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# The Milky Way's Cosmic Floor: We Live on a 30-Million-Light-Year Sheet of Dark Matter

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## Introduction: The Quiet Neighborhood Paradox

For nearly a century, the kinematics of the Milky Way and its neighbors have posed a puzzle in observational cosmology. The Milky Way resides within the Local Group -- dominated by our galaxy and Andromeda (M31) -- encircled at ~12 million light-years (3.75 megaparsecs) by a "Council of Giants" including M81 and Centaurus A.[1] Under the CDM (Lambda Cold Dark Matter) cosmological model anchored by the cosmic microwave background, gravitational attraction around such a massive group should generate large random "peculiar velocities" that disturb the smooth Hubble expansion.[2][3]

Yet observations show that the local Hubble flow between 3 and 10 million light-years is remarkably "cold," with a velocity dispersion below 30 to 50 km/s.[2][4] Simultaneously, the classical "Timing Argument" -- calculating the mass needed for the Milky Way and Andromeda to overcome cosmic expansion and approach each other -- requires well over 1012 solar masses.[5] Distributed in a sphere, that mass would strongly decelerate nearby galaxies.[2][6]

In January 2026, a study in Nature Astronomy by Ewoud Wempe (Kapteyn Astronomical Institute) and collaborators resolved this discrepancy.[2][7][8] Using Bayesian field-level inference, the team demonstrated that the Local Group is embedded within a flattened "sheet" of dark matter stretching over 30 million light-years, containing over four times the mass of a spherical model while naturally damping in-plane peculiar velocities.[2][6][7]

## Architecture of the Local Dark Matter Sheet and the Local Void

The Local Dark Matter Sheet is a coherent, flattened cosmic wall that defines near-field galactic geography:[9][10]

* Dimensions: Spanning ~10.4 megaparsecs (~34 million light-years) in diameter, the structure hosts a thin plane of visible galaxies (~0.465 Mpc or 1.5 Mly thick) embedded within a dark matter wall roughly 1.6 Mpc (5.2 Mly) thick.[9][10]

* Overdensity: With twice the mean cosmic density, the sheet encloses more than four times the mass inferred from spherical models within 4 Mpc.[2][7][10]

* Local Void Compression: Bounding the ~45 Mpc (150 Mly) Local Void, the sheet moves away from the underdense void center at ~260 km/s, compressing the boundary wall.[9][11][12][13]

| Parameter | | Measured / Inferred Value | | Cosmological Significance |

| Sheet Diameter | | ~10.4 Mpc (~34 Mly) | | Encompasses Local Group & Council of Giants [1][9] |

| Thickness (DM / Galaxies) | | ~1.6 Mpc / ~0.465 Mpc | | Flattened dark matter wall & luminous plane [9][10][14] |

| In-Plane Dispersion | | < 30 - 50 km/s | | Dynamically "cold" local Hubble flow [2][4] |

| Void Evacuation Velocity | | ~260 km/s | | Bulk motion away from expanding Local Void [9][12] |

| Enclosed Mass (< 4 Mpc) | | > 4x Spherical Model | | Satisfies Timing Argument mass budget [2][7] |

## Gravitational Equilibrium: Solving the Cold Hubble Flow

The Wempe et al. solution rests on classical gravitational potential physics: the spatial geometry of a mass distribution fundamentally alters its local acceleration field.[2][8] In a conventional spherical halo model, dark matter acts effectively as a central point attractor located at the Milky Way-Andromeda barycenter. Any test galaxy situated 3 to 10 million light-years away experiences a strong, uncompensated inward gravitational pull that brakes its cosmic recession and generates large line-of-sight peculiar velocities.[2][4]

In a laterally extended planar sheet reaching out to 10 megaparsecs, however, mass is distributed across a vast two-dimensional wall. A galaxy residing within the midplane of the Local Sheet feels the inward gravitational attraction of the central Local Group, but simultaneously experiences a competing outward gravitational pull exerted by the massive surrounding rings of the outer sheet.[2][6] This planar gravitational tug-of-war cancels a substantial fraction of the net radial force inside the plane. Consequently, galaxies embedded within the Local Sheet "float" in near-equilibrium, drifting apart smoothly with the unperturbed Hubble expansion while galaxies located above or below the sheet experience steep vertical potential gradients and rain rapidly downward onto the wall.[2][8]

## Methodology: Field-Level Bayesian Reconstruction (BORG)

Because dark matter neither emits nor absorbs electromagnetic radiation, mapping its three-dimensional architecture around our specific cosmic coordinates required an inverse dynamical reconstruction rather than unconstrained forward simulations.[7][15] Wempe and collaborators utilized the Bayesian Origin Reconstruction from Galaxies (BORG) hierarchical field-level inference framework.[2][15][20] Assimilating three-dimensional galaxy coordinates and high-precision radial velocities from catalogs such as Cosmicflows-3, BORG applies Hamiltonian Markov Chain Monte Carlo Bayesian statistics and conservation of mass to sample millions of plausible primordial density fields in the early universe.[15][20]

Each candidate initial state is evolved forward over 13.8 billion years using gravitational N-body solvers rooted in statistical mechanics to generate dynamical "virtual twins" of the Local Group and 31 surrounding galaxies.[6][7] Cross-calibrating these constrained reconstructions against halo occupation distributions from flagship cosmological simulations -- including IllustrisTNG and Uchuu -- confirmed that every posterior realization capable of simultaneously

reproducing the infall velocity of Andromeda and the cold local Hubble flow required embedding the Local Group within a massive, flattened dark matter sheet rather than a spherical knot or narrow filament.[6][7][16]

## Cosmological Implications: The Timing Argument and Supergalactic Plane

The confirmation of the Local Dark Matter Sheet unifies three foundational pillars of near-field cosmology:[2][17]

* Reconciling the Kahn-Woltjer Timing Argument: First formulated in 1959, the Timing Argument demands several trillion solar masses in the Local Group to have overcome cosmic expansion and initiated the mutual infall of the Milky Way and Andromeda.[5] The sheet model proves this dark matter reservoir is genuinely present -- stored across the extended planar wall where its geometry shields neighboring Hubble-flow galaxies from radial braking.[2][7]

* Alignment with the Supergalactic Plane: The Local Sheet aligns closely with the larger Supergalactic Plane -- the superstructure of galaxy clusters including the Virgo Cluster and Great Attractor first recognized by Vesto Slipher and G rard de Vaucouleurs -- explaining the strong kinematic anisotropy between cold in-plane expansion and hot perpendicular infall.[2][17][18][22]

* Zel'dovich Pancake Collapse: Under Ya. B. Zel'dovich's relativistic collapse approximation, primordial overdensities collapse first into two-dimensional sheets ("cosmic pancakes"), then into filaments, and finally into virialized clusters.[19][21] Supported by Atacama Large Millimeter/submillimeter Array (ALMA) observations of massive protogalaxies such as SPT0311-58 forming inside dense sheets less than a billion years after the Big Bang, the Local Sheet represents an active first-stage cosmic pancake.[2]

## Conclusion: Mapping the Invisible Floor of the Local Group

By demonstrating that a 34-million-light-year dark matter wall conceals over four times the mass of a spherical halo while preserving a dynamically quiet in-plane Hubble flow, field-level Bayesian reconstructions have resolved a decades-old tension in CDM cosmology.[2][7][15] Rather than drifting in an isolated spherical halo, the Milky Way and Andromeda ride atop a vast, invisible continental shelf of dark matter compressed by the expansion of the Local Void.[10][12]

Updates... (Nov 23, 2026): Added exact publication dates to Reference 18 (Freeman, Jan 31, 2013; arXiv:1301.7509 / ASPCS 471) and Reference 20 (Nov 1, 2024), normalized the References heading, and consolidated earlier primary DOI/arXiv updates (Wempe et al., 2026 Nature Astronomy and arXiv:2601.17125; McCall, 2014; Tully et al., 2008/2019; Courtois et al., 2013; Shandarin & Zeldovich, 1989).

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