On the stability of morphological parameters measurements with redshift

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Introduction

To understand how galaxies were formed and evolved, we need to measure their properties at different redshifts. Traditional morphological and structural parameters (e.g. Sérsic intensity, effective radius and index, concentration, asymmetry, Petrosian Radius, Gini coefficient) may be dependent on the image sampling, PSF and SNR. So in order to measure how the morphology of these objects evolve with time, we need to know how robust our measurements are at different redshifts. In this way, we used the FERENGI application to simulate the effect of observing the same galaxy at different redshifts. We applied the procedure to the FREI database to artificially redshift local galaxies up to 1.5 Gpc ($z = 0.4$) and then used the FOTOMETRIKA package to measure several morphological and structural parameters. In this way we were able to check how the measurements behave as the spatial resolution and the SNR decreases. Those parameters that depend on the distance can be corrected for and compared with other measurements, given that we have a Cosmology model. Other parameters, such as asymmetry (both traditional and an improved version), are found to be present stable measurements with redshift.

Cosmological model

In order to understand how the redshift affects the measurements, we need a cosmological model that describe the universe expansion. In our case, the FRWL metric and the Friedmann’s equation are the mathematical description necessary. Thus, the distance in the line of sight in this case is

$$D = D_\text{H} \int_0^z \frac{dz'}{(\Omega_m(1+z')^3 + \Omega_r (1+z')^2 + \Omega_k)}$$

where $\Omega_m$, $\Omega_r$ and $\Omega_k$ are the energy density parameters, which is dependent from the cosmological model and $D_\text{H}$ is the Hubble distance defined as

$$D_\text{H} = \frac{c}{H_0}$$

for a flat $\Lambda$ - CDM universe, $\Omega_k \approx 0$. In FERENGI, the numerical values for $\Omega_m$ and $\Omega_r$ are 0.3 and 0.7 respectively. $H_0$ is parameterized as follows

$$H_0 = h \times (100 \text{ km s}^{-1} \text{ Mpc}^{-1}), \ h = 0.7$$

MORFOMETRYKA measurements

FERENGI simulates the redshifting of an object to a given distance. It applies the correct cosmological corrections for size, surface brightness and bandpass shifting. Barden et al. 2008 calls this process “artificial redshifiting”. In our case, we wrapped FERENGI’s code to produce images of the selected nearby galaxy into several redshifts in a given interval of 50 Mpc, from 0.1 Gpc to 1.5 Gpc.


Measurements with redshift

Conclusions

- Concentration, Asymmetry, Gini and Sérsic parameters can be measured reliably by MORFOMETRYKA.
- $A_1$ asymmetry index (this work) discriminates better than traditional index $A_1$.
- $C_1$ (outer) concentration discriminates better than $C_1$ (inner).
- Image sampling is crucial for morphometry measurements. General advice is:

$$\text{pixel size} < \frac{R_e}{15}$$

- Measurements converge to the PSF values with increasing redshift. Reliable measurements are limited to distances where

$$R_e > 2 \text{ PSF}_\text{PSF}$$

References (cont.)


References

- Barden, M.; Jahnke, K.; Haußler, B. 2008: FERENGI: Redshifting Galaxies from SDSS to GEMS, STAGES, and COSMOS; ApJS 175, 105B.