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GRAVITATIONAL LENSES EXPLAINED WITH AN EXTENDED THEORY OF GRAVITY

**** The theory models the deflection of light when passing near massive bodies***

**** The extension proposed to Einstein´s general relativity also provides a description for the accelerated expansion of the Universe.***

**** Astrophysicists from IA-UNAM pursue their research in gravitation and cosmology.***

Drs. Sergio Mendoza and Xavier Hernández and their colleagues, at the Instituto de Astronomía (IA) of the Universidad Nacional Autónoma de México (UNAM) have found a coherent way to explain the deflection of light in galaxies and groups of galaxies (an effect known as gravitational lensing) using their extended theory of gravity, rather than assuming the existence of dark matter particles.

Current astrophysical and cosmological phenomenology is typically explained under the assumption of the existence of two dark and as yet directly unobserved entities: dark matter and dark energy. Since this assumption is inferred through gravitational interactions, rather than direct detections, the IA-UNAM researchers have developed an alternative approach based on modifying or extending the theory of gravity.

The work by the IA-UNAM researchers, Dr. Mendoza and Dr. Hernandez, together with Dr. J.C. Hidalgo and postgraduate students MScs. T. Bernal and L.A. Torres, shows that their extended theory of gravity is capable of explaining the dynamics of stars and planets at scales equivalent to those of our solar system, and of galaxies and groups of galaxies as well as the deflection of light produced by these systems, known as gravitational lensing. This effect is seen when light coming from bright and distant sources passes close to massive systems, such as a group of galaxies, and appears to be deflected. This is interpreted as a

consequence of the curvature of space-time due to the observed mass distribution, and more generally constitutes a test which can be used to validate a theory of gravity.

A complete theory of gravity must properly explain a large set of cosmological observations. In a first approximation, Dr. S. Mendoza with his students BSc. D. Carranza and MSc. L.A. Torres have recently shown that the current expansion of the Universe can be understood with the same extended theory of gravity without invoking dark energy or dark matter. The IA-UNAM group thus continues its research in extragalactic and cosmological tests.

When a relativistic theory of gravity is constructed, it must succeed in explaining the motion of massive particles (such as planets or stars) and massless ones (such as light trajectories). One of the most celebrated examples in this context was Einstein's prediction, validated nearly 100 years ago, of the deflection light suffers when grazing the Sun, during the solar eclipse of 1919, and the accounting for the modifications observed in the orbit of the planet Mercury.

The foundation for this proposed metric theory of gravity lies in the change in behavior of gravity at a certain scale, and in that the transition point is tied to the concentration of matter in the system. The behavior of astrophysical systems with a sufficiently high density (such as the Solar System) is well explained with Einstein's general relativity. However very rarefied astrophysical systems (such as the outskirts of galaxies, and our current universe as a whole) require a new understanding. The behavior of systems at such large scales is not in agreement with the predictions of general relativity, unless either the concepts of dark matter and dark energy are introduced, or, as proposed in these papers, modifications to gravity are considered.

Reference:

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"Gravitational lensing with f(chi) = chi^{3/2} gravity in accordance with astrophysical observations". Monthly Notices of the Royal Astronomical Society, Oxford University Press. Preprint available at http://dx.doi.org/10.1093/mnras/stt752

Further reading:

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T. Bernal, S. Capozziello, J.C. Hidalgo & S. Mendoza (2012), "Recovering MOND from extended metric theories of gravity", European Physical Journal C 71:1794. Preprint available at arxiv.org/abs/1108.5588

S. Mendoza (2012), "Extending Cosmology: The Metric Approach", Open Questions in Cosmology, InTech, available at intechopen.com/books/open-questions-in-cosmology/extending-cosmology-the-metric-approach

D.A. Carranza, S. Mendoza & L.A. Torres (2013), "A cosmological dust model with extended f(chi) gravity", European Physical Journal C, 73:2282. Preprint available at arxiv.org/abs/1208.2502

X. Hernandez (2012), "A Phase Space Diagram for Gravity", Entropy. Available at mdpi.com/1099-4300/14/5/848