Kinematic scaling relations of CALIFA and MaNGA galaxies:

a dynamical mass proxy for galaxies across the Hubble sequence.

E. Aquino-Ortíz, O. Valenzuela, S.F. Sánchez, H. Hernández-Toledo, V. Ávila-Reese, A. Rodriguez-Puebla, B. Mancillas.

Instituto de Astronomía, Universidad Nacional Autónoma de México, A.P. 70-264, 04510 CDMX, Mexico

Abstract.

We used ionized gas and stellar kinematics for 667 spatially resolved galaxies publicly available from the CALIFA 3rd Data Release and for ~ 3000 galaxies from the MaNGA survey (SDSS-IV collaboration) with the aim of studying kinematic scaling relations as the Tully & Fisher (TF) relation using rotation velocity, the Faber & Jackson (FJ) relation using velocity dispersion, and also a combination of rotation velocity and velocity dispersion through the SK parameter defined as $S_K^2=KV_{rot}^2+\sigma^2$ with constant K. When we use the SK parameter, all galaxies, regardless of the morphological type, lie on the same scaling relation, showing a tight correlation with the total stellar mass. We calibrate the kinematic SK dynamical mass proxy in order to make it consistent with sophisticated published dynamical models within 0.15 dex. We show that the SK proxy is able to reproduce the relation between the dynamical mass and the stellar mass in the inner regions of galaxies. Our result may be useful in order to produce fast estimations of the central dynamical mass in galaxies and to study correlations in large galaxy surveys.

Kinematic scaling relations.

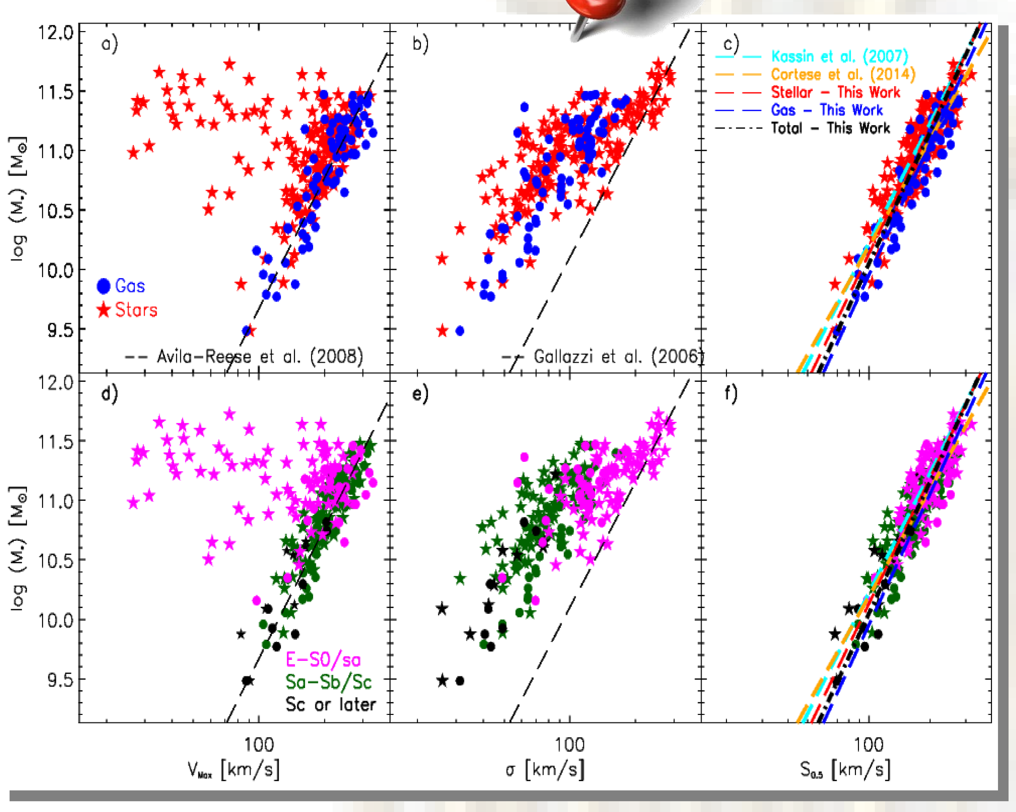

Figure 1.-

Figure 1.- Kinematic scaling relations with spatially resolved kinematics. *Left panels:* Tully & Fisher (TF) relation with the black line representing the orthogonal best-fit TF relation from Avila-Reese et al. (2008). *Middle panels:* Faber & Jackson (FJ) relation with the black line the best-fit FJ relation from Gallazzi et al. (2006). *Right panels:* The M*-S0.5 relation, cyan and yellow lines indicate the best-fit M*-S0.5 relation from Kassin et al. (2007) and Cortese et al. (2014), respectively, whereas the black line represent our best-fit. *Top panels:* red star and blue circles represent galaxies with stellar and ionized gas kinematics. *Bottom panels:* galaxies with different morphological types; magenta indicate elliptical and lenticular galaxies, green are Sa and Sb galaxies and black symbols are Sc galaxies.

Figure 2.- M*-S0.5 scaling relation for ~3000 galaxies from the MaNGA survey. Galaxies of any morphological type lie on the same scaling relation in agreement with previous studies. *The reduction in the scatter combining rotation velocity and velocity dispersion in a single parameter, indicate that together they trace the gravitational potential than each one separately.*

Preliminary result.

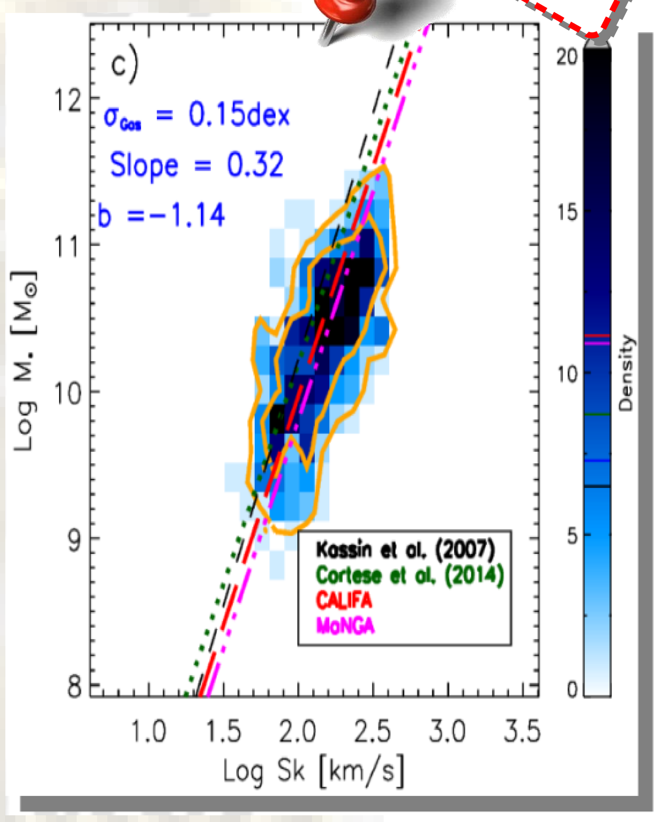

Figure 2.-

SK as a proxy of the dynamical mass.

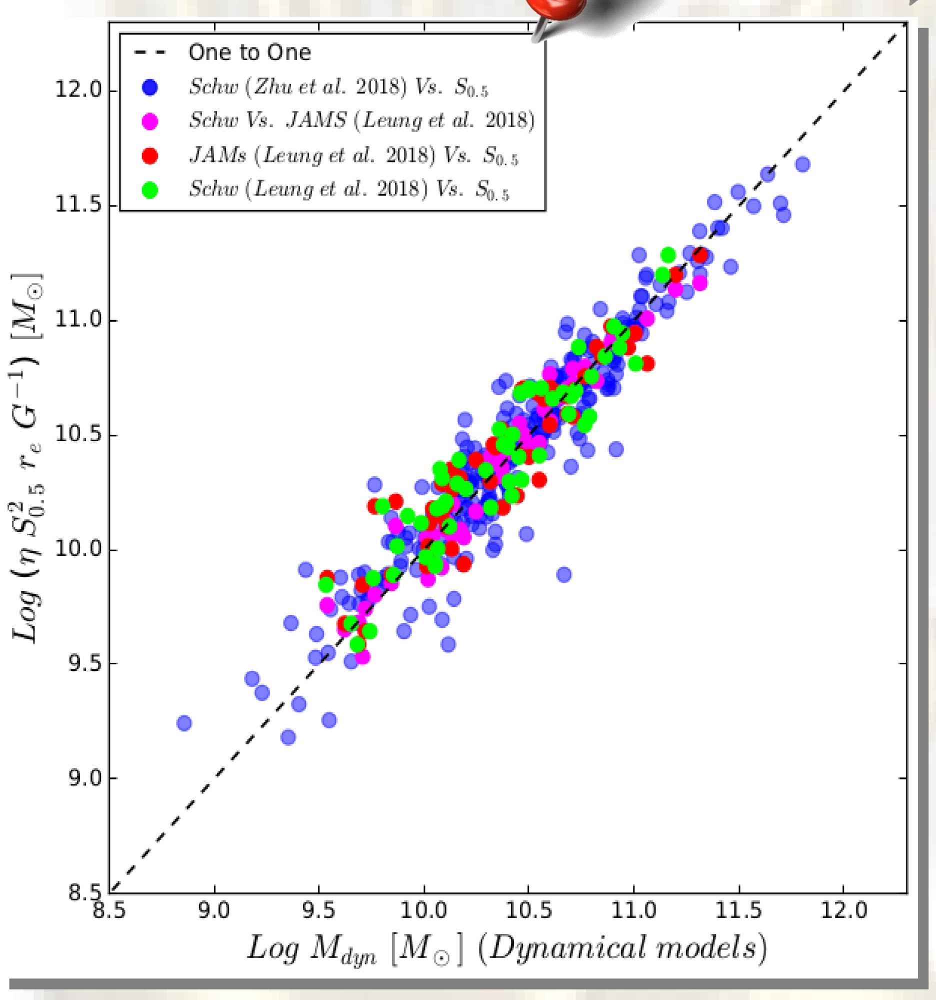

Figure 3.-

Assuming that the M* - S0.5 scaling relation is a consequence of a more physical relation between the dynamical mass and the stellar mass in the inner regions, we suppose that the S0.5 parameter traces the dynamical mass as follow:

$$M_{dyn} \propto S_{0.5}^2 \Rightarrow M_{dyn} = \eta \frac{r_r S_{0.5}^2}{G} = \eta \frac{r_r (0.5 V_{rot}^2 + \sigma^2)}{G},$$

where rr is a characteristic radius of the galaxy, G the gravitational constant and eta is a structural coefficient which encapsulate information of the shape of the galaxy, projection effects, dynamical structure, etc. We calibrate our dynamical mass proxy based on the S0.5 parameter using more sophisticated tools as the JAMs and Schwarzschild dynamical models from Leung et al. (2018) and Zhu et al. (2018). *We found that the enclosed dynamical mass within the effective radius can be robustly recovered using a single coefficient eta ~ 1.8 for all the galaxies, with a narrow dispersion of 0.15dex.*

Figure 3.- One to one relation between dynamical masses inferred from dynamical models and kinematic parameter S0.5. Blue symbols are the comparison between the Schwarzschild models by Zhu et al. (2018) with our estimations. Red and green symbols are the comparison between JAMs and Schwarzschild models by Leung et al. (2018) with our estimations, respectively. Both comparisons shown a scatter of ~ 0.15dex. Magenta symbols are the comparison between Schwarzschild and JAMs estimations with a scatter of 0.08dex.

The dynamical to stellar mass relation.

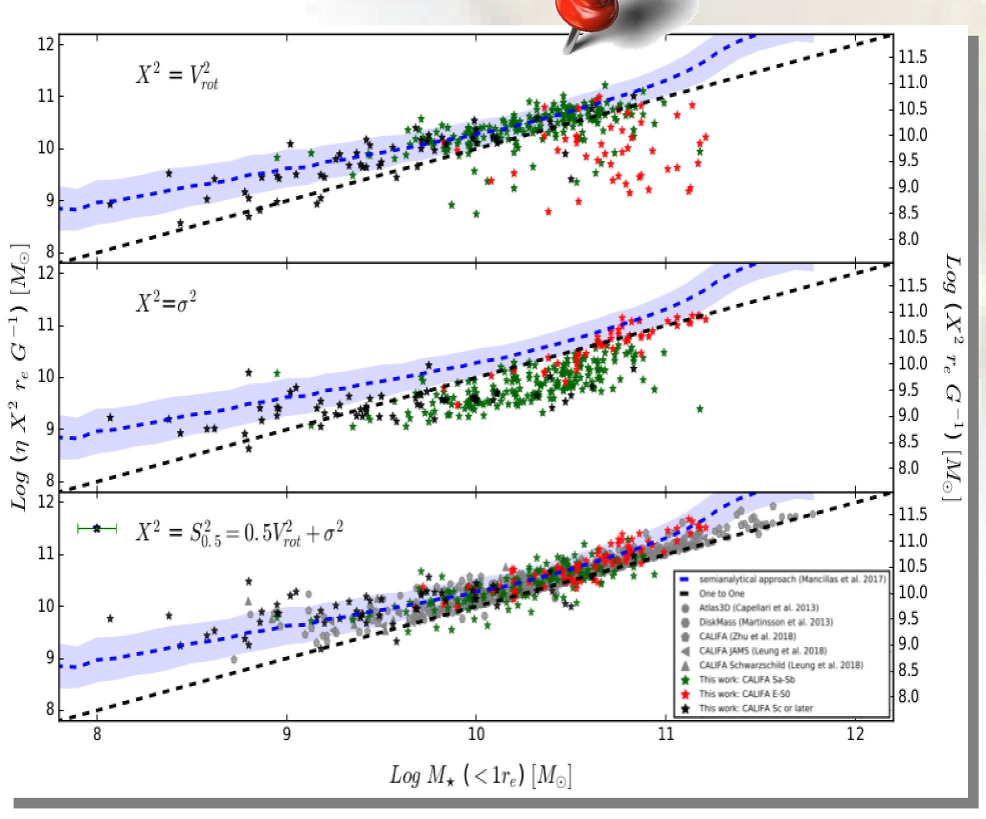

Figure 4.-

Figure 4.- Mdyn-M* relations. In top and medium panels we assume that galaxies are rotation or velocity dispersion dominated to estimate the dynamical mass within the effective radius. Red, green and black star symbols represent our CALIFA sample, whereas gray symbols are from the literature compilation. The S0.5 dynamical mass estimations perform better than the ones based either only on rotation or dispersion. In the bottom panel we used the S0.5 parameter to estimate the dynamical mass and compare them with theoretical predictions based on detailed dynamical models. As a reference we also show the semi-empirical predictions of Mancillas et al. (2017) (blue shaded region) which use eta=1 and are also consistent with our estimations.

Figure 5.- Mdyn-M* relations based on the S0.5 parameter including our preliminary result using MaNGA data.

Our distribution of Mdyn-M* follows a linear and nearly one-to-one relation for masses in the intermediate range. In the low mass range there is a clear deviation, with galaxies showing larger dynamical masses than their stellar masses, which indicates that in the low-mass regime galaxies are more dark-matter dominated as less massive they are, even within the effective radius.

Preliminary result.

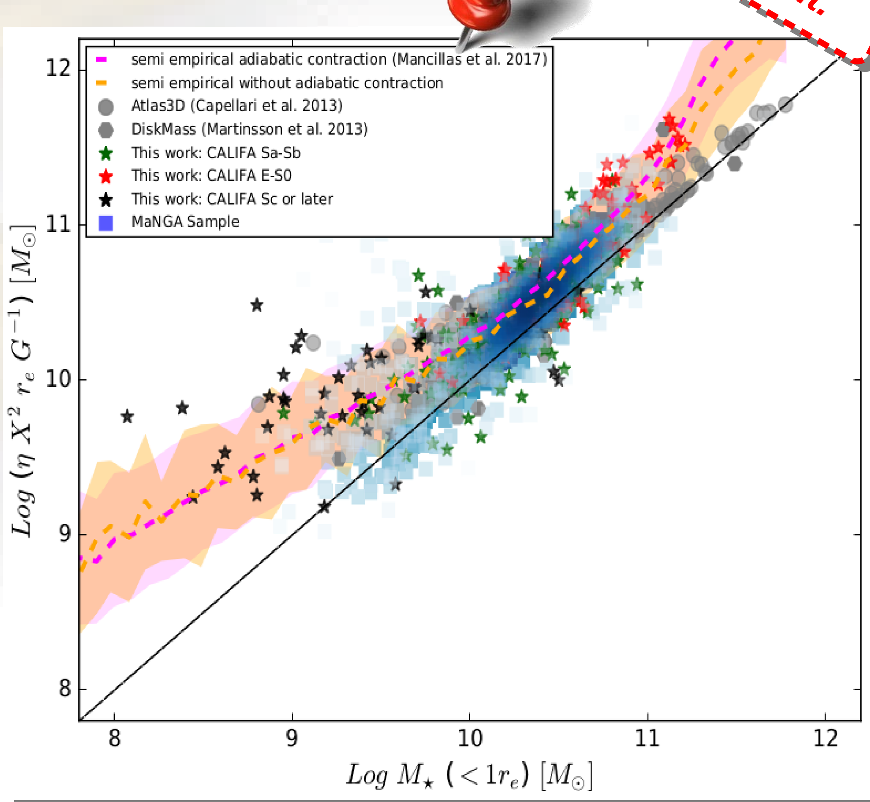

Figure 5.-

Conclusions.

* The M*-S0.5 is a tighter correlation than the TF and the FJ relations when galaxies of all morphological types are considered.

* The S0.5 is a better proxy of the dynamical mass of galaxies.

* We propose a simple but competitive procedure to estimate the dynamical mass in galaxies, easier to apply to massive surveys than more detailed analysis, although with lower precision.