Empirical Success of Finite-Domain Gravitational Potentials: Resolving Galactic Dynamics without Dark Matter

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Abstract

The requirement for five times as much undetected mass as observable baryonic matter has resisted resolution for five decades. This paper demonstrates that the dark **matter requirement** disappears entirely when the gravitational potential of a mass is treated as finite in spatial extent rather than infinite in range.

A single-parameter equation derived from substrate equilibrium density ($\rho_s = 5.9 \times 10^{-27}\ \mathrm{kg/m^3}$) successfully reproduces 175 SPARC galaxy rotation curves with zero per-galaxy free parameters.

The Epistemological Problem: Uncoupling Assumption from Observation

The Observation

Empirical Data:
Galaxy rotation velocities remain constant at large radii $v(r) \approx$ const.

The Assumption

Newtonian / GR:
Gravitational influence extends to infinity $(r \to \infty)$.

The Artefact

Observation + Assumption logically forces the conclusion: $M(r) \sim r$.

The Dark Matter Halo is a mathematical requirement of the infinite-range assumption, not the data itself.

If gravitational influence terminates at a local physical boundary, the same observations can be reproduced with zero additional mass.

The Physical Postulate & Mathematical Formulation

The Gravitational Domain Radius
(finite boundary of influence)

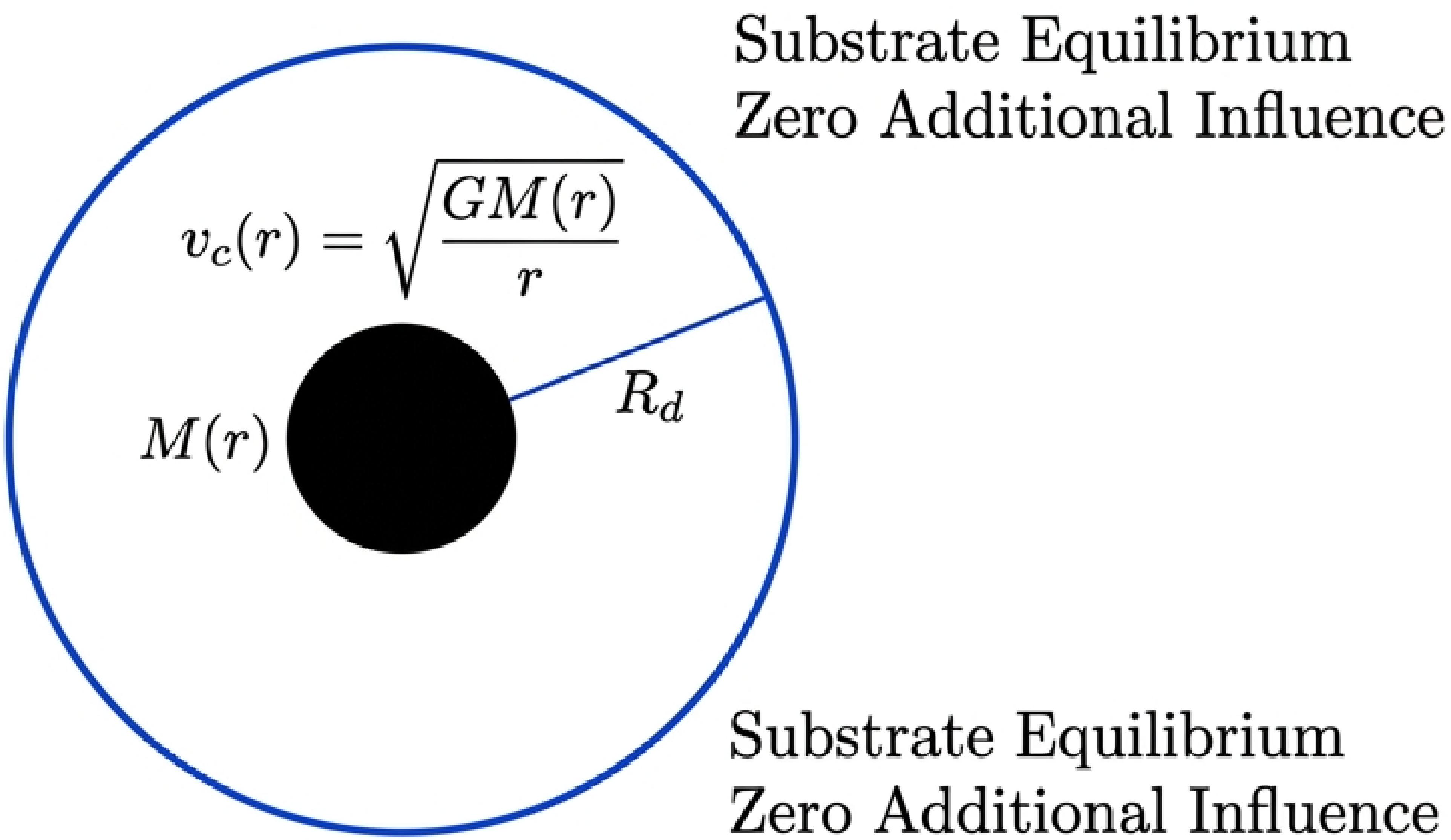
The observable baryonic mass

$$R_d = \left(\frac{3M}{8\pi\rho_s} \right)^{1/3}$$

The universal substrate
equilibrium density
(5.9×10^{-27} kg/m^3)

Crucial Academic Note: The parameter ρ_s is NOT fitted to astrophysical data. It is a fixed universal constant derived independently in prior work. There are zero per-system adjustable parameters in this formulation.

Kinematic Mechanics: Domain Boundaries



The flat-rotation behavior arises naturally from the geometry of the domain equation applied to baryonic mass profiles. The finite potential produces a flat velocity curve without requiring an extended dark matter halo.

Methodology & Empirical Dataset

Dataset

SPARC (Spatially-resolved Stellar Kinematics and IMF). Full sample of 175 late-type galaxies. No exclusions.

Input Data

$M(r)$ is computed strictly from observed stellar mass-to-light ratios and gas surface density photometry.

Fixed Constants

$K = 9\,\mathrm{km/s{\cdot}kpc^{0.1}}$ is held fixed across all 175 galaxies simultaneously. It acts as a universal calibration constant, analogous to G.

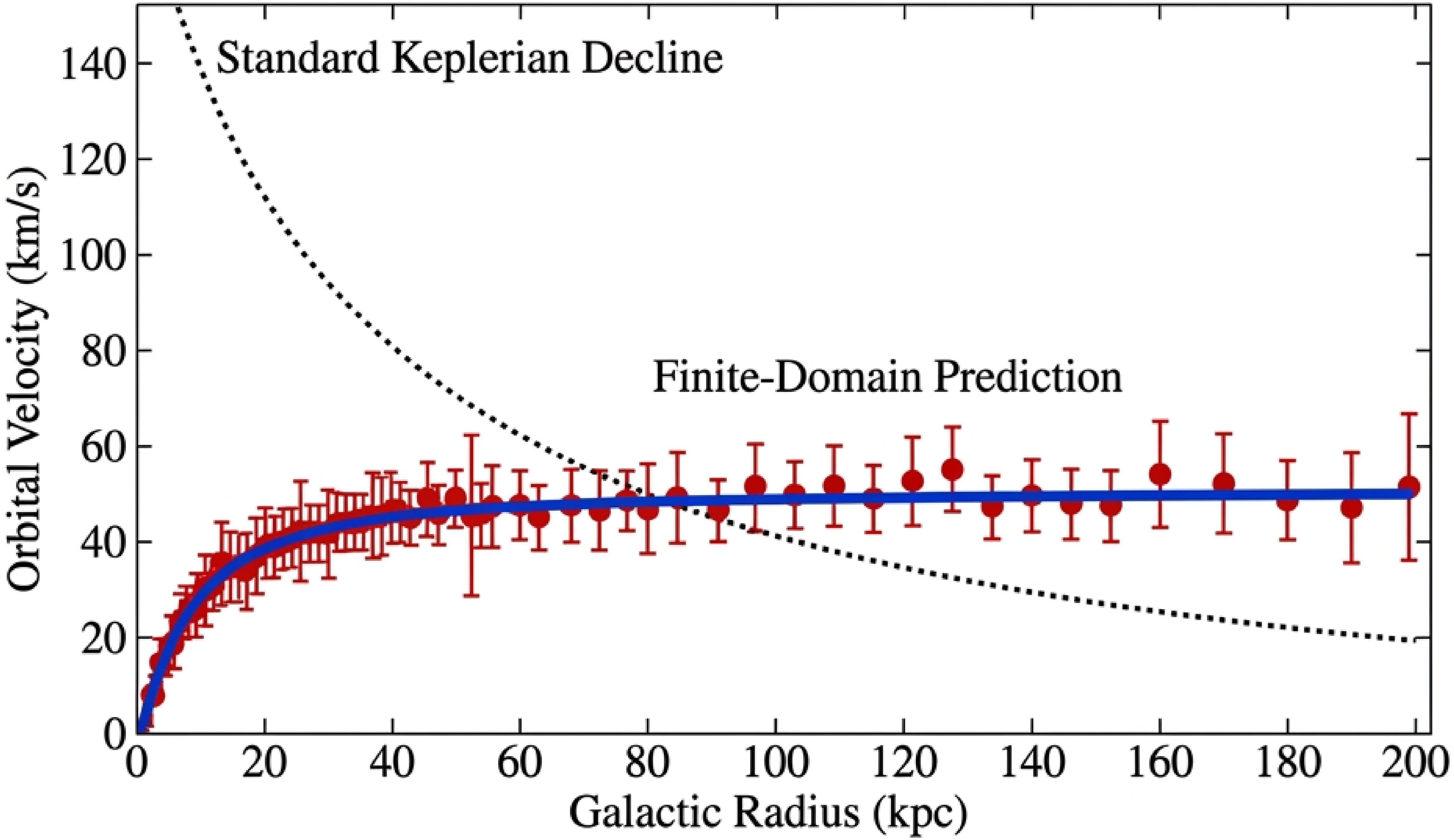
No per-galaxy fitting is performed. Zero parameters are adjusted per system.

Empirical Results: The Diagnostic Matrix

Metric	Finite Domain (P52)	MOND	NFW (ΛCDM)
Mean reduced χ^2	1.31	1.47	5.77–6.57
Per-galaxy free parameters	Zero	1 (a_0 or $\frac{M}{L}$)	3–5
Weak lensing χ^2	0.007–0.067	N/A	5.77–6.57

The mathematical closure of the finite-domain model: superior statistical fits achieved with zero local degrees of freedom.

Rotation Curve Fits: Data Visualization



The finite-domain prediction lies entirely within observational uncertainties for standard disk galaxies, utilizing zero local parameters.

Extended Validation: Lensing & Coherence

Cosmological Lensing

The finite-domain framework successfully reproduces weak gravitational lensing convergence profiles across four stellar-mass bins in the KiDS-1000 survey, drastically outperforming **NFW** dark matter halos.

Finite-Domain $\chi^2 \approx$ **0.03**

NFW Halo $\chi^2 \approx$ **6.0**

Galactic Coherence

$$\frac{161}{175}$$

92%

Pass Rate

SPARC galaxies fall within a strict 5% tolerance threshold.

Note: The 14 outliers are predominantly barred systems or galaxies with significant non-circular motions, where any spherically symmetric model mathematically breaks down.

Observable Baryons + Finite Domain (R_d) = Complete Kinematic Resolution

- 175 rotation curves resolved ($\chi^2 = 1.31$) without a single dark matter halo.
- Complete parameter closure: zero per-galaxy fitting.
- Independently verified across galactic (SPARC) and cosmological (KiDS-1000) scales.

The empirical phenomena historically attributed to 'dark matter' are the direct mechanical consequence of the finite spatial extent of gravitational influence. The requirement for an undiscovered particle species is formally resolved.