Size *Does* Matter: the SFI++ Size-Luminosity Relation and the Spins of Halos Hosting Sc Galaxies*

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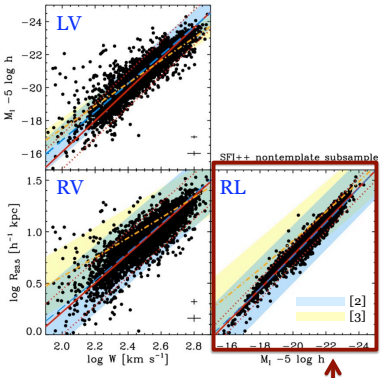
We derive scaling relations between the sizes, luminosities, and rotation velocities of ~4000 late-type disk galaxies from the SFI++ catalogue, in order to constrain models of galaxy formation and evolution. We focus on the size-luminosity (RL) and size-rotation velocity (RV) relations, and show that using homogeneously derived, inclination-corrected isophotal radii instead of disk scale lengths produces significantly tighter relations than previously reported. Combining the small intrinsic scatter of the SFI++ RL relation with a simple model for disk galaxy formation, we find that the range of disk spin parameters allowed by the data is at least 7 times smaller than that of the halo spin parameters produced in cosmological simulations. Unless angular momentum redistribution in late-type disks is more effective than current models suggest, this discrepancy implies that the halos hosting Sc galaxies have a much narrower distribution of spin parameters than cosmology predicts.

Scaling Relations in the SFI++

- The SFI++ [1] contains ~5000 spirals with measures of velocity width, I-band disk size and luminosity

Size, quality and homogeneity of SFI++ unrivalled for scaling relation studies of late-type spirals

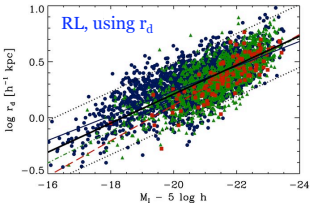
- We construct luminosity-velocity (RL), size-velocity (RV), and size-luminosity relations for the SFI++ "template" (cluster) and "non-template" (field) samples
- Instead of disk scale lengths, we adopt homogeneously measured, inclination-corrected isophotal radii for R



Scatter in the SFI++ RL relation is 2.5-4 times smaller than found for other large galaxy samples

Why is the RL Relation Scatter So Low?

- We reproduce the larger scatter previously reported when a scale-length is used for R; *there is no intrinsic bias in the sample*
- Why the difference in scatter? Disk scale lengths are notoriously difficult to measure and inclination-correct [4], because the disk is neither optically thick nor optically thin at intermediate radii



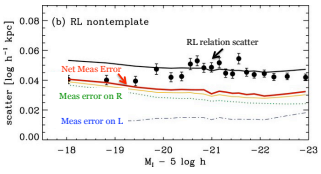
- Scale lengths are accurate to no better than ~25% [5], particularly for inclined disks; this uncertainty increases the scaling relation scatter

Smaller scatter in RL relation produced by adoption of (more reliable) isophotal radii

* Saintonge, A. & Spekkens, K. 2011, ApJ, 726, 77,

Error Budgets and Intrinsic Scatter

- With well-understood uncertainties on R, it is possible to construct a detailed error budget, taking correlated measurement errors into account

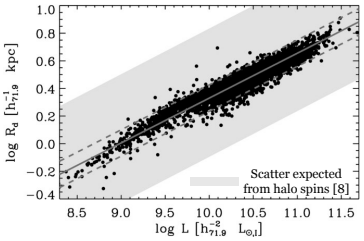


- Comparison with incompleteness simulations for SFI++ template [6] suggest an incompleteness bias for $M_I - 5\log h > -20$

RL relation scatter consistent with constant intrinsic scatter, biased by incompleteness at the low-L end.

Implications for Cosmology: Halo Spins

- In galaxy formation models that relate disk properties to those of the dark matter halos in which they're embedded [7], the RL relation scatter constrains the scatter in disk angular momentum in late-type disks
- We compare the RL relation to a simple galaxy formation model [7], converting R to scale-length units using the mean isophotal radius to scale-length at each magnitude in the SFI++



- The RL relation is well-modelled with mass-to-light ratio and disk mass fraction relations from [8], and the characteristic spin of collisionless halos from [9]. However, the intrinsic RL relation scatter is ~7 times lower than that in collionless halo spin parameters.

Unless angular momentum redistribution in late-type disks is more effective than current models suggest, halos hosting Sc galaxies have a much narrower distribution of spin parameters than cosmology predicts.

[1] Springob et al. 2007, ApJS, 172, 599
[2] Courteau et al. 2007, ApJ, 671, 203
[3] Pizagno et al. 2005, ApJ, 633, 844
[4] Giovanelli et al. 1995, AJ, 110, 1059
[5] Mollenhoff 2004, A&A, 415, 63
[6] Masters et al. 2006, ApJ, 653, 861
[7] Mo, Mao & White 1998, MNRAS, 295, 319
[8] Dutton et al. 2007, ApJ, 654, 27
[9] Bullock et al. 2001, ApJ, 555, 240