New theory of gravity might explain dark matter

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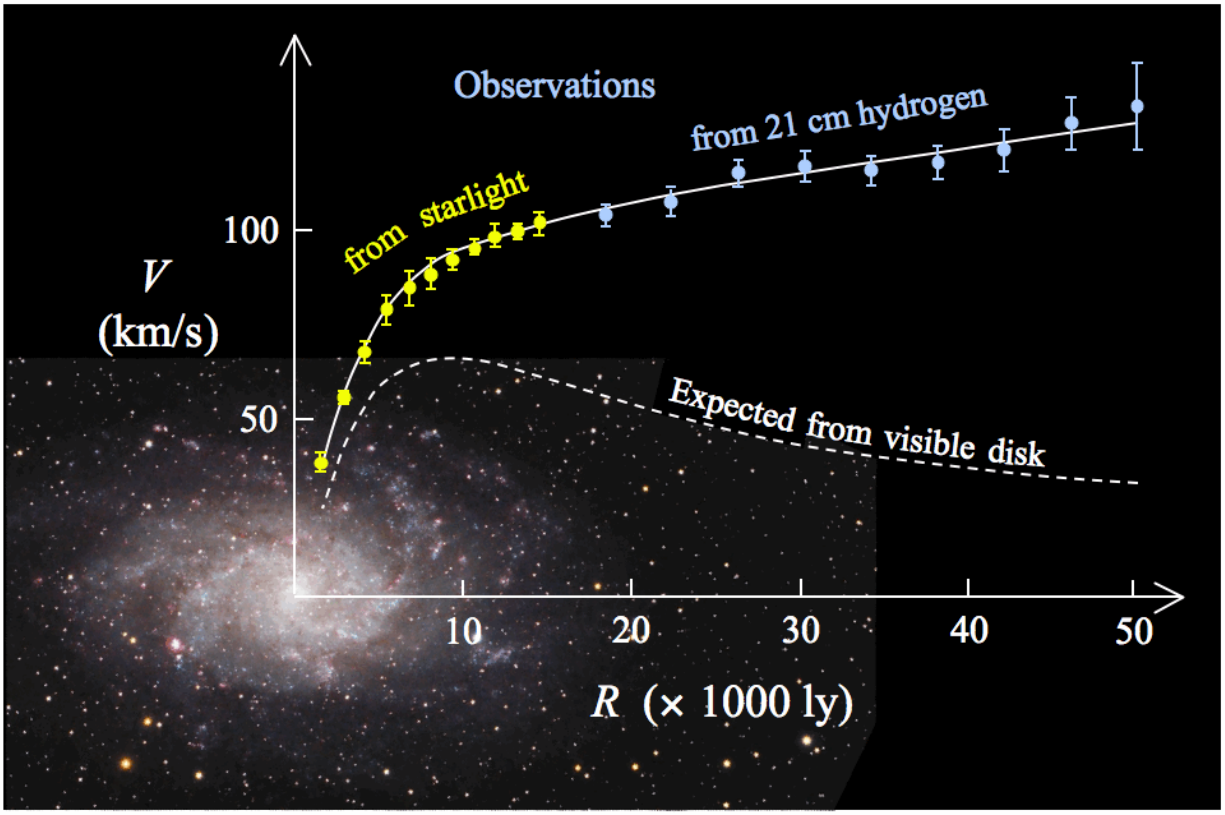

Credit: Wikipedia

A new theory of gravity might explain the curious motions of stars in galaxies. Emergent gravity, as the new theory is called, predicts the exact same deviation of motions that is usually explained by invoking dark

matter. Prof. Erik Verlinde, renowned expert in string theory at the University of Amsterdam and the Delta Institute for Theoretical Physics, published a new research paper today in which he expands his groundbreaking views on the nature of gravity.

In 2010, Erik Verlinde surprised the world with a completely new theory of gravity. According to Verlinde, gravity is not a fundamental force of nature, but an emergent phenomenon. In the same way that temperature arises from the movement of microscopic particles, gravity emerges from the changes of fundamental bits of information, stored in the very structure of spacetime.

Newton's law from information

In his 2010 article (On the origin of gravity and the laws of Newton), Verlinde showed how Newton's famous second law, which describes how apples fall from trees and satellites stay in orbit, can be derived from these underlying microscopic building blocks. Extending his previous work and work done by others, Verlinde now shows how to understand the curious behaviour of stars in galaxies without adding the puzzling dark matter.

The outer regions of galaxies, like our own Milky Way, rotate much faster around the centre than can be accounted for by the quantity of ordinary matter like stars, planets and interstellar gasses. Something else has to produce the required amount of gravitational force, so physicists proposed the existence of dark matter. Dark matter seems to dominate our universe, comprising more than 80 percent of all matter. Hitherto, the alleged dark matter particles have never been observed, despite many efforts to detect them.

No need for dark matter

According to Erik Verlinde, there is no need to add a mysterious dark matter particle to the theory. In a new paper, which appeared today on the ArXiv preprint server, Verlinde shows how his theory of gravity accurately predicts the velocities by which the stars rotate around the center of the Milky Way, as well as the motion of stars inside other galaxies.

"We have evidence that this new view of gravity actually agrees with the observations, " says Verlinde. "At large scales, it seems, gravity just doesn't behave the way Einstein's theory predicts."

At first glance, Verlinde's theory presents features similar to modified theories of gravity like MOND (modified Newtonian Dynamics, Mordehai Milgrom (1983)). However, where MOND tunes the theory to match the observations, Verlinde's theory starts from first principles. "A totally different starting point," according to Verlinde.

Adapting the holographic principle

One of the ingredients in Verlinde's theory is an adaptation of the holographic principle, introduced by his tutor Gerard 't Hooft (Nobel Prize 1999, Utrecht University) and Leonard Susskind (Stanford University). According to the holographic principle, all the information in the entire universe can be described on a giant imaginary sphere around it. Verlinde now shows that this idea is not quite correct—part of the information in our universe is contained in space itself.

This extra information is required to describe that other dark component of the universe: Dark energy, which is believed to be responsible for the accelerated expansion of the universe. Investigating the effects of this additional information on ordinary matter, Verlinde comes to a stunning conclusion. Whereas ordinary gravity can be encoded using the information on the imaginary sphere around the universe, as he showed

in his 2010 work, the result of the additional information in the bulk of space is a force that nicely matches that attributed to dark matter.

On the brink of a scientific revolution

Gravity is in dire need of new approaches like the one by Verlinde, since it doesn't combine well with quantum physics. Both theories, crown jewels of 20th century physics, cannot be true at the same time. The problems arise in extreme conditions: near black holes, or during the Big Bang. Verlinde says, "Many theoretical physicists like me are working on a revision of the theory, and some major advancements have been made. We might be standing on the brink of a new scientific revolution that will radically change our views on the very nature of space, time and gravity."

More information: Emergent Gravity and the Dark Universe, E. P. Verlinde, 7 Nov 2016. arxiv.org/abs/1611.02269

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