Methodological Document: Definition and Measurement of Galactic Parameters

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1. Flat Rotation Velocity (V_{flat}, km/s)

How it was measured: Extracted from the rotation curves published in SPARC (Lelli et al. 2016), mainly based on 21 cm (HI) observations.

Reference radius: V_{flat} is defined as the mean velocity in the outer region of the curve where it stabilizes (no significant slope).

Corrections applied:

- Inclination: corrected using angles derived from optical photometry and HI kinematics.
- Dispersion: standard correction applied for gas pressure in dwarf galaxies.
- Exclusions: galaxies without a clear flat section were flagged as "review".

2. Gas Mass (M_{gas}, $M_\odot$)

Content considered: HI detected via the 21 cm line, multiplied by a factor of 1.36 to account for primordial He.

Molecular gas: CO $\rightarrow$ H_2 included only for the few galaxies where SPARC provides data; for most galaxies, it is not included.

Flux–mass conversion: depends on the distance adopted in SPARC (scaled with $H_0 = 73$ km/s/Mpc).

3. Stellar Disk Mass (M_{disk}, $M_\odot$)

Method: Photometry in Spitzer 3.6 μm band (NIR), less sensitive to dust extinction.

M/L factor: Fixed mass-to-light ratio $M/L = 0.5\, M_\odot/L_\odot$ (Chabrier IMF).

Radial extension: Integrated up to the maximum radius of the available rotation curve (R_{max}).

4. Stellar Bulge Mass ($M_{\rm bul}$, $M_\odot$)

Technique: Photometric bulge/disk decomposition using Sérsic profile fits in NIR images.

Separation criterion: Central component with index $n > 2$ and effective radius $< 1/5$ of the disk.

Galaxies without bulges: flagged as `has_bulge = False`, with $M_{\rm bul} = 0$.

5. Total Mass ($M_{\rm total}$, $M_\odot$)

Important: In this analysis, $M_{\rm total} \neq$ dynamical mass.

Definition:

$$M_{\rm total} = M_{\rm gas} + M_{\rm disk} + M_{\rm bul}.$$

Interpretation: It is the baryonic mass, excluding dark matter halos.

Justification: In the toy model, the "near field" (possible halo analogue) is treated as a dynamical effect, not as explicit mass.

6. Structural Ratios

Bulge-to-total:

$$\frac{M_{\rm bul}}{M_{\rm gas} + M_{\rm disk} + M_{\rm bul}}.$$

Used as a morphological proxy to distinguish early- from late-type galaxies.

Disk-vs-gas ratio:

$$\frac{M_{\rm disk}}{M_{\rm gas}}.$$

Indicator of stellar-dominated vs. gas-dominated systems.

Both ratios are used to interpret the toy model's sensitivity to morphology and environment.

7. Galaxy Sample Selection

Source: SPARC catalog (Spitzer Photometry & Accurate Rotation Curves).

Initial number: 175 galaxies.

Exclusion criteria:

- Rotation curves with too few points ($N_{\rm points} < 3$).
- Extreme inclinations ($i < 30°$ or $i > 85°$).
- Quality flagged as "uncertain" in SPARC.

Final result: 150–160 galaxies qualified, labeled as `ok` or `review` depending on data consistency.