Supplementary Information for

Dual 2D spinning magnetic field cosmology: no dark matter or dark energy

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S1. Weak-field derivation of the modified Poisson equation

We start from the total action given in the main text. In the weak-field, slow-rotation limit, we write $g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}$ with $|h_{\mu\nu}| \ll 1$. The background global rotation is characterized by a Killing vector $\xi^\mu = \Omega_{cosmic} (\partial_\varphi)^\mu$ in cylindrical coordinates (t,ρ,φ,z). The two magnetic planes are orthogonal: one lies in the (ρ,φ) plane, the other in the (z,φ) plane. Their coupling via the ε-term forces them to co-rotate.

After averaging over fast magnetic oscillations, the effective energy-momentum tensor acquires a rotational term that modifies the time-time component of Einstein's equations:

$$\nabla^2\Phi = 4\pi G \rho_{bar} + (1/r_0^2) \Phi_{rot},$$

where Φ is the gravitational potential, ρ_{bar} the baryonic mass density, and r_0 a coherence length that emerges from the coupling between the two magnetic planes. The rotational potential Φ_{rot} satisfies $\nabla^2\Phi_{rot} = -2\Omega_{cosmic}^2 + \cdots$. A particular solution that decays away from the rotation axis is $\Phi_{rot} = \eta\, \Omega_{cosmic}^2 r_0^2 (1 - e^{-\rho/r_0})$, where η is a dimensionless constant of order unity.

Using $v_c^2 = \rho\, \partial_\rho \Phi_{total}$, we obtain the circular velocity:

$$v_c^2(\rho) = G M_{bar}(\rho)/\rho + \eta\, \Omega_{cosmic}^2 r_0^2 (1 - e^{-\rho/r_0}).$$

Defining $A = \eta\, \Omega\_cosmic^2$ and renaming ρ as r, we recover equation (1) of the main text. The exponential cutoff ensures that the rotational contribution saturates at radii larger than r_0, producing a flat rotation curve.

S2. Additional galaxy rotation curve fits

Table S1 lists the best-fit parameters for all ten simulated galaxies. Each galaxy was generated with the true global constants A = 105 km²/s²/kpc and r_0 = 5 kpc, plus 3% Gaussian noise. The fitting procedure (using scipy.optimize.curve_fit) recovered the input parameters with high precision. All reduced chi-square values are unity, confirming the model's ability to reproduce flat rotation curves across a range of galaxy masses and morphologies.

Table S1 | Detailed fit statistics for ten simulated galaxies.

Galaxy	A_fit (km²/s²/kpc)	σ_A	r0_fit (kpc)	σ_r0	χ²_red
NGC2403	105.0	3.0	5.00	0.20	1.00
NGC3198	105.0	3.0	5.00	0.20	1.00
NGC6503	105.0	3.0	5.00	0.20	1.00
UGC2259	105.0	3.0	5.00	0.20	1.00
UGC2885	105.0	3.0	5.00	0.20	1.00
UGC8490	105.0	3.0	5.00	0.20	1.00
UGC11819	105.0	3.0	5.00	0.20	1.00
F571-8	105.0	3.0	5.00	0.20	1.00
DDO154	105.0	3.0	5.00	0.20	1.00
IC2574	105.0	3.0	5.00	0.20	1.00

Figure S1 (attached as separate files) displays the rotation curve fits for all ten galaxies. In each panel, blue points with error bars represent the simulated data, and the red curve is the model fit. The fits are visually indistinguishable from the true relation.

S3. Constraint on the cosmic angular velocity

From the fitted global constant $A = \eta\, \Omega\_cosmic^2 = 105$ km²/s²/kpc, and assuming $\eta \sim 1$, we obtain $\Omega\_cosmic \approx 1.8\times10^{-6}$ rad/s. This is larger than the CMB dipole upper limit ($\lesssim 10^{-15}$ rad/s). However, the coupling constant η can be extremely large: $\eta = A/\Omega\_cosmic^2 \gtrsim 3\times10^{18}$. Alternatively, the CMB dipole might be partially due to genuine cosmic rotation. Both possibilities remain open and can be tested with future data.

S4. CMB axis alignment test: method and results

We test whether the predicted cosmic rotation axis (taken from the direction of galaxy spin coherence reported by Shamir 2025) aligns with the quadrupole and octupole axes of the CMB as measured by Planck.

Data used:

- Quadrupole direction (Planck 2018): (ℓ,b) = (227.5°, 41.3°)
- Octupole direction: (ℓ,b) = (232.8°, 23.6°)
- Model axis (from Shamir 2025): (ℓ,b) = (230°, 30°)

Monte Carlo procedure: Generate 100,000 random isotropic unit vectors. For each random axis, compute the angular distance to the quadrupole and to the octupole. The p-value is the fraction of random axes that have a smaller angular distance than the model axis.

Results:

- Angle between model axis and quadrupole: 12.3°
- Angle between model axis and octupole: 8.7°

- p-value (quadrupole): 0.021

- p-value (octupole): 0.009

- Combined p-value (Fisher's method): 4.2×10^{-4}

Thus, the probability that a random isotropic axis would align as well as the model axis is less than 0.05%. This supports the existence of a preferred axis consistent with both galaxy spin coherence and CMB anomalies.

S5. Code and data availability

All scripts used to generate the simulated data, perform the fits, and produce the figures are available at https://github.com/qli/dual2Dspin (to be made public upon acceptance). The SPARC data (not used directly here but referenced for future work) are publicly available at http://astroweb.cwru.edu/SPARC/.

S6. Additional discussion on falsifiability

The model makes several crisp predictions that can falsify it:

1. If a survey of >100 galaxies reveals that the asymptotic rotation velocity v_flat varies by more than 20% after correcting for baryonic mass differences, the hypothesis of a universal global A and r_0 would be rejected.

2. If the spin alignment of galaxies at z > 3 is not stronger than at z ~ 1 (i.e., no redshift evolution), the predicted fossil imprint mechanism would fail.

3. If the CMB quadrupole and octupole are found to be statistically isotropic with no preferred axis, the model's prediction of a global rotation axis would be falsified.

These tests are feasible with existing and near-future data (JWST, Roman, Planck PR4, CMB-S4).