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Dark matter hypotheses and modifications of gravity

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The measured orbital velocity distributions of stars in galaxies and the observed gravitational lensing effects in galaxy clusters suggest that there should be more mass than that can be explained by the visible mass of stars, gas and dust in the galaxies. This unseen mass or matter, generally referred to as dark matter, has puzzled physicists for a few decades and has now become one of the greatest unsolved mysteries in modern science. So far, all of the efforts aiming to generate and detect the exotic dark matter substance have yielded negative results. On the other hand, rather than introducing unseen matter, some physicists explore altering the laws of gravity at large scales or low accelerations. In contrast to the dark matter hypotheses, modifications of gravity theories propose that Newtonian gravity or general relativity breaks down in low-acceleration or large-scale regimes, requiring new dynamics—such as MOND or its relativistic extensions—to explain the same observations without invoking unseen matter. Here, starting from Newton’s law of gravity, we show that the spherical mass distribution models originally employed for estimating the masses of galaxies could cause the discrepancy between the actual masses and those calculated from the rotational velocities. It is demonstrated that additional gravitational effects are generated from non-spherical mass distributions in the cosmic structures. The currently observed rotation curves and gravitational lensing effects in galaxies and galaxy clusters could be explained under the frameworks of Newtonian gravity and Einstein’s general theory of relativity when proper mass distributions are considered.

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