Kinematics of galaxy bulges, disks, and gas

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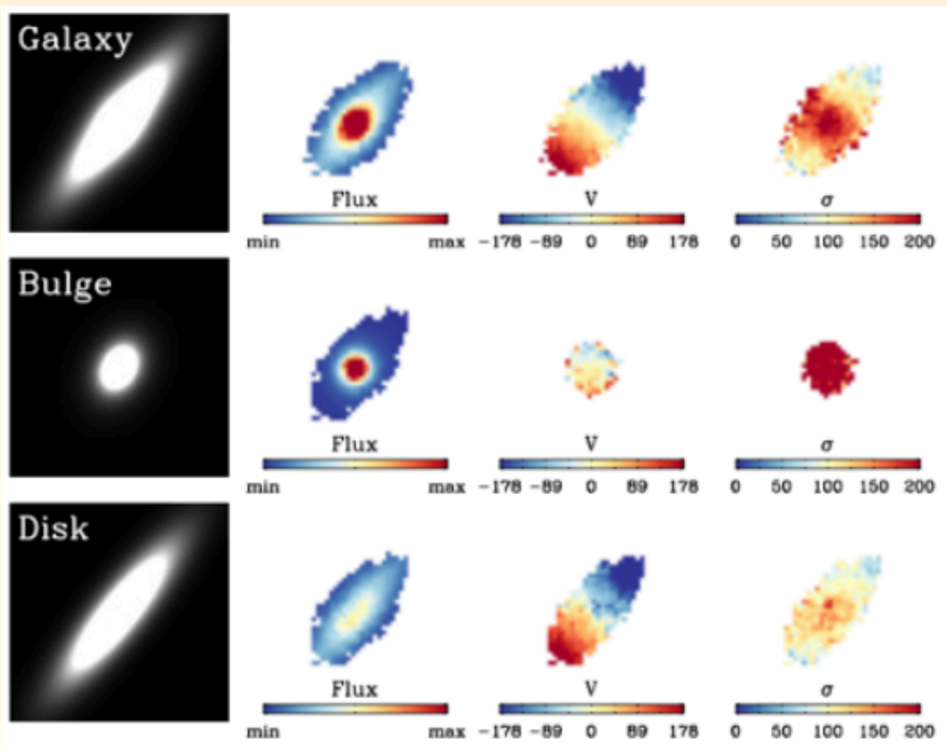
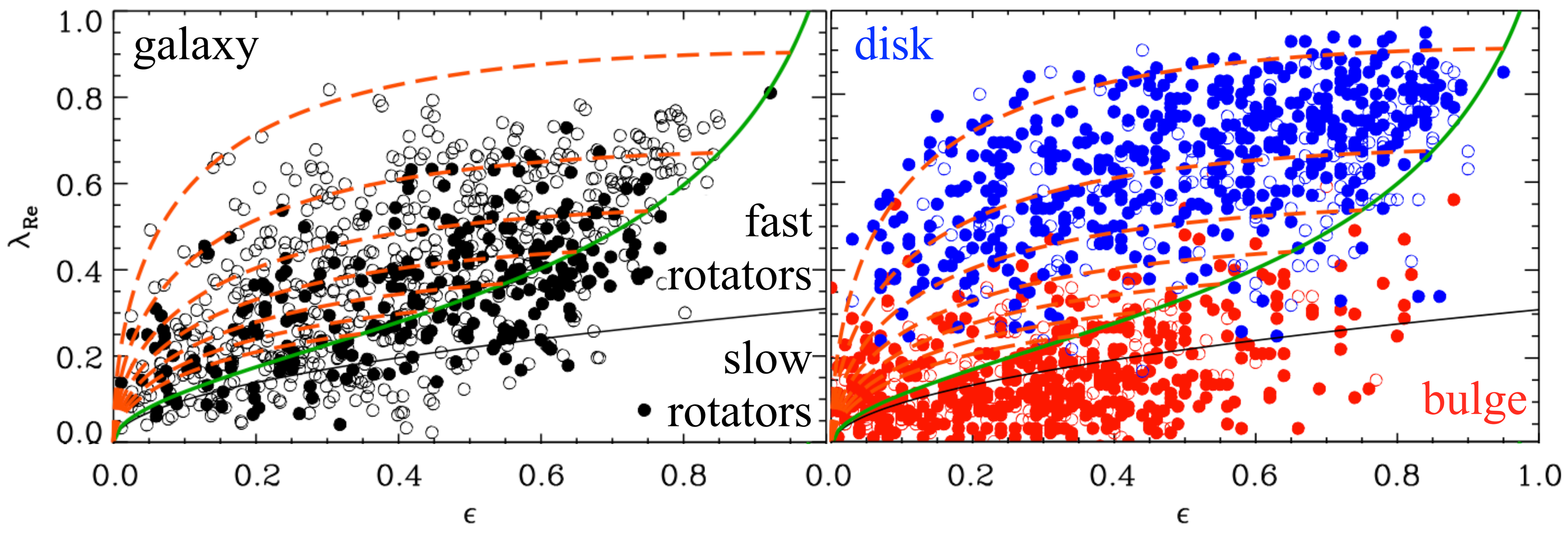
Decomposed stellar kinematics of bulge and disk for 826 SAMI galaxies (Oh et al. 2020 MNRAS.495.4638)



- We used the Penalized Pixel-Fitting method (pPXF; Cappellari & Emsellem 2004; Cappellari 2017) to simultaneously fit stellar kinematics of galaxy bulges and disks with a photometric priors (w_B and w_D) which have been derived from photometric bulge-disk decomposition for each spaxel over the galaxy (Casura et al. 2019; Barsanti et al. 2020).
- A two-component kinematic fitting sometime yields unphysical solutions originated from local minimum of χ^2. Oh et al. (2020) introduces a new subroutine of PPXF for dealing with degeneracy in the solutions (see also Tabor et al. 2017).
- We spectroscopically decomposed bulge and disk kinematics for 826 SAMI galaxies with various morphological types. Our sample is the largest to date with spectroscopic bulge-disk decomposition and the first such sample to include all morphological types.

Galaxy bulge and disk are kinematically distinct

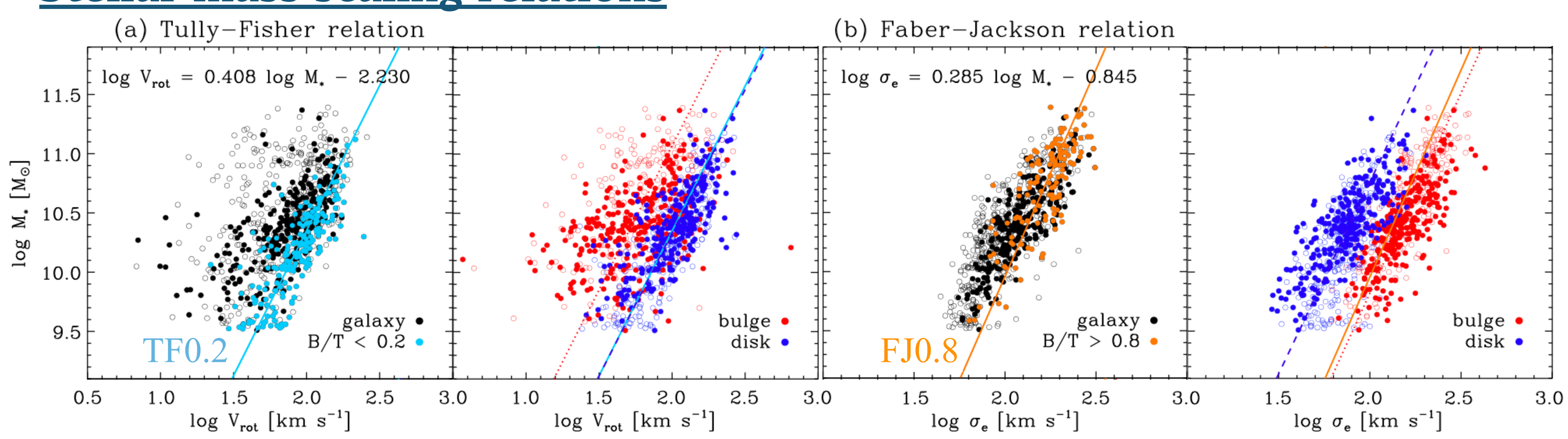


- We show that the bulge and disk components are kinematically distinct
- The λ_{Re} (spin parameter proxy) –ε (ellipticity) plane is often used as a diagnostic for fast and slow rotators (Emsellem et al. 2007; 2011):

$$\lambda_R = \frac{\langle R|V|\rangle}{\langle R\sqrt{V^2+\sigma^2}\rangle} = \frac{\sum_{i=0}^{N_{spx}} F_i R_i |V_i|}{\sum_{i=0}^{N_{spx}} F_i R_i \sqrt{V_i^2+\sigma_i^2}}$$

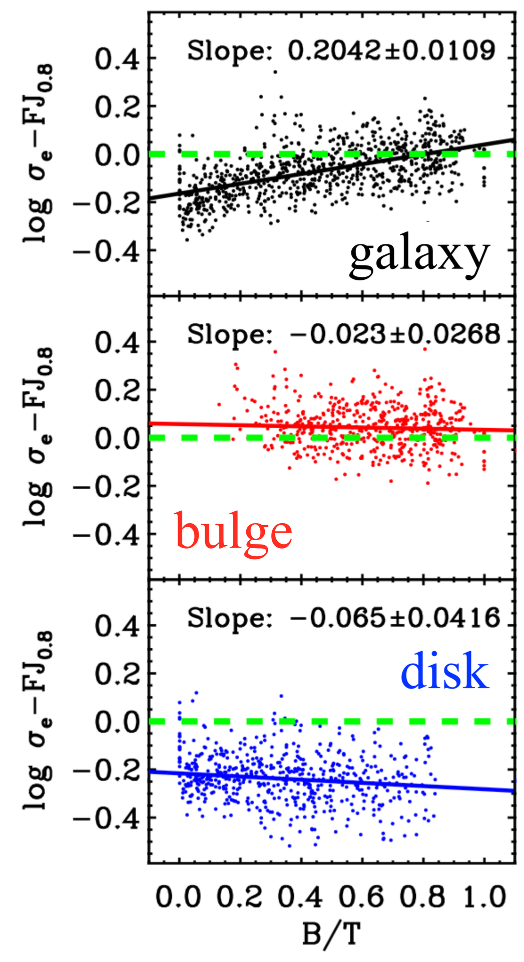
- The spin parameter λ_R indicates bulges are pressure-dominated systems and disks are supported by rotation

Stellar mass scaling relations



- Galaxies with a high bulge fraction (B/T) have Vrot that are substantially scattered toward lower values than the fiducial Tully-Fisher (TF) relation for galaxies with B/T < 0.2 (TF0.2)
- We found a tight correlation between the total stellar mass M∗ and Vrot for disk components that is close to TF0.2. Note that the disk components in this study even include those from early-type galaxies
- The Tully-Fisher (TF) relation is not an exclusive relation for late-type galaxies but general mass scaling for rotating components (i.e. disks) of all galaxy types
- The same logic applies in the Faber-Jackson (FJ) relation suggesting it provides a scaling between mass and velocity dispersion for both components, with the same slope but with different zero points

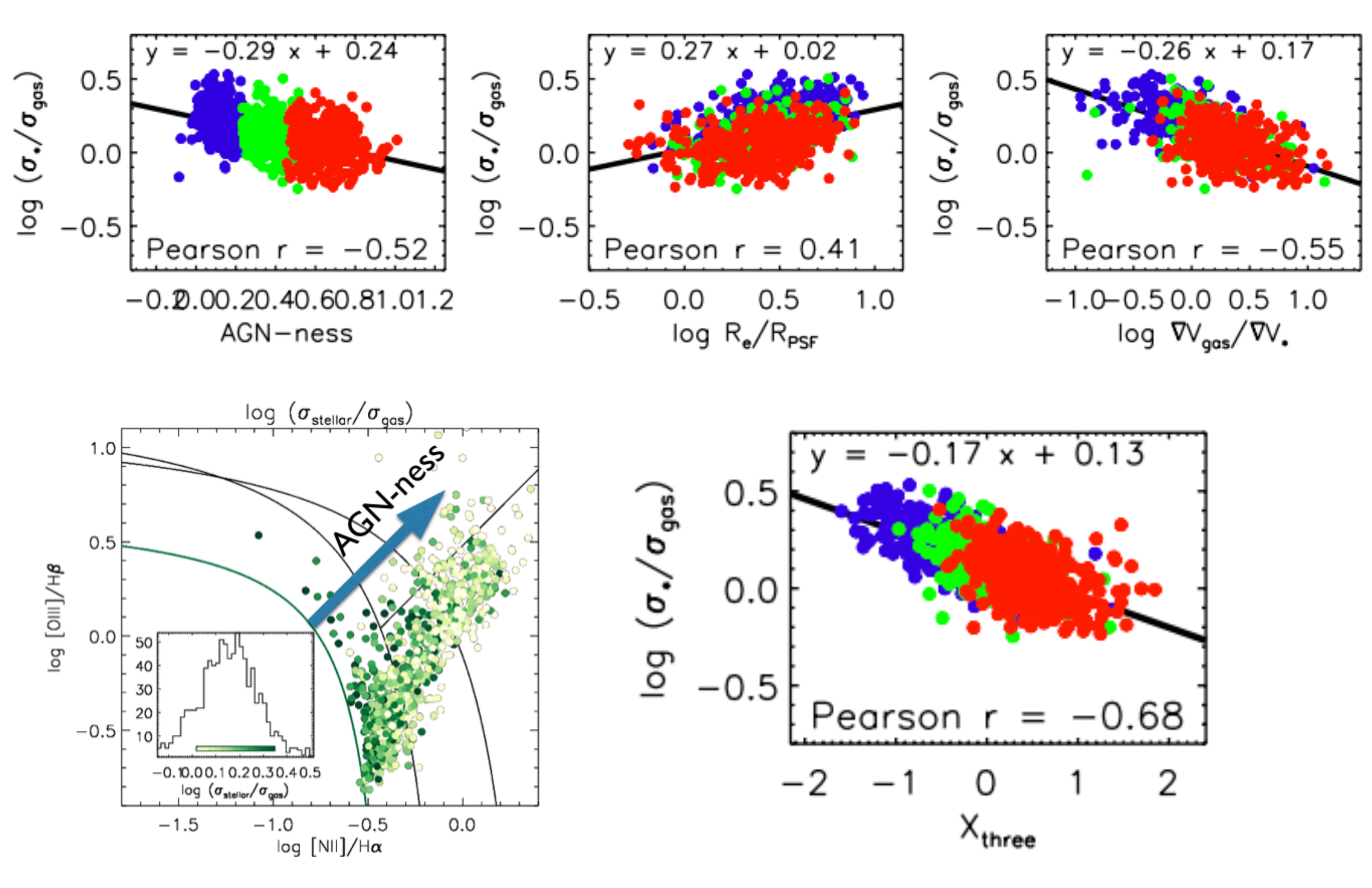
Residual trends in TF FJ relations



FJ0.8 (dashed line) is the fiducial FJ relation for galaxies with B/T > 0.8

- Both TF and FJ relations show highly significant residual correlations with galaxy properties
- The bulge and disk components have no trends in their residuals w.r.t. the TF and FJ scaling laws, but the combination of two components with different weights as a function of mass, B/T, colour and morphology means that galaxies in general do show residual trends with these quantities

Gas kinematics is more sensitive to power sources than stellar kinematics



Xthree = log ($\nabla V_{star}/\nabla V_{gas}$) - 1.15 log ($R_e/R_{PSF}$) + 0.95 (AGN-ness)

- The gas velocity dispersion (σ_{gas}) measured using emission lines is not always smaller than the stellar velocity dispersion (σ_{star}). The difference in the velocity dispersions ($\sigma_{star}/\sigma_{gas}$) correlates with various galaxy properties (e.g. stellar mass, size, age, star-formation rate SFR, etc.).
- Three parameters are suspected to have causal connections to ($\sigma_{star}/\sigma_{gas}$), which also explain the correlation between ($\sigma_{star}/\sigma_{gas}$) and the other galaxy parameters: the relative size of the galaxy and the PSF (R_e/R_{PSF}); the ratio of the stellar and gas velocity gradients ($\nabla V_{star}/\nabla V_{gas}$), and 'AGN-ness' (the orthogonal departure from the star-forming sequence in emission-line diagnostics)
- The impact of beam smearing (which depends on both R_e/R_{PSF} and $\nabla V_{star}/\nabla V_{gas}$) is crucial when comparing gas and stellar velocity dispersions
- There still is a correlation between 'AGN-ness' and $\sigma_{star}/\sigma_{gas}$ even after allowing for the impact of beam smearing. The 'AGN-ness' can be a proxy for the accretion rate of the central black hole. Jets, outflows, turbulence powered by the central black hole may boost the dispersion of gas kinematics.
- In conclusion, the gas velocity dispersion is more sensitive to power sources than the stellar dispersion.

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