MOND vs. dark matter: Research suggests that rotation curves of galaxies stay flat indefinitely

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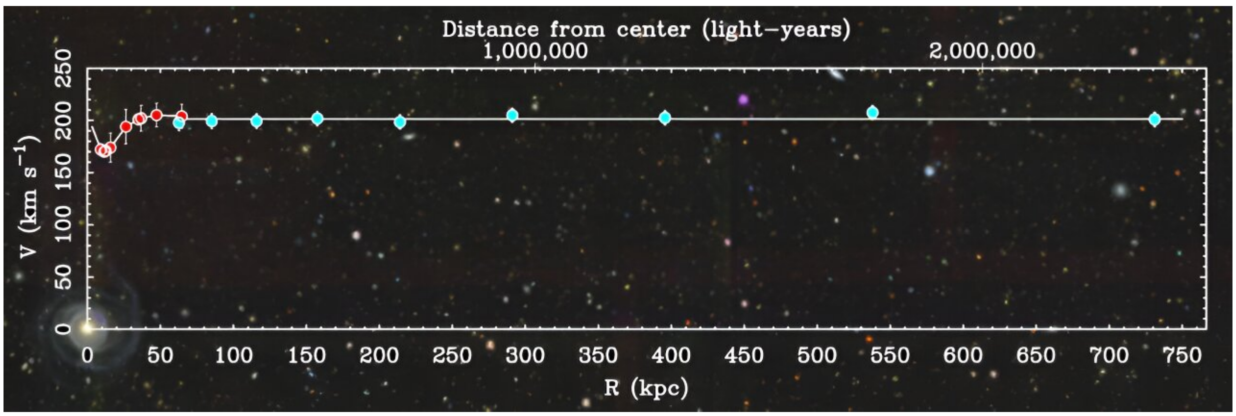

The primary technique Mistele used in his research, gravitational lensing, is a phenomenon predicted by Einstein's theory of general relativity. As part of the research, Mistele plotted out what's called Tully–Fisher relation on a chart to highlight the empirical relationship between the visible mass of a galaxy and its rotation speed.

In a discovery that challenges the conventional understanding of cosmology, scientists at Case Western Reserve University have unearthed new evidence that could reshape our perception of the cosmos.

Tobias Mistele, a post-doctoral scholar in the Department of Astronomy at Case Western Reserve's College of Arts and Sciences, pioneered a revolutionary technique using "gravitational lensing" to delve into the enigmatic realm of dark matter. He found that the rotation curves of galaxies remain flat for millions of light years with no end in sight.

The work has been published on the pre-print server *arXiv*.

Scientists have previously believed that the rotation curves of galaxies must decline the farther out you peer into space.

Traditionally, the behavior of stars within galaxies has puzzled astronomers. According to Newtonian gravity, stars on the outer edges should be slower due to diminished gravitational pull. This was not observed, leading to the inference of dark matter. But even dark matter halos should come to an end, so rotation curves should not remain flat indefinitely.

Mistele's analysis defies this expectation, providing a startling revelation: the influence of what we call dark matter extends far beyond previous estimates, stretching at least a million light-years from the galactic center.

Such a long range effect may indicate that dark matter—as we understand it—might not exist at all.

"This finding challenges existing models," he said, "suggesting there exist either vastly extended dark matter halos or that we need to fundamentally reevaluate our understanding of gravitational theory."

Stacy McGaugh, professor and director of the Department of Astronomy in the College of Arts and Sciences, said Mistele's findings, slated for publication in the *Astrophysical Journal Letters*, push traditional boundaries.

"The implications of this discovery are profound," McGaugh said. "It not only could redefine our understanding of dark matter, but also beckons us to explore alternative theories of gravity, challenging the very fabric of modern astrophysics."

Turning Einstein's theory on its head

The primary technique Mistele used in his research, gravitational lensing, is a phenomenon predicted by Einstein's theory of general relativity. Essentially, it occurs when a massive object, like a galaxy cluster or even a single massive star, bends the path of light coming from a distant source. This bending of light happens because the mass of the object warps the fabric of spacetime around it. This bending of light by galaxies persists over much larger scales than expected.

As part of the research, Mistele plotted out what's called Tully–Fisher relation on a chart to highlight the empirical relationship between the visible mass of a galaxy and its rotation speed.

"We knew this relationship existed," Mistele said. "But it wasn't obvious that the relationship would hold the farther you go out. How far does this behavior persist? That's the question, because it can't persist forever."

Mistele said his discovery underscores the necessity for further exploration and collaboration within the scientific community—and the possible analysis of other data.

McGaugh noted the Herculean—yet, so far, unsuccessful—efforts in the international particle physics community to detect and identify dark matter particles.

"Either dark matter halos are much bigger than we expected, or the whole paradigm is wrong," McGaugh said.

"The theory that predicted this behavior in advance is the modified gravity theory MOND hypothesized by Moti Milgrom as an alternative to dark matter in 1983. So, the obvious and inevitably controversial interpretation of this result is that dark matter is a chimera; perhaps the evidence for it is pointing to some new theory of gravity beyond what Einstein taught us."

More information: Tobias Mistele et al, Indefinitely Flat Circular Velocities and the Baryonic Tully-Fisher Relation from Weak Lensing. *arXiv* (2024). arxiv.org/abs/2406.09685

Provided by Case Western Reserve University

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