With the rise of large-scale spectroscopy surveys, the amount of self-consistent data has reached unprecedented magnitudes. This data can be used to derive a multitude of parameters for the targeted galaxies, which may help to further improve established tools, such as the fundamental plane of early-type galaxies.

Using SDSS DR14 data, we identified about 290,000 early-type galaxies within a sample of more than 1,260,000 galaxies below a redshift of 0.5. Applying a group finder and the standard calibrations, we calibrated the traditional fundamental plane with these data sets. By carefully studying the residuals and the survey parameters, we managed to develop two improved versions of the traditional fundamental plane: the stellar mass fundamental (hyper-)plane and the dynamical fundamental plane. Each fundamental plane suffers from different systematic biases and corresponding statistical uncertainties. The main question is how much (hidden) redshift-dependence/bias one is willing to tolerate for a substantial improvement in distance measurement. As a constancy test, we compared these new distances to other distance indicators such as supernovae Type Ia and the Tully-Fisher relation.

### Observational data

We used SDSS DR14 as the primary source of data for our project. For our applications, we selected all galaxies with spectroscopic data below a redshift of $z < 0.5$. Hence, our data set is composed of the SDSS main galaxy sample, the SDSS LRG (low- and high-z) sample, the BOSS DR14 sample, and the BOSS CMASS sample. We used colour-cuts and the shape of the luminosity profiles to identify early-type galaxies within the basic data set. For additional calibrations, we took advantage of the kinematic data by Graham (2018) based on MaNGA as well as the SDSS-based value add catalogues by Maraston (2009).

### Group finder

In order to collapse the redshift-space distortion caused by peculiar motions inside galaxy clusters, we applied a friends-of-friends group finder algorithm to our basic data set. We used the Millennium simulation re-run with WMAP parameters to create our mock-catalogues based on the SDSS/BOSS selection function and calibrated the algorithm following the methods of Robotham (2011).

### Traditional fundamental plane

The fundamental plane is an empirical relation between the physical radius $R_e$, the central velocity dispersion $σ_e$, and the surface brightness $μ_0$ that can be used a redshift independent distance indicator:

$$\log(R_e) = a \cdot \log(μ_0) + b \cdot μ_0 + c \quad (1)$$

It requires several calibrations that are actually redshift-dependent: Tolman-effect (purely physical), K-correction (physical and model-dependent), size-correction (physical and model-dependent), evolution (mostly model-dependent), and Malmquist bias corrections.

### Stellar mass fundamental (hyper-)plane

The most dominant factor causing the scatter of the traditional fundamental plane are the stellar masses of the galaxies (Hogg & Bernardi, 2009).

$$\log_10(R_e) = a \cdot \log_10(M_*) + b \cdot μ_0 + c + d \cdot \log_10(M_*) \quad (2)$$

By adding an additional term depending on the stellar mass $M_*$ to the traditional, we were able to correct for that bias. However, all stellar mass models contain hidden information on the redshift (via absolute magnitudes) causing another systematic bias.

### Dynamical fundamental plane

To avoid relying on any specific stellar mass model as well as to consider various selection biases and evolutionary effects with a specific model, we split the large sample of 290,000 early-type galaxies in a tight set of overlapping bins. To keep our approach empirical and as model-independent as possible, we only split the sample in bins of directly observable quantities such as redshift and the apparent magnitude. We calculated the fundamental plane coefficients in each bin and fitted a 2D-function to the coefficients:

$$\log_10(R_e) = a \cdot \log_10(μ_0) + b \cdot μ_0 + c \cdot \log_10(M_*) \quad (3)$$

### Kinematic distances

With the rise of integral field spectroscopic surveys (MaNGA, Califa, SAMI), new opportunities to study well-known distance indicators such as the fundamental plane and the Tully-Fisher relation open up. In the last decade, we learned that early-type galaxies have significant rotational support, which is indicated by the $Ω_b$ parameter (Emel'chev et al. 2007). However, the naive approach does not provide an improvement, which means that a more sophisticated analysis is necessary to make use of the full potential of integral field spectroscopic data.