Do dark matter and dark energy exist?

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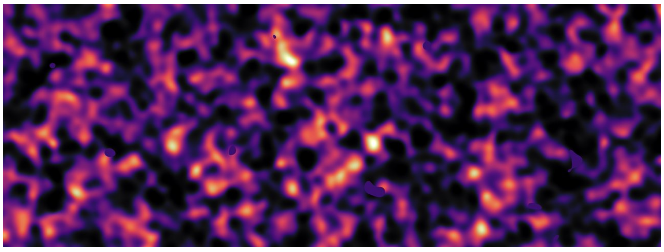

Dark matter map of KiDS survey region (region G12). Credit: KiDS survey

Researchers have hypothesized that the universe contains "dark matter." They have also posited the existence of "dark energy." These two hypotheses account for the movement of stars in galaxies and for the accelerating expansion of the universe. But according to a researcher at UNIGE, these concepts may be no longer valid, as universal phenomena can be demonstrated without them. This research exploits a new theoretical model based on the scale invariance of empty space. This research is reported in *The Astrophysical Journal*.

In 1933, the Swiss astronomer Fritz Zwicky claimed there is substantially more matter in the universe than we can actually see. Astronomers called this unknown matter "dark matter," a concept that was to take on yet more importance in the 1970s, when the U.S. astronomer Vera Rubin invoked this enigmatic matter to explain the movements and speed of the stars. Scientists have subsequently devoted considerable resources to identifying dark matter in space, on the ground and at CERN, but without success. In 1998, a team of Australian and U.S. astrophysicists discovered the acceleration of the expansion of the universe, earning the Nobel Prize for physics in 2011. However, in spite of enormous science resources, no theory or observation has been able to define this energy that is allegedly stronger than Newton's gravitational attraction. In short, dark matter and dark energy are mysteries that have stumped astronomers for decades.

A new model based on the scale invariance of empty space

The way physicists represent the universe and its history are described by Einstein's equations of general relativity, Newton's universal gravitation and quantum mechanics. The consensus at present is that of a Big Bang followed by expansion. "In this model, there is a starting hypothesis that hasn't been taken into account, in my opinion," says André Maeder, honorary professor in the Department of Astronomy in UNIGE's Faculty of Science. "By that, I mean the scale invariance of empty space; in other words, empty space and its properties do not change following a dilatation or contraction."

Empty space plays a primordial role in Einstein's equations as it operates in a quantity known as a "cosmological constant," and the resulting model depends on it. Based on this hypothesis, Maeder is now re-examining the Standard Model of the universe, pointing out that the scale invariance of empty space is also present in the fundamental theory of electromagnetism.

When Maeder carried out cosmological tests on his new model, he found that it matched observations. He also found that the model predicts the accelerated expansion of the universe without having to factor in dark energy. In short, it appears that dark energy may not actually exist since the acceleration of the expansion is contained in the equations of the physics.

In a second stage, Maeder focused on Newton's law, a specific instance of the equations of general relativity. The law is also slightly modified when the model incorporates Maeder's new hypothesis. Indeed, it contains a very small outward acceleration term, which is particularly significant at low densities. This amended law, when applied to clusters of galaxies, leads to masses of clusters in line with that of visible matter (contrary to what Zwicky argued in 1933). This means that no dark matter is needed to explain the high speeds of the galaxies in the clusters. A second test demonstrated that this law also predicts the high speeds reached by the stars in the outer regions of galaxies (as Rubin had observed), without having to resort to dark matter to describe them. Finally, a third test looked at the dispersion of the speeds of the stars oscillating around the plane of the Milky Way. This dispersion, which increases with the age of the relevant stars, can be explained very well using the invariant empty space hypothesis, while there was before no agreement on the origin of this effect.

Maeder's discovery paves the way for a new conception of astronomy that will raise questions and generate controversy. "The announcement of this model, which at last solves two of astronomy's greatest mysteries, remains true to the spirit of science: nothing can ever be taken for granted, not in terms of experience, observation or the reasoning of human beings," concluded André Maeder.

More information: Andre Maeder. Dynamical Effects of the Scale Invariance of the Empty Space: The Fall of Dark Matter?, *The Astrophysical Journal* (2017). DOI: 10.3847/1538-4357/aa92cc , iopscience.iop.org/article/10. … 847/1538-4357/aa92cc , On *Arxiv*: arxiv.org/abs/1710.11425

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