Dark matter may be an illusion caused by the quantum vacuum

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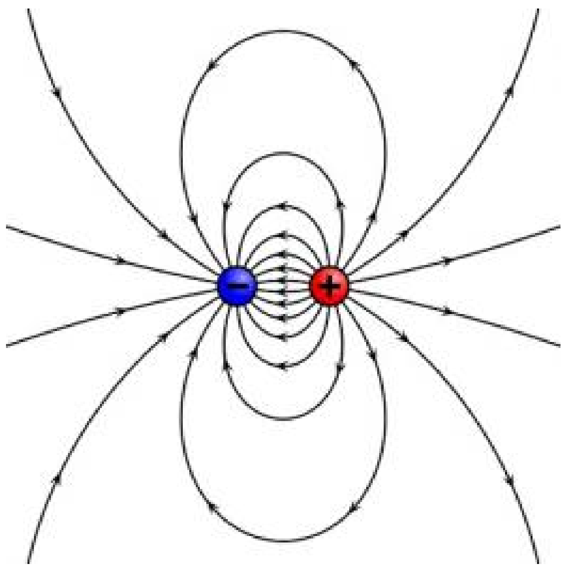

When polarized, virtual gravitational dipoles in the quantum vacuum can produce a stronger-than-predicted gravitational field. (An electric dipole is shown. Currently, mainstream physics assumes there is only a positive gravitational charge.) Image credit: Wikimedia Commons

(PhysOrg.com) -- One of the biggest unsolved problems in astrophysics is that galaxies and galaxy clusters rotate faster than expected, given the amount of existing baryonic (normal) matter. The fast orbits require a larger central mass than the nearby stars, dust, and other baryonic objects can provide, leading scientists to propose that every galaxy resides in a halo of (as yet undetectable) dark matter made of non-baryonic particles. As one of many scientists who have become somewhat skeptical of dark matter, CERN physicist Dragan Slavkov Hajdukovic has proposed that the illusion of dark matter may be caused by the gravitational polarization of the quantum vacuum.

"The key message of my paper is that dark matter may not exist and that phenomena attributed to dark matter may be explained by the gravitational polarization of the quantum vacuum," Hajdukovic told *PhysOrg.com*. "The future experiments and observations will reveal if my results are only (surprising) numerical coincidences or an embryo of a new scientific revolution."

Like his previous study featured on PhysOrg about a cyclic universe successively dominated by matter and antimatter, Hajdukovic's paper on a dark matter alternative is also an attempt to understand cosmological phenomena without assuming the existence of unknown forms of matter and energy, or of unknown mechanisms for inflation and matter-antimatter asymmetry. In the case of the fast rotational curves of galaxies, he explains that there are currently two schools of understanding the phenomenon.

"The first school invokes the existence of dark matter, while the second school invokes modification of our law of gravity," he said. "I suggest a third way, without introducing dark matter and without modification of the law of gravity."

His ideas (like those in the previous paper) rest on the key hypothesis that matter and antimatter are gravitationally repulsive, which is due to the fact that particles and antiparticles have gravitational charge of opposite sign. (Though like matter, antimatter is gravitationally attractive with itself.) Currently, it is not known whether matter and antimatter are gravitationally repulsive, although a few experiments (most notably, the AEGIS experiment at CERN) are testing related concepts.

"Concerning gravity, mainstream physics assumes that there is only one gravitational charge (identified with the inertial mass) while I have assumed that, as in the case of electromagnetic interactions, there are two gravitational charges: positive gravitational charge for matter and negative gravitational charge for antimatter," Hajdukovic explained.

If matter and antimatter are gravitationally repulsive, then it would mean that the virtual particle-antiparticle pairs that exist for a limited time in the quantum vacuum are "gravitational dipoles." That is, each pair forms a system in which the virtual particle has a positive gravitational charge, while the virtual antiparticle has a negative gravitational charge. In this scenario, the quantum vacuum contains many virtual gravitational dipoles, taking the form of a dipolar fluid.

"We can consider our universe as a union of two mutually interacting entities," Hajdukovic said. "The first entity is our 'normal' matter (hence we do not assume the existence of dark matter and dark energy), immersed in the second entity, the quantum vacuum, considered as a sea of different kinds of virtual dipoles, including gravitational dipoles."

He goes on to explain that the virtual gravitational dipoles in the quantum vacuum can be gravitationally polarized by the baryonic matter in nearby massive stars and galaxies. When the virtual dipoles align, they produce an additional gravitational field that can combine with the gravitational field produced by stars and galaxies. As such, the gravitationally polarized quantum vacuum could produce the same "speeding up" effect on the rotational curves of galaxies as either hypothetical dark matter or a modified law of gravity.

As Hajdukovic explains, the effect of the stronger gravitational field can be understood by looking at what happens when an electric field rather than a gravitational field causes polarization. He gives an example of a dielectric slab being inserted into a parallel plate capacitor, which results in a decrease in the electric field between the plates. The decrease is due to the fact that the electric charges of opposite sign attract each other. But if the electric charges of opposite sign were repulsive instead of attractive, then the electric field would increase. Back to the quantum vacuum scenario, since the gravitational charges of opposite sign are repulsive, the strength of the gravitational field increases.

In his paper, Hajdukovic also presents equations in support of this scenario, one of which allows calculating the effects of the gravitational polarization at different distances from the center of a galaxy, which are in good agreement with observations. He also derives the famous Tully-Fisher relation as a consequence of the gravitational repulsion between matter and antimatter. This relation is an empirical law based on numerical data collected by numerous observations of galaxies and clusters of galaxies, and is still unexplained in the framework of dark matter hypotheses.

Overall, Hajdukovic's proposal lies in contrast with another concept proposed in the past few years by physicists Luc Blanchet and Alexandre Le Tiec. Although that idea also involves a dipolar fluid composed of gravitational dipoles, instead of being composed of virtual baryonic matter in the quantum vacuum, the dipolar fluid is a new form of dark matter. The dark matter is gravitationally polarized by the gravitational field of baryonic matter, such as massive stars and galaxies, which results in a stronger gravitational field. In other words, Blanchet and Le Tiec propose that dark matter in the form of gravitational dipoles of unknown nature can reconcile dark matter and Modified Newtonian Dynamics (MOND) theory, a modification of gravity; on the other hand, Hajdukovic proposes that virtual gravitational dipoles in the quantum vacuum can lead to a stronger gravitational field.

In the end, Hajdukovic notes that much more work needs to be done before claiming that this possibility is the correct one. For one thing, the rotational curves of galaxies are not the only phenomenon that can be explained by dark matter. Observations of the cosmic microwave background, gravitational lensing, supernovae, and other data can also be better explained by the existence of dark matter than without it. With many scientists currently investigating dark matter and other alternatives, Hajdukovic hopes that new answers will continue to be discovered.

More information: Dragan Slavkov Hajdukovic. “Is dark matter an illusion created by the gravitational polarization of the quantum vacuum?” *Astrophys Space Sci* (2011) 334:215-218. DOI:10.1007/s10509-011-0744-4