Galaxy Evolution and Feedback across Different Environments
Proceedings IAU Symposium No. 359, 2020
T. Storchi-Bergmann, W. Forman, R. Overzier & R. Riffel, eds.
doi:10.1017/S1743921320002318

Curvature of galaxy brightness profiles

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Abstract. Galaxy morphologies reflect the shapes of galaxies and their structural components, such as bulges, discs, bars, spiral arms, etc. The detailed knowledge of the morphology of a galaxy provides understanding of the physics behind its evolution, since the time of its formation, including interaction processes and influence of the environment. Thus, the more precisely we can describe a galaxy structure, the more we may understand about its formation and evolution. We present a method that measures curvature, using images, to describe galaxy structure and to infer the morphology of each component of a galaxy. We also include some preliminary results of curvature measurements for galaxies of the Southern Photometric Local Universe Survey (S-PLUS) DR1 data release and for jellyfish galaxies of the Omega Survey. We find that the median of the curvature parameter and the integrated area under the curvature give us clues on the morphology of a galaxy.

Keywords. galaxies:structure, galaxies:morphology, galaxies:morphometry, differential geometry: curvature

1. Introduction

One way to understand better how the morphology of a galaxy behaves is to quantify how many structural components there are in a galaxy. Each one of these components are directly or indirectly related to its dynamical properties. Thus, having a complete picture of the structure of a galaxy in terms of its components – how the light is distributed along different parts – might improve our knowledge regarding their morphology and evolution. There are many attempts to extract morphometric properties of galaxies (e.g. Conselice 2014). However, it is not certain how we can use them to study different parts of a galaxy. In (Lucatelli *et al.* 2019) we have introduced the method of curvature in order to discriminate these differences in galaxy morphologies. This enabled us to quantify approximately how many components there are in a galaxy in cases we have sufficient spatial resolution.

1.1. *Curvature* $\widetilde{\kappa}$

From differential geometry, the curvature κ of a uni-dimensional function $f(x)$ is defined as (e.g. Tenenblat 2008) $\kappa(x) \equiv f''/(1+f'^2)^{3/2}$ where $f' = \frac{\mathrm{d}f}{\mathrm{d}x}$. It measures how

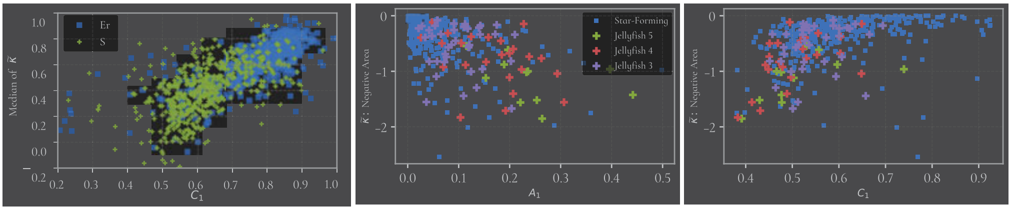

Figure 1. Left: Relation between the median of $\widetilde{\kappa}$ with the concentration C_1 index for a sample of galaxies from S-PLUS–DR1 data (Mendes de Oliveira *et al.* 2019). "S" means spirals and "Er" elliptical rounded, from GalaxyZoo. **Centre/Right:** Relation between area under $\widetilde{\kappa}$, C_1 and asymmetry A_1, for galaxies of the OMEGA survey. Jellyfish galaxies are indicated by "plus" labels and by their JClasses, 5, 4 and 3, see Roman-Oliveira *et al.* (submitted).

the tangent vector's curve changes as we move on the function and here it is applied to the light profile†

$$\widetilde{\kappa}(\chi) \equiv \frac{\mathrm{d}^2\nu(\chi)}{\mathrm{d}\chi^2}\left[1+\left(\frac{\mathrm{d}\nu(\chi)}{\mathrm{d}\chi}\right)^2\right]^{-3/2} \xrightarrow{\text{discrete}} \widetilde{\kappa} \equiv \frac{\delta\chi_i\ \delta^2\nu_i - \delta\nu_i\ \delta^2\chi_i}{(\delta\chi_i^2+\delta\nu_i^2)^{3/2}}, \quad (1.1)$$

where χ is the normalized projected radius of the galaxy and $\nu(\chi)$ is the normalized logarithm of the light profile I.

2. Results and Discussions

We present here some applications and preliminary results from curvature applied to S-PLUS and Omega survey galaxies. These first results are based on a simple approach which is to compute the area under the curvature profile and its median. This gives us a scalar value from it, being interpreted as a morphometric index.

In the left of Figure 1 it is shown the relation between the median of the curvature with the concentration index C_1 Conselice (2003) for a sample of S-PLUS-DR1 galaxies with classes from GalaxyZoo (Lintott *et al.* 2011). There is a distinct relation between both parameters. Spirals (green) have lower C_1 and curvature values than ellipticals (blue). In the centre and right of the same figure we show the relation between the total integrated area under the curvature with C_1 and the asymmetry A_1 parameter (Ferrari *et al.* 2015; Abraham *et al.* 1996) for galaxies of the Omega Survey (HST F606W). Star-forming galaxies are labelled in blue squares and jellyfish galaxies in cross symbols (purple, green and red), with colours indicating JClass 3, 4 and 5, Roman-Oliveira *et al.* (submitted). Despite some scatter, we can see a distinction between the Jellyfish candidates and other star forming galaxies in the $\widetilde{\kappa}$Area $\times C_1 \times A_1$ diagram.

References

Abraham, R., van den Bergh, S., Glazebrook, K. *et al.* 1996, *ApJS*, 107, 1
Conselice, C. 2003, *ApJS*, 147, 1
Conselice, C. 2014, *ARAA*, 52, 291
de Oliveira, C. M., Ribeiro, T., Schoenell, W., *et al.* 2019, *MNRAS*, 489, 241
Ferrari, F., de Carvalho, R. R., & Trevisan, M. 2015, *Apj*, 814, 55
Lintott, C., Schawinski, K., Bamford, S., *et al.* 2011, *MNRAS*, 410, 166
Lucatelli, G. & Ferrari, F. 2019, *MNRAS*, 489, 1161
Tenenblat, K. 2018, *Edgard Blucher*, 2nd

† https://gitlab.com/gefersonlucatelli/kurvature

https://doi.org/10.1017/S1743921320002318 Published online by Cambridge University Press