

# ROTATION OF GALAXIES IS GOVERNED BY GRAVITY OF THE UNIVERSE

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Rotation of galaxies is illuminated by the old principle of least action. The natural law accounts for a system in its surroundings, here specifically a galaxy in the surrounding Universe [1-4].

According to this general tenet the gravitational potential due to all matter in the expanding Universe relates to the universal curvature which, in turn, manifests itself as the universal acceleration. According to this perspective the orbital velocities from the central bulge to distant perimeters are understood to balance both the galactic and universal acceleration. Since the galactic acceleration decreases from the galaxy's center toward its luminous edge, the orbital velocities of ever more distant stars and gas clouds tend toward a value that tallies the universal acceleration. This tiny term has been acknowledged earlier by including it as an ad hoc parameter in the modified gravitational law, but here the additional acceleration is understood to result from the ubiquitous gravitational potential that spans across the expanding Universe.

This resolution of the galaxy rotation problem is compared with observations and contrasted with models of dark matter. Also, other astronomical observations that have been interpreted as evidence for dark matter are discussed in light of the least-action principle.

[1] A. Annila, Least-time paths of light. [MNRAS 416, 2944 \(2011\)](#).

[2] M. Koskela and A. Annila, Least-action perihelion precession. [MNRAS 417, 1742 \(2011\)](#).

[3] A. Annila, Probing Mach's principle. [MNRAS 423, 1973 \(2012\)](#).

[4] A. Annila, Cosmic rays report from the structure of space. [Advances in Astronomy ID 135025, \(2015\)](#).