Do the same spin–entropy weights fit other galaxies?

The original current predicts part of the speed excess

Christopher Grenke's original spherical galaxy equation uses the weighted radial spin current $Q_r = \beta_s s J_r / c^2$. Its exponential trial profile, $Q_r = C \exp(-r/r_s)$, has two measurable curve parameters. The 52 inner measurements of NGC 2403 give $\mathbf{C = 0.08817\ kg/m^2}$ and $\mathbf{r_s = 16.75\ kpc}$. The remaining 21 measurements give a speed error of 3.73 km/s. The following test carries those same two values into other galaxies. Each contributes its own baryonic speed curve.

Whole measured curves	Baryons alone, km/s	With original current, km/s	Galaxies improved
Other SPARC	48.33	31.38	104 of 130
PROBES	68.79	37.26	237 of 245
LITTLE THINGS dwarfs	18.77	23.67	4 of 10
External surveys combined	66.82	36.73	241 of 255

Errors are means of individual galaxy root-mean-square errors (RMSE). The 255 external galaxies supply 16,381 speed measurements. The paired mean reduction is 30.10 km/s, with a conditional 95% galaxy-bootstrap interval of 28.34 to 31.79 km/s. The smaller dwarf sample goes in the opposite direction. Keeping only the outer halves of eligible external curves gives 73.14 km/s for baryons and 36.51 km/s for the same fixed original current. It improves 236 of 243 outer curves with zero target-speed fitting.

Does another calibration of C close the gap?

With r_s fixed, 130 other SPARC galaxies select 0.8291 times the NGC 2403 amplitude. This lowers the mean error within held SPARC folds, yet raises the external error from 36.73 to **39.21 km/s**. Allowing both original parameters to move gives C = 0.05420 kg/m² and r_s = 110.55 kpc. Its external error is **36.90 km/s**. The paired change of +0.17 km/s has a 95% interval from −0.35 to +0.69.

The archive also scales amplitude by baryonic mass and disk area, and length by disk size. Refitting that prescription changes its external error from 44.68 to 41.75 km/s. The archived population slower-rise benchmark gives 32.76 km/s on these curves. These comparisons establish predictive value for the original radial current and identify how much error persists under different existing prescriptions.

Project equation guide §9 · November 22 galaxy_transfer.py · SPARC mass models · PROBES release · LITTLE THINGS rotation curves. Every paired score and both fitted weights are in the research files.

What the original field equations let gravity measure

With a stationary, spherical extra field and a regular integration constant, the archive gives $v^2 - v_b^2 = 4\pi G r Q_r$. Baryons retain their adopted disk model. The spin–entropy equation in the same convention is $\beta_s \nabla \cdot J = 2\gamma_s \nabla^2 s - U'(s)$. Integration to r gives

$$c^2 Q_r = \gamma_s (s^2)' - sI(r)/r^2, \text{ where } I(r) = \int_0^r t^2 U'(s(t))\, dt.$$

This determines a combination of the entropy gradient and restoring potential. The signed reconstruction covers 19,413 speed rows in 386 galaxies. Across 19,269 distinct radii, 574 give $Q_r \le 0$ under the adopted baryonic models. Those radii remain in the results. For NGC 2403, Q_r at 20.87 kpc is 0.02835 kg/m^2. Integrating Q_r from 0.16 to 20.87 kpc gives 3.351×10^{19} kg/m. Mass, inclination and distance uncertainties propagate into this inversion.

Why two separate microscopic numbers do not emerge

Suppose U' vanishes on the field range. This is an allowed example of the unspecified potential. For a given measured Q and fixed $\gamma_s > 0$, the radial equations then admit

$$s^2(r) = s^2(r_0) + (c^2/\gamma_s)\int_{r0}^r Q_r(t)\, dt, \text{ and } J_r(r) = c^2 Q_r(r)/(\beta_s s(r)).$$

Different central entropies and nonzero values of β_s give the same Q and the same speeds wherever the chosen s^2 is positive. Both radial equations hold for every pair. An independent matter equation with measured inputs could select one pair. The normalized entropy variable $\sigma = \sqrt{(2\gamma_s)}s$ identifies $\beta_s/\sqrt{(2\gamma_s)}$ as the coupling independent of entropy units. The speed derivatives for multiplying s or J_r by a constant are identical. The resulting two-column matrix has rank one across all 16,381 external measurements.

Can an amplitude produce a flat exterior?

Flat excess speed requires $Q_r \propto 1/r$. In the constant-potential example, s^2 must grow as ln r over that interval. The field equations admit such a profile with suitable current and boundary conditions. The original exponential gives $d \ln v_x / d \ln r = (1 - r/r_s)/2$ for the excess speed v_x. Its slope vanishes at r_s and becomes negative beyond it, whatever C is. Changing the weight alone cannot extend that flat point into an asymptotically flat curve. The original action leaves the material current and the entropy potential to be specified.

Across NGC 2403's 21 outer radii, a log–log fit to the inferred Q gives a slope of −0.651. The frozen exponential gives −0.922 on exactly those radii. Multiplying C can shift the whole curve up or down, but the predicted radial falloff stays too steep for this mass model.

Original equations §§6, 8–10 · direct_source.csv contains signed measurements summarized per galaxy · field_checks.json verifies the entropy equation and its integral on three different entropy/current solutions.

Two combinations of spin and entropy in a regular core

Write a smooth spherical scalar as $s = s_0 + s_2 r^2 + s_4 r^4 + \dots$ and a smooth radial current as $J_r = j_1 r + j_3 r^3 + \dots$. Substituting into the original stationary entropy equation fixes two relations between the coefficients. U'_0 and U''_0 denote derivatives of the entropy potential at s_0.

$$3\beta_s j_1 = 12\gamma_s s_2 - U'_0. \quad 5\beta_s j_3 = 40\gamma_s s_4 - U''_0 s_2.$$

For $Q_r = q_1 r + q_3 r^3 + \dots$, the gravitational source measures $c^2 q_1 = \beta_s s_0 j_1$ and $c^2 q_3 = \beta_s (s_0 j_3 + s_2 j_1)$. Thus $q_3/q_1 = j_3/j_1 + s_2/s_0$ whenever $s_0 j_1$ is nonzero. It is possible to recover the sum of the relative spin and entropy curvatures. Assigning either part separately requires an independent radial measurement.

Apply the result to the archive's slower-rise profile

The later profile specifies $v_x^2 = V^2[1 - \arctan(x)/x]$, with $x = r/r_c$, $V^2 = \sqrt{(GM_b a_*)}$ and $r_c = \eta R_d$. Its series determines $q_1 = V^2/(12\pi G r_c^2)$ and $q_3 = -V^2/(20\pi G r_c^4)$. The earlier exponential has a nonzero radial magnitude at the center and a central density cusp. This smooth-core expansion applies to the later branch.

NGC 2403, using its inner 52 points	Combination inferred from the fit
Core radius and force normalization	$r_c = 1.6555$ kpc and $a_* = 2.0019 \times 10^{-10}$ m/s^2
Central weighted-source coefficients	$q_1 = 2.391 \times 10^{-21}$ kg/m^3 and $q_3 = -5.497 \times 10^{-61}$ kg/m^5
Relative spin and entropy curvature	$j_3/j_1 + s_2/s_0 = -3/(5r_c^2) = -0.2189$ kpc^{-2}

These values extrapolate a fitted profile to the center. The first NGC 2403 measurement lies at 0.097 core radii. In 172 of the 242 eligible PROBES galaxies even the first radius lies beyond the fitted core radius, so their separate core parameters can be weakly constrained.

Dropping one occupied inner kiloparsec at a time shifts the NGC curvature sum from −0.326 to −0.159 kpc^{-2}. Dropping the 2–3 kpc bin raises the original exponential's outer error from 3.73 to 8.10 km/s. These are eleven sensitivity tests using the same outer measurements.

Multiplying the source by 1.0887 increases q_1 and q_3 by the same fraction. It preserves q_3/q_1 and the core radius. At fixed mass it raises a_* by 18.53% and the limiting speed by 4.34%. The flat outer speed already appears in the chosen slower-rise profile. Its gravitational curve is identical to a pseudo-isothermal halo with matching amplitude and core radius.

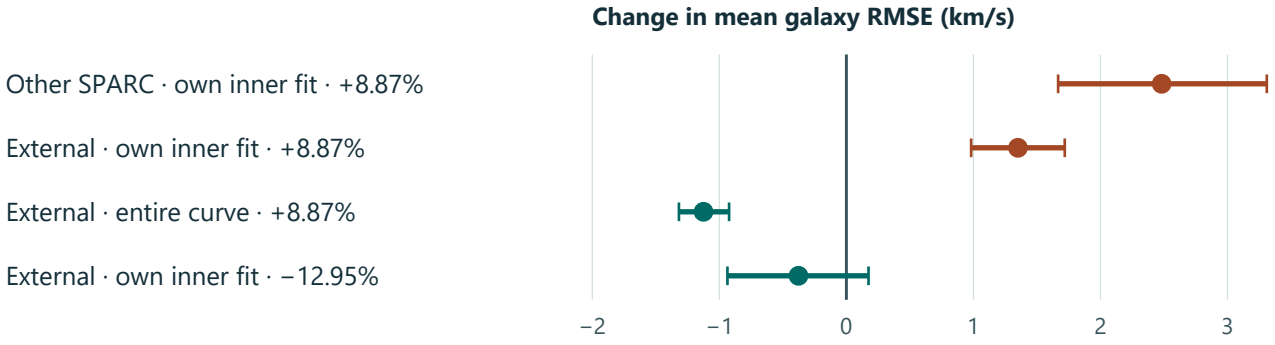
Equation guide §§6, 8–10 · archived NGC2403_field_study/analysis/kinematics.py · source_combinations.csv includes the model-inferred central coefficients, fitted boundaries and radial coverage of every eligible galaxy.

The 8.87% change in other resolved galaxies

The archived NGC 2403 slower-rise fit gives an outer RMSE of 4.8967 km/s. It underpredicts 20 of 21 outer speeds. Optimizing the source multiplier on those 21 points gives 1.088725. The chat's rounded 1.0887 reproduces **1.9851 km/s** and changes the final prediction from 128.40 to 133.10 km/s against 134.00 observed. Inner error rises from 6.31 to 7.21 km/s. The original chat used these outer points to find the adjustment.

Application of the same 1.0887 multiplier	Before, km/s	After, km/s	Galaxies improved
Other SPARC, own inner fit → outer radii	13.78	16.26	26 of 94
External, own inner fit → outer radii	25.81	27.16	92 of 243
External, frozen NGC parameters → whole curve	36.66	35.53	197 of 255

In the first two rows, a galaxy's inner half fixes its amplitude and core size before the multiplier is applied to its outer half. In the last row, NGC 2403 supplies the fitted acceleration and size ratio, the target supplies mass and disk size, and all target speeds are held out. The improvement reverses sign between these two questions. Only one external LITTLE THINGS dwarf meets the inner-fit sampling rule.



Whiskers show conditional 95% intervals from paired galaxy resampling. A positive difference means larger error. For the external outer halves, the 8.87% increase costs **1.35 km/s [0.98, 1.72]** on average. A single multiplier learned instead from 94 other SPARC outer curves is **0.8705**. It gives 25.43 km/s externally, a change of −0.38 km/s [−0.94, +0.17], and improves 113 of 243 galaxies. Applied to NGC 2403, that same independent correction raises the outer error to 11.48 km/s.

NGC2403_replay.csv · calibrations.csv · summary.csv · archive_checks.csv. The archive's 712 matched rotation scores reproduced within 0.00050 km/s. These tests reuse previously explored surveys and condition on their baryonic models.

An independent speed proxy and the missing measurement

The archive contains 11,758 additional galaxies with integrated 21 cm hydrogen line widths. Its selection excludes matches to the resolved samples. The inclination- and redshift-corrected half-width gives one speed proxy per galaxy. The slower-rise model predicts an asymptotic speed $(GM_b a_*)^{1/4}$. The line width samples the emitting disk over a finite range of radii and can differ from this limit. The original exponential decays at infinity. A finite-radius width prediction for that profile would require the distribution of emitting gas and its velocity profile.

Stellar-mass estimate and sample	Galaxies	Speed-proxy RMS before → after, km/s	Improved
Taylor, all eligible	11,758	39.89 → 40.97	4,317
Taylor, higher-quality subset	4,372	39.87 → 41.33	1,556
McGaugh, all eligible	11,647	43.11 → 45.76	2,832

The same 8.87% source increase raises the aggregate width error under both archived stellar-mass estimates. The higher-quality subset requires inclination 45–75 degrees and signal-to-noise at least ten. Widths and resolved rotation residuals have different observational meanings and are reported separately.

What else in ESFD could determine the weights?

Existing branch or data	Independent information needed for the coupling
Direct ESFD spin tensor and polarization	The original J_s is the axial projection of the antisymmetric spin tensor. A calibrated signed radial spin density in the relevant material would supply J_r. H I maps and flows measure gas column and motion. Radio intensities and polarization constrain magnetic fields or photons.
Entropy dynamics and stellar thresholds	A measured entropy mode with known normalization could constrain $U''/(2\gamma_s)$. A confirmed stellar crossing with independently known B, Ω and Λ_{tim} would fix $\kappa_s s = \Lambda_{tim}/\Omega - B$ in that object. The archived timing supplies no such matched crossing.
Rotation and lensing	Speeds measure a gravitational potential. Lensing constrains a combination of metric potentials. Another gravity measurement alone leaves the split between spin and entropy ambiguous.

At the same radius in a galaxy, an independently normalized s(r) and signed $J_r(r)$ would give $\beta_s = c^2 Q_r/[s(r)J_r(r)]$. With U' fixed and $\nabla^2 s$ nonzero, γ_s would then follow from $[\beta_s \nabla\cdot J + U'(s)]/(2\nabla^2 s)$. These are tests in the original variables. The archived neutron polarization and mixed-mode grids are model calculations. They supply no coincident radial measurement of these fields.

ALFALFA source tables · Durbala et al., ALFALFA–SDSS catalog · original equation guide §§2, 6, 8 and 12 · width_checks.csv independently replays the archived width controls before applying the NGC 2403 weight.