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Estimating Baryonic Specific Angular Momentum from Stellar Kinematics

Milena Jovanović

Astronomical Observatory of Belgrade

Rotation Curves $V_{\text{circ}} = f(r)$

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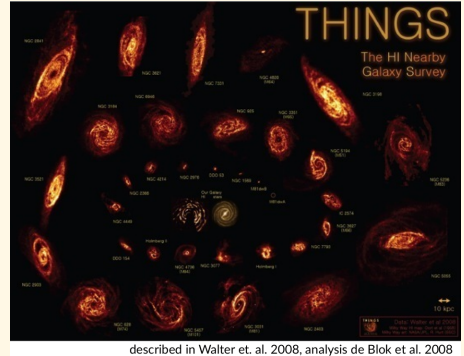
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- A long-established tool for studying galaxy dynamics
- Disk tracers: H I, H α , CO (tracing H $_2$), stars; halo probes: GCs and satellites
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- Limitations: sensitivity–resolution trade-off; long observing times for deep, resolved mapping

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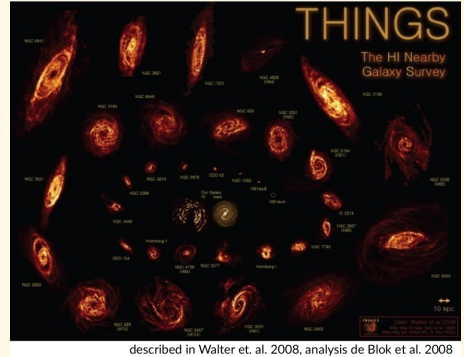


described in Walter et. al. 2008, analysis de Blok et al. 2008

- NGC 3351, NGC 3627 from THINGS
- AGC 242019, ESO444-G084, UGC00891 from literature (She et al. 2021; Côté et al. 2000; van Zee et al. 1997)

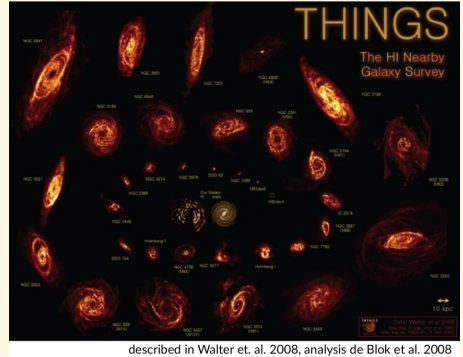
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- How does specific angular momentum depend on galaxy mass and morphology?
- We need a larger, representative sample!
- The challenge: obtaining rotation curves that extend far enough to constrain specific angular momentum

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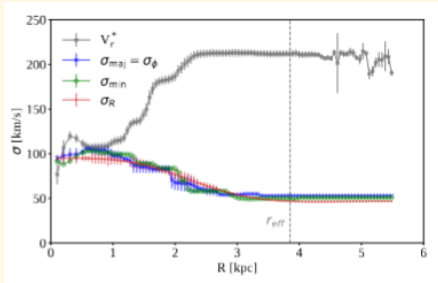
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- Possible route: stellar IFU surveys —large samples and spatially resolved kinematics; limited radial coverage (MaNGA: ~ 1.5 or $2.5R_{\text{eff}}$).

MUSE spectra

- Calibrated MUSE datacubes from the ESO Science Archive; selected high-S/N spaxels over 475–680 nm and applied Voronoi binning to preserve S/N in the outer field (Cappellari & Copin 2003)
- Used pPXF with GALAXEV templates to extract stellar radial velocity and velocity dispersion; matched spectral resolution and continuum shape, and masked emission lines
- Reconstructed 2D kinematic maps; for dwarf galaxies, a second pPXF fit with fixed stellar kinematics yielded the more ordered H α velocity field
- Modeled the velocity field in the same manner as H I, using GIPSY's `rotcur` to determine V_{sys} , kinematic center, i , PA, and **rotation velocity** V_{rot}

MUSE–H I comparison: asymmetric drift

NGC 3351



Asymmetric-drift correction

$$(V_c^*)^2 = (V_r^*)^2 + \sigma_\phi^2 - \sigma_R^2 \left[1 + \frac{d \ln I_\star}{d \ln r} \right] - r \frac{d\sigma_R^2}{dr}.$$

V_r^* : stellar rotation; V_c^* : circular velocity.

$I_\star$: stellar surface brightness; r : radius.

Assuming $\sigma_z = \sigma_\phi$:

$$\sigma_\phi = \sigma_{\text{maj}}, \quad \sigma_R = \sqrt{\frac{\sigma_{\text{min}}^2 - \sigma_{\text{maj}}^2 \cos^2 i}{\sin^2 i}}.$$

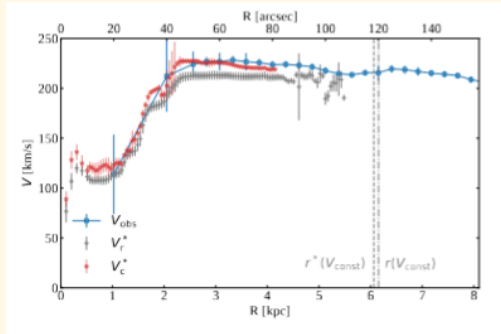
σ_R, σ_ϕ : radial and azimuthal dispersions.

$\sigma_{\text{maj}}, \sigma_{\text{min}}$: observed major/minor-axis dispersions; i : inclination.

Based on Noordermeer et al. (2008).

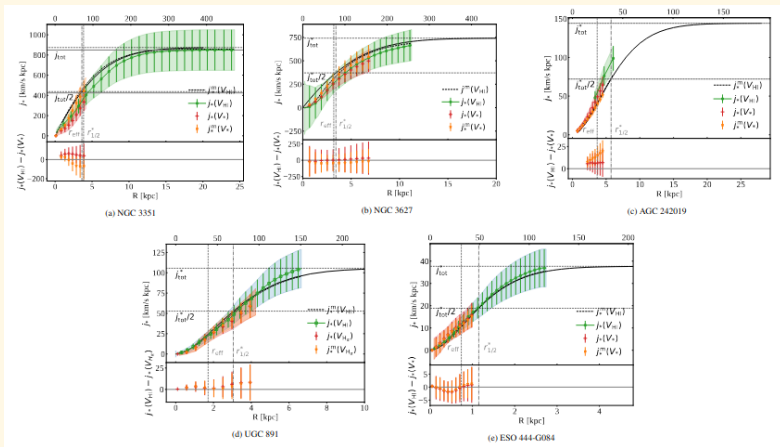
MUSE–H I comparison

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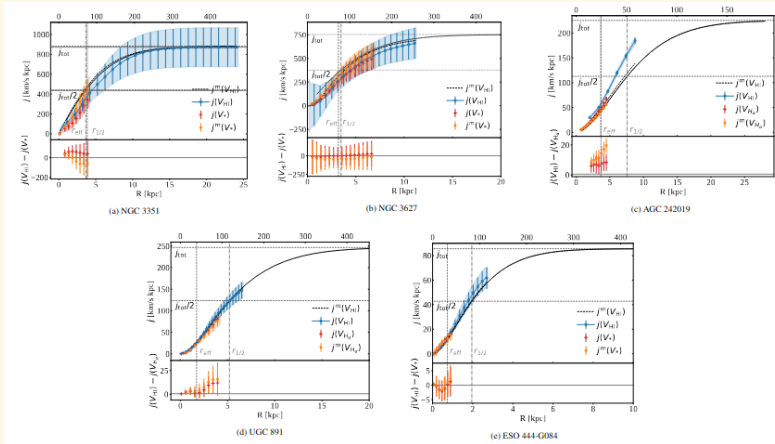


Blue: H I velocity (V_{obs}); grey: uncorrected stellar velocity (V_r^*).
Red: corrected stellar velocity (V_c^*).

The Stellar Specific Angular Momentum



The Baryonic Specific Angular Momentum





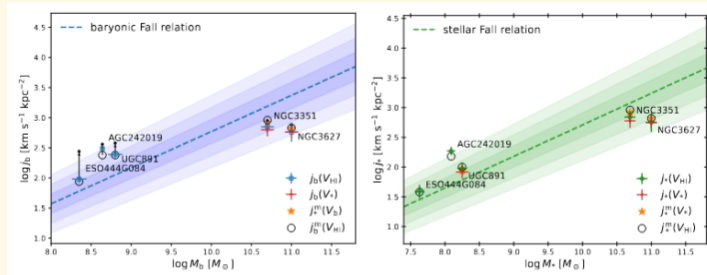
THANK YOU!

Collaborators:

- Ana Lalović, PI
- Slađana Knežević

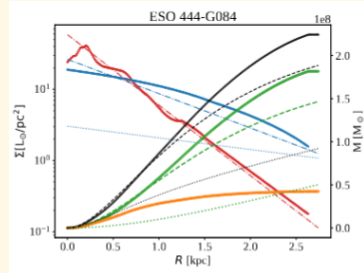
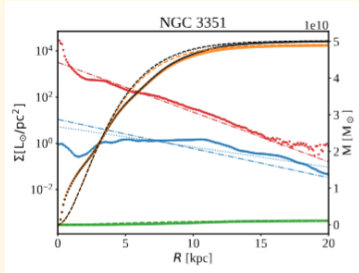
Photo Credit: NGC 3627 taken by MUSE on ESO's Very Large Telescope

Fall Relation



Red crosses designate total baryonic (left) and stellar (right) specific angular momentum using stellar circular velocities for HSB galaxies or $H\alpha$ circular velocities for dwarfs. Orange stars show the corresponding specific angular momenta using exponential disk models for both stars and gas, with stellar circular velocities; open circles use the same models with $H\text{I}$ circular velocities. Black points show the latter estimates using the W_0 -branch solution of the Lambert equation for $H\text{I}$ disks.

Luminosity and Mass Density



Dash-dotted lines in the corresponding colors are exponential disk models. The dotted blue line corresponds to the W_0 -branch of the Lambert equation, while the dash-dotted blue line uses the W_{-1} -branch solution. Orange and blue points and lines show the cumulative stellar and gaseous mass distributions, respectively. Black points and dashed lines represent the baryonic mass density distributions using the W_{-1} -branch solution; the dotted black line corresponds to the W_0 -branch.