arXiv*: DOI: 10.48550/arxiv.2408.00822

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