

Scaling relations for galaxies of all types with CALIFA and MaNGA surveys.

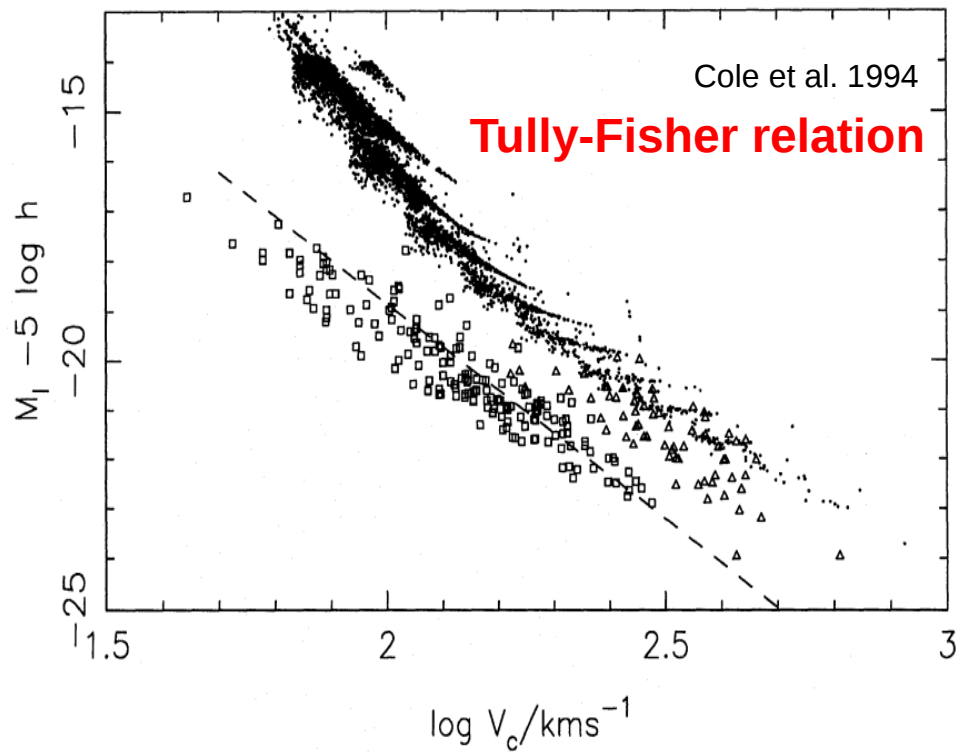
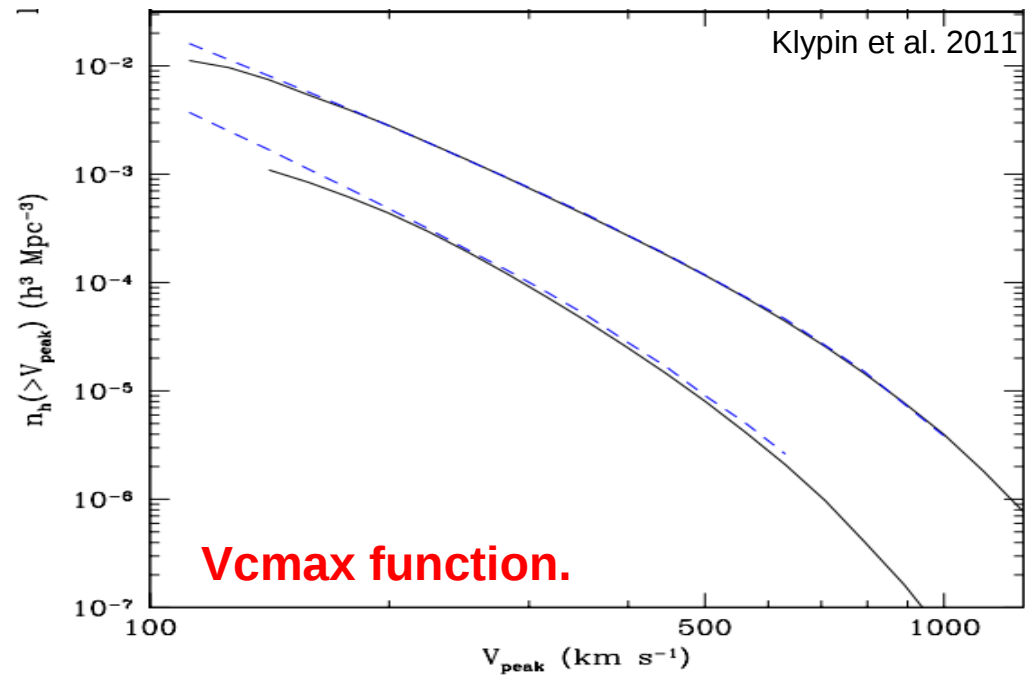
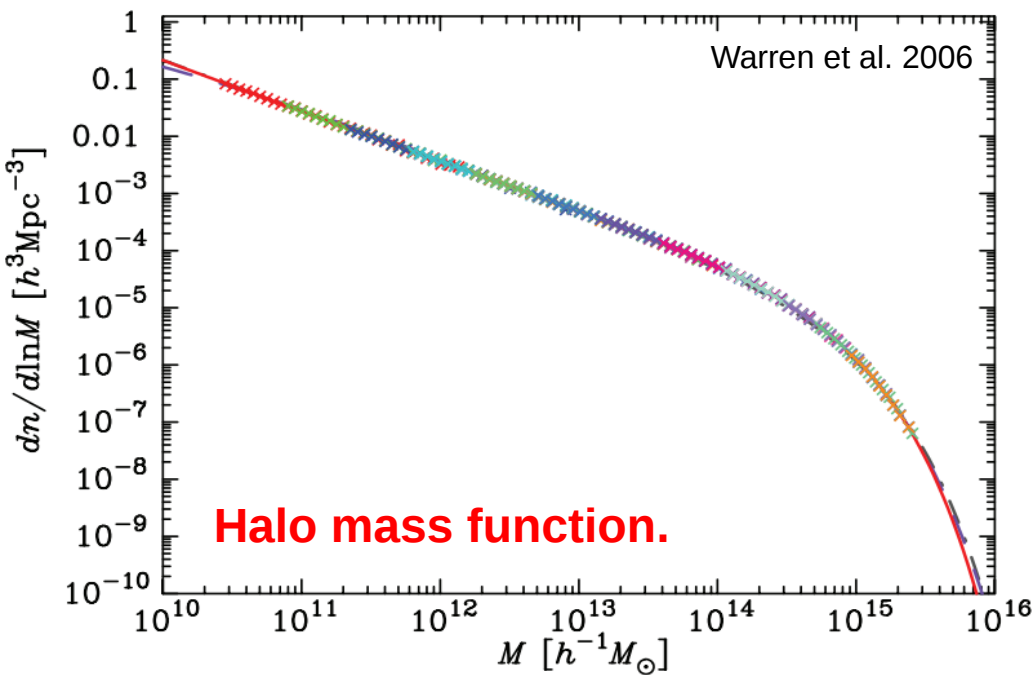
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Cozumel, Q. Roo, 2016

Motivation: Structure formation in the LCDM.

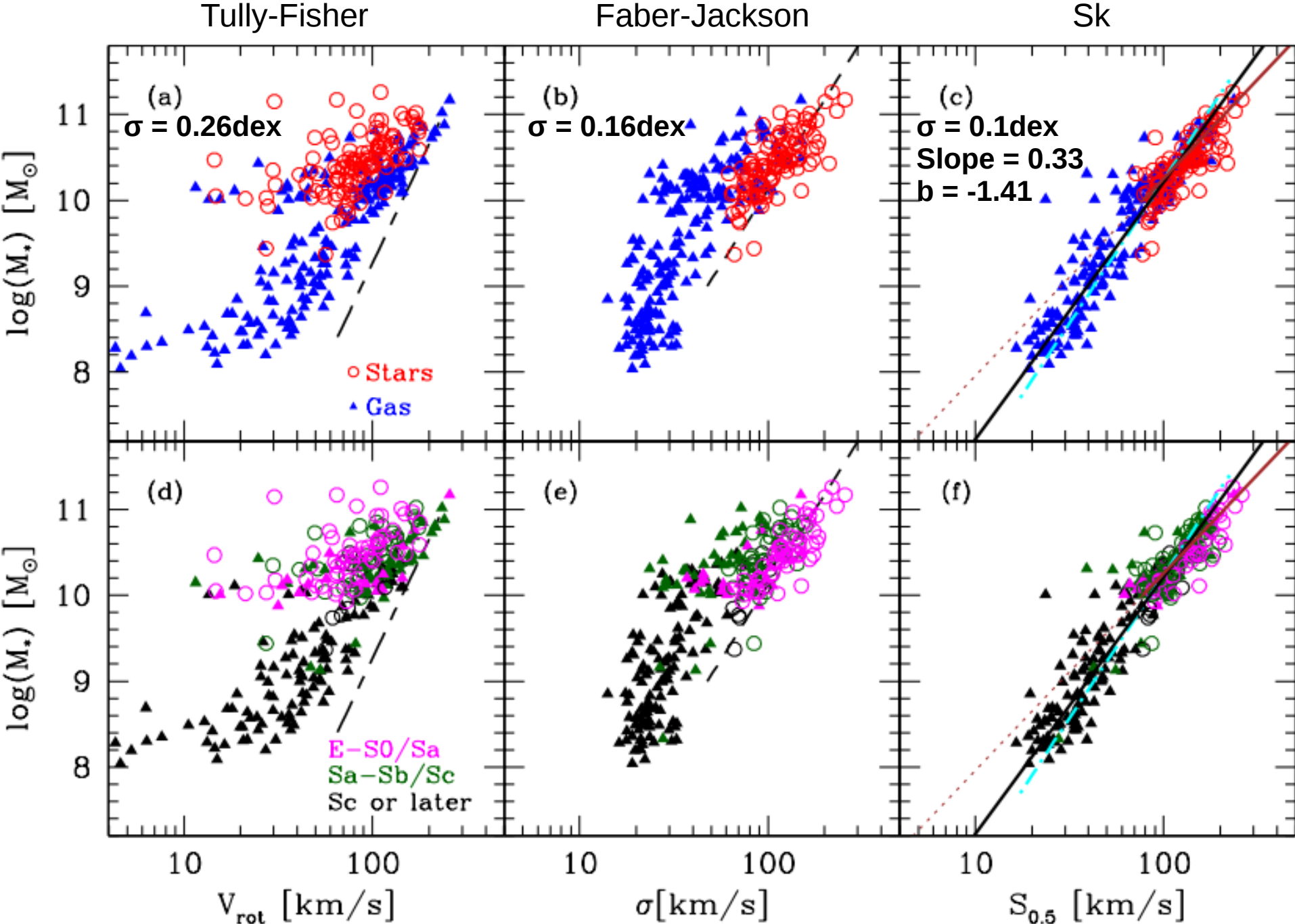


Motivation: Scaling relations

- Galaxy evolution and environmental effects are likely to modify the shape of Tully-Fisher relation. [Weiner et al. 2006A](#), [Corteau 1997](#).
- Different works have investigating the possibility of bringing galaxies of all types onto the same scaling relation. [Zaritsky et al. \(2008\)](#), [Kassin et al. \(2007\)](#), [Cortese et al. \(2014\)](#)

$$S_K^2 = KV_{rot}^2 + \sigma^2$$

Cortese et al., 2014 - SAMI

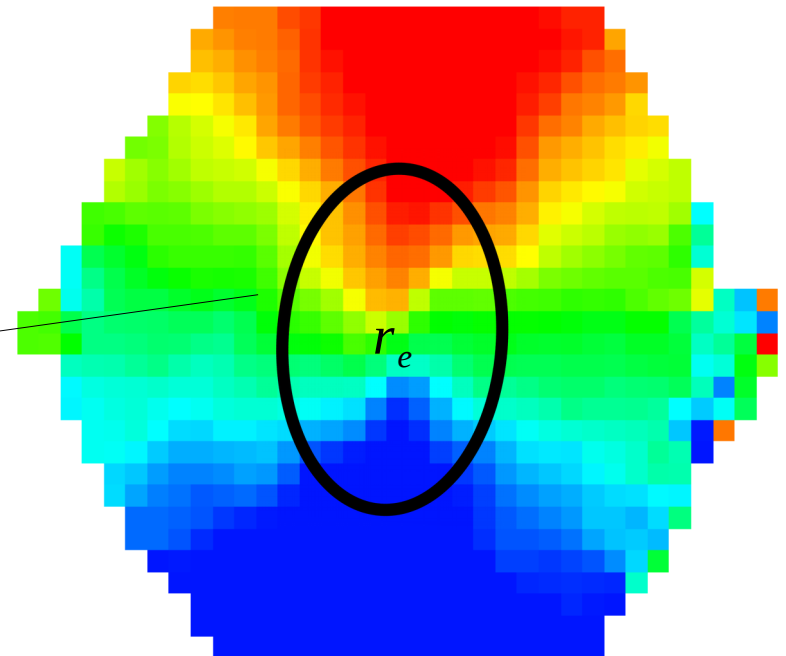
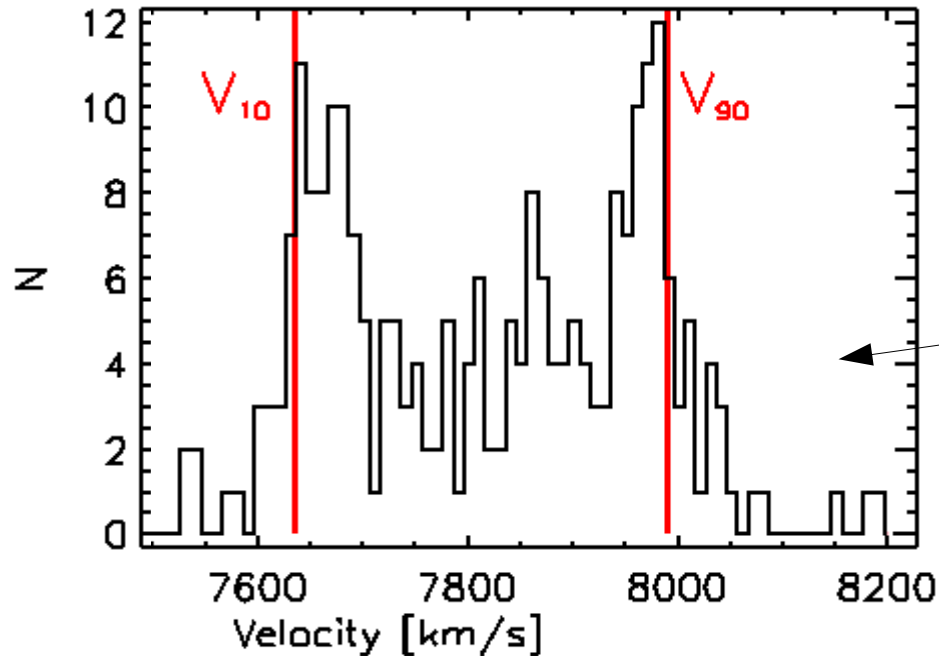


Methodology: We follow the same procedure as Cortese et al. (2014)

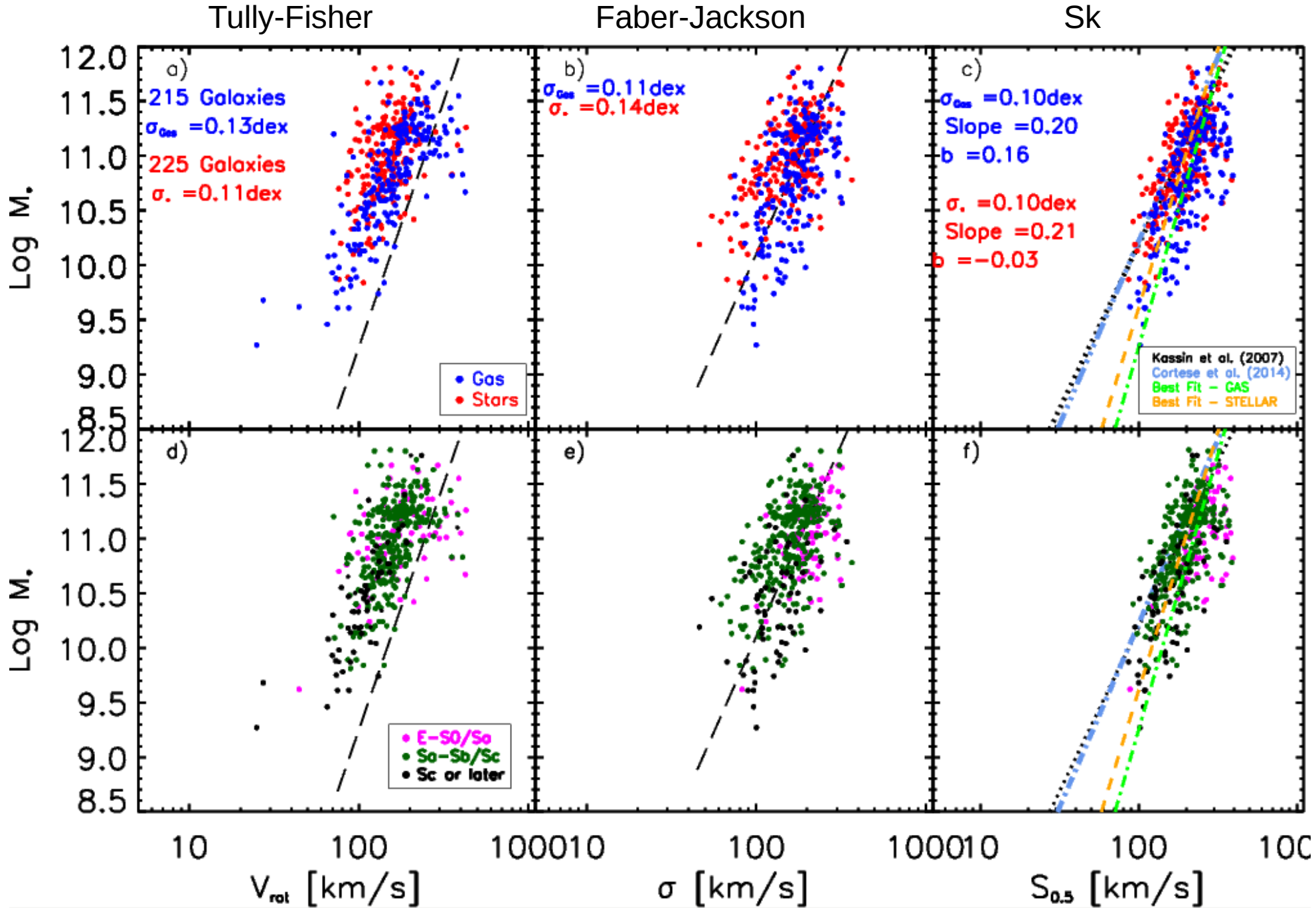
Line-of-sight velocity and dispersion maps were obtained using the PIPE3D (S. F. Sánchez et al. 2007).

Gas and Stellar rotational velocity: *Similar to integrated HI profile*

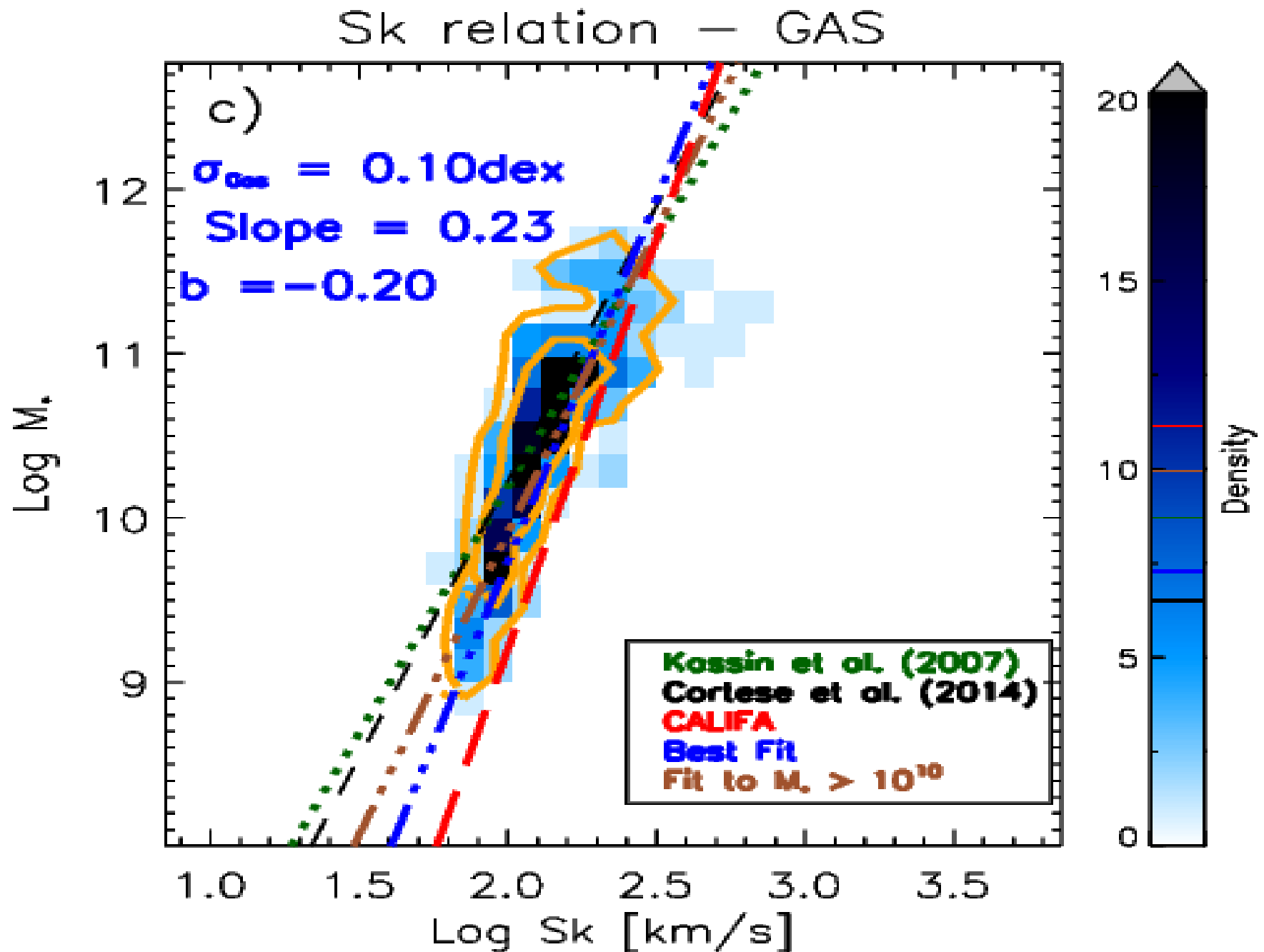
$$V_{rot} = \frac{W}{2(1+z)\sin(i)}$$



Results: Scaling relations: CALIFA Sample



Sk Scaling relation: MaNGA Sample **Preliminary results**



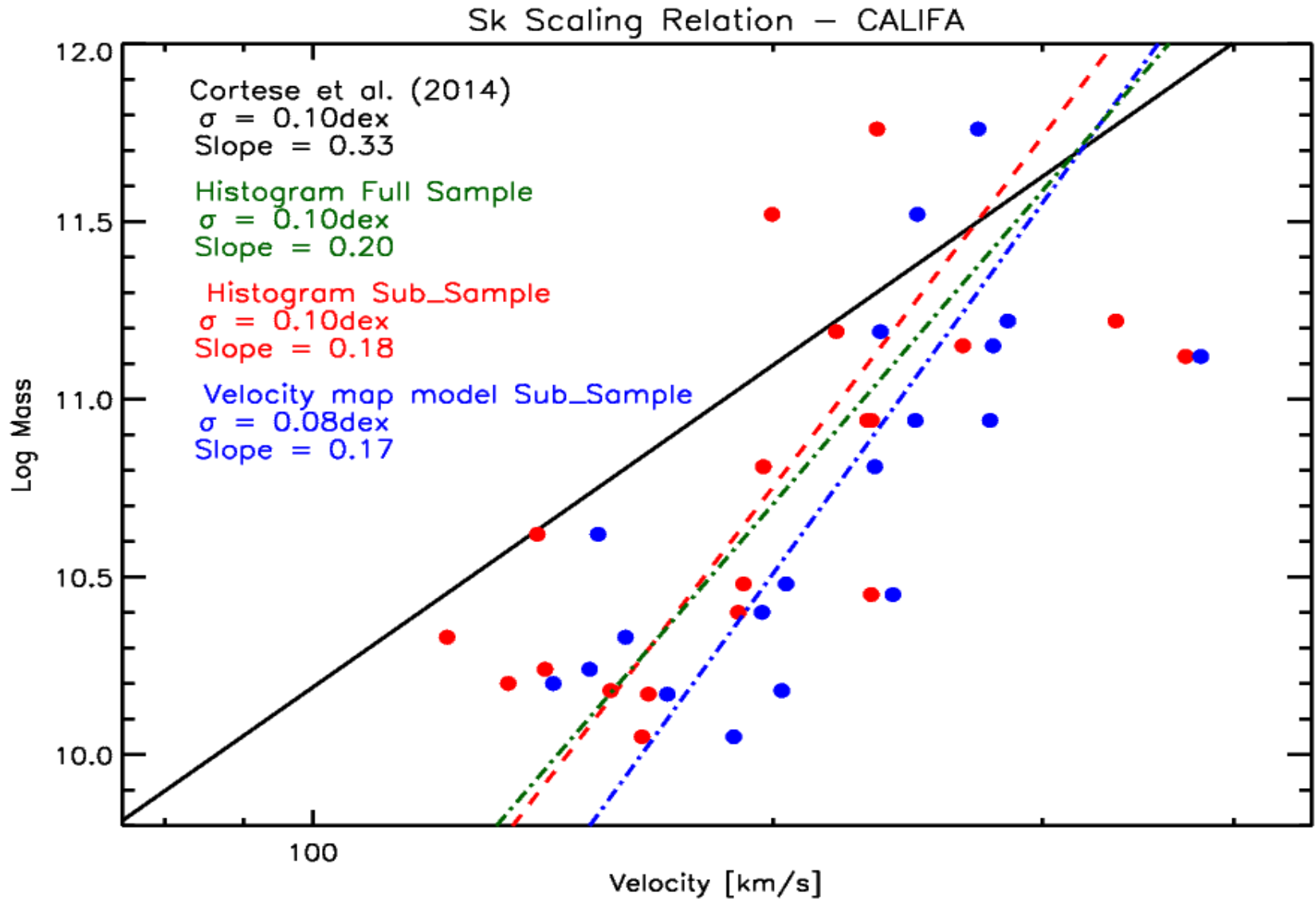
Summary:

Sk Scaling relation:

Survey	Galaxies	Slope	Intercept	Scatter
<i>SAMI</i>	<i>193</i>	0.33	-1.41	0.1dex
<i>CALIFA</i>	<i>215</i>	0.20	0.16	0.1dex
<i>MaNGA</i>	<i>357</i>	0.23	-0.20	0.1dex


work in Progress:

A well resolved sub-sample of CALIFA galaxies




This result shows the importance of detailed kinematic analysis in Spiral galaxies.

More Details: Poster #61



MCMC ANALYSIS OF BIASES IN THE INTERPRETATION OF DISK GALAXY KINEMATICS.

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ABSTRACT

The new generation of galaxy surveys like SAMI, CALIFA and MaNGA opens up the possibility of studying simultaneously properties of galaxies such as spiral arms, bars, disk geometry and inclination, stellar and gas mass distribution, 2D kinematics, etc. The previous task involves exploring a complicated multi-dimensional parameter space. Paglioli et al. (2018) introduces Bayesian statistics and MCMC (Monte Carlo Markov Chain) to changes to construct dynamical models of spiral galaxies. In our study we model synthetic velocity fields that include non-circular motions and compare different disk configurations to verify in previous models observations. We apply popular reconstruction techniques in order to estimate the geometrical disk parameters, such as: inclinations, rotation curve shape and inclination or radial velocity which are crucial to construct the scaling relations. We conclude that a detailed analysis of kinematics in galaxies using MCMC technique will be reflected in accurate estimations of galaxy properties and more robust scaling relations, otherwise physical conclusions may be importantly biased.

INTRODUCTION

The most robust prediction of the cosmological model Λ CDM is the "dark matter halo" (Binney et al. 2008) which can be used and to maintain circular velocity function for halos and sub-halos (Klypin et al. 2011). The information about dark matter halos we have the scaling relations as Tully-Fisher (TF) (Tully & Fisher 1977) and Faber-Jackson (FJ) (Faber & Jackson 1975) which connects dark matter halos properties with galaxy observables. For example, TFH connects the halo mass, circular velocity with the rotation curve, star formation history, i.e., luminosity and this relation also offers some insights into the physics of disk galaxy formation and evolution.

Wetzel et al. (2010) studied the TFH in four bands: B, R, I and K, for three different estimations of rotational velocity, the band that scales and slope depend on the technique used to estimate the rotational velocity. We using a sample of CALIFA galaxies did a comparison between the TFH with the Vrot estimated with the width of velocity maps (Vrot) and modeling the velocity field. In Figure 1 show the results, where scales and slope decrease with Vrot estimated modeling the velocity maps in agreement with Wetzel et al. (2010).

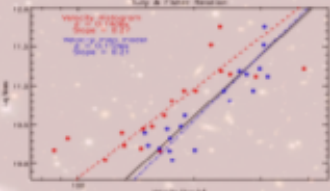


Figure 1. Comparison between the Tully-Fisher and the width of Vrot estimated with the velocity maps and Vrot estimated modeling the velocity maps. Black dots represent Vrot with the TFH and blue dots modeling kinematic maps.

Disk asymmetries, star formation, nuclear activity, inflows outflows can produce non-circular motions in rotation lines (in the Vrot estimation). The Fig. 1 shows the importance of detail kinematic analysis in galaxies.

SYNTHETIC VELOCITY MAPS

In order to study the non-circular motions effect in the Vrot estimations (in galaxies we construct a great variety of synthetic velocity maps including a 2D symmetric distribution as described using the next equation:

$$V_{\text{model}} = V_{\text{sys}} + \sin(i) [V_{\theta} \sin(\theta) - V_{\phi} \cos(2\theta)] \cos(\theta) - V_{\phi} \sin(2\theta) \sin(\theta) \quad (1)$$

where V_{sys} is the systemic velocity, i the inclination, V_{θ} tangential velocity component, θ the azimuthal angle from the major axis in the plane of the disk, θ_0 the angles relative to the bar axis, V_{ϕ} and V_{θ} are the amplitudes of the tangential and radial components of the non-circular flow, respectively.

In Figure 2 we show three synthetic velocity maps for different geometrical configurations, i.e., with different inclination and position angle, as well as different bar orientations.

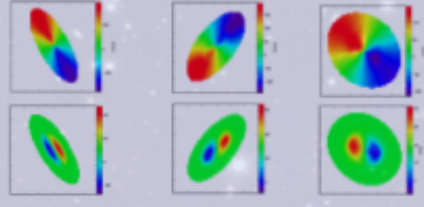


Figure 2. Top 3 synthetic velocity maps and Fourier points for the case of a non-inclined bar, respectively: Left (i = 0°, $\theta_0 = 0^\circ$ and $\phi = 0^\circ$), Middle (i = 0°, $\theta_0 = 45^\circ$ and $\phi = 0^\circ$) and Right (i = 0°, $\theta_0 = 0^\circ$ and $\phi = 45^\circ$).

In the next sections we modeled the synthetic velocity maps to explore if we can recover geometric parameters, inclination circular velocity and the rotation curve shape.

KINEMATIC ANALYSIS

To carry out our kinematic modeling of velocity maps we use the publicly available VIRE code developed by Spethius and Willock (2007). This code allows us three types of kinematic models. The simplest model includes rotation only, the second model includes disk asymmetries as a lopsided galaxy and finally, the symmetric model introduces non-circular flows produced by a bar-like. Assuming a flat disk and using a Fourier mode decomposition around center, a map with m modes is given by, kinematic center (R_c, ϕ_c) , inclination i , disk PA and rotational velocity measured for bi-symmetric distribution we also need determine the bar position angle (respect to galaxy major axis) as well as radial and tangential non-circular motions components.

VIRE use a **Levenberg-Marquardt (LM) algorithm** as a minimization technique. The LM algorithm uses a maximum likelihood approach to answer the question: How likely is the data we given a set of geometric parameters? This routine estimates the 2-D maximum likelihood estimator by using a gradient search through parameter space. The caveat with least-squared approaches is that for data with low than optical sampling corresponding to many local minima in χ^2 -space, the LM routine is sensitive to initial guesses and is easily trapped.

To solve this problem we implement a Bayesian technique and a **Multi-Starts Markov Chain (MSMC)**, that parallel method of sampling the parameter space that rapidly converges to posterior probability distribution of the input parameters using the Metropolis-Hastings algorithm, (e.g. Paglioli et al. (2018)).

RESULTS

These synthetic datasets tell us that if we consider a larger number of iterations we ensure that we are covering the whole space of parameters. The following figures show the results of the detailed kinematic analysis for three synthetic velocity maps with different geometry.

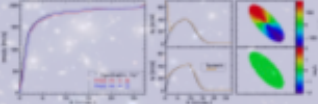


Figure 3. $i=0^\circ$ Velocity map with $i = 0^\circ$, $PA = 20^\circ$ including a bi-symmetric distribution and a bar-like with $\phi = 0^\circ$. In this case the rotation curve including only rotational velocity (red curve) (rotation curve map) by rotation curve need to construct the synthetic map (Black curve). When we modeled including a bi-symmetric distribution we see that the rotation curve (Blue curve) is in agreement with the synthetic.

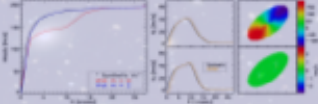


Figure 4. $i=0^\circ$ Velocity map with $i = 0^\circ$, $PA = 20^\circ$ including a bi-symmetric distribution and a bar-like with $\phi = 0^\circ$. In this case the rotation curve including only rotational velocity (red curve) (rotation curve map) by rotation curve need to construct the synthetic map (Black curve). When we modeled including a bi-symmetric distribution we see that the rotation curve (Blue curve) is in agreement with the synthetic.

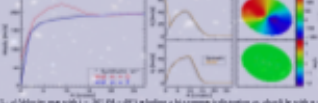


Figure 5. $i=0^\circ$ Velocity map with $i = 0^\circ$, $PA = 45^\circ$ including a bi-symmetric distribution and a bar-like with $\phi = 0^\circ$. In this case the rotation curve including only rotational velocity (red curve) (rotation curve map) by rotation curve need to construct the synthetic map (Black curve). When we modeled including a bi-symmetric distribution we see that the rotation curve (Blue curve) is in agreement with the synthetic.

DISCUSSION AND CONCLUSIONS

In this poster we show three important examples in order to show that for the model including only rotational velocity in the rotation curve shape is affected in the region where we have non-circular motions (See Fig. 3, 4 and 5), can be used as a model of rotation curve and rotation curve. It means that it is not a good estimate of circular velocity in this disk. After modeling only rotational velocity, we modeled with our MSMC, we began to model non-circular motions in the system and we model the non-circular motions and we can see that we recover the rotation curve shape, the geometrical parameters of the rotation curve as well.

We conclude that a detailed analysis of kinematics in galaxies using MCMC technique will be reflected in accurate estimations of galaxy properties and more robust scaling relations, otherwise physical conclusions may be importantly biased.

CONCLUSIONS:

- Scaling relation using the S parameter is more tight than Tully-Fisher and Faber-Jackson relation.
- There is a possible indication of systematic differences between scaling relations using different samples (SAMi, CALIFA and MaNGA).
- We emphasize the importance of detail study of kinematics in galaxies.
- After understanding all possible uncertainties we will be ready to test theoretical models.

Methodology: We follow the same procedure as Cortese et al. (2014)

Line-of-sight velocity and dispersion maps were obtained using the PIPE3D (S. F. Sánchez et al. 2007).

The final sample was selected as follows:

- I. In each kinematic maps the spaxels with errors greater than 20 km/s and 50 km/s for gas and stars, respectively are discarded.
- II. The fraction (f) of good spaxels within an ellipse of semi-major axis equal to effective radius, inclination and position angle must be greater than 80%.

Gas and Stellar rotational velocity: *Similar to integrated HI profile*

$$V_{rot} = \frac{W}{2(1+z)\sin(i)}$$

