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Measuring bulge and disk surface brightness in disk galaxies

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The analysis of the light distribution of galaxy is a crucial step in studying their structural components and therefore it plays a key role in understanding the processes that led to galaxy formation and evolution. For example, this allows to investigate the 3D shape of bulges and disks or when combined with kinematic data to derive the mass distribution of the luminous matter of galaxies in order to constrain their dark matter content.

Conventional bulge-disk photometric decompositions based on elliptically averaged surface-brightness profiles are subject to strong systematic errors due to the different intrinsic shapes of bulge and disk and to the viewing angle of the galaxy (*e.g.*, [1]). Several 2D decomposition techniques have been developed in the last years (*e.g.*, [2], [3]).

Here we present an automatic and 2D parametric photometric decomposition to derive the parameters of the structural components of disk galaxies. It differs from the previous ones for the choice of guess parameters, seeing convolution, and allowing free position angles for bulge and disk. The fitting algorithm adopts a Sérsic and exponential model for the bulge and disk component, respectively. Our aim is to apply our code for photometric decomposition to study high and low surface-brightness galaxies.

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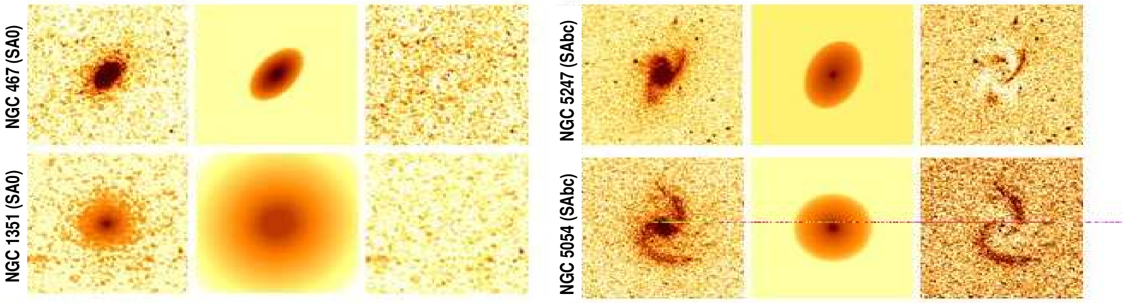

Figure 1: Examples of 2D decomposition of galaxies from the 2MASS archive. For each galaxy the $K-$band image, the 2D photometric model, and the fit residuals are shown.

To derive the photometric parameters of the Sérsic bulge (I_e, r_e, n, q_{bulge}, and PA$_{bulge}$) and exponential disk (I_0, h, q_{disk}, and PA$_{disk}$) we fitted iteratively a surface-brightness (SB hereafter) model, $I_{model}(x,y) = I_{bulge}(x,y) + I_{disk}(x,y)$, to the observations using a non-linear χ^2 minimization based on a robust Levenberg-Marquardt method.

The guesses for the 9 free parameters are derived by a parametric fit of the ellipse-averaged SB radial profile (I_e, r_e, n, I_0, and h), and by the analysis of the ellipticity (q_{bulge}, q_{disk}) and position angle radial profiles (PA$_{bulge}$, PA$_{disk}$). The fit is done in intensity units, and all pixels can have either the same or Poissonian weight. Masks can be built in either automatic or interactive mode to reject foreground stars, CCD defects, dust lanes and other image features that could spoil the fit. We take into account seeing smearing by convolving our model in each iteration step with a circular PSF Gaussian, a circular PSF Moffat function, or a PSF image. Convolution is performed by computing convolution integrals and not Fast Fourier Transform to prevent the lost of high-order harmonics.

To test the reliability of our method, we have also developed a routine which allow us to built mock galaxies images with a random combination of structural parameters within different ranges. Varying these ranges we can generate artificial galaxies for each observing setup, in order to constraint the reliability of our code. The formal errors associated to the χ^2 minimization are very small ($< 1\%$), therefore Monte Carlo simulations are needed to estimate errors on fitted parameters.

In Fig. 1 we show some examples of 2D decomposition of real galaxies obtained from the 2MASS archive. Good fits produce smooth and symmetric residual images. We expect that all the non-symmetric structures (*e.g.*, bars and spiral arms) as well as symmetric components which are not still included in the model (*e.g.*, lenses and rings) will be enhanced in the residual image.

References

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