Galaxy morphometry for multicomponent galaxies: curvature brightness profile

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"Cosmology in the era of large surveys"

Outline

Galaxy classification is a powerful tool to the understand the evolution of structures in the universe. Galaxy formation and evolution is imprinted in their current morphology. To study galaxy morphology nowadays, when data volume is beyond human processing capabilities, we have to appeal to objective and algorithmic ways to characterize galaxy morphology. One approach is to use galaxy morphometry. One of our main goals of the present work is to investigate the presence of multicomponent in galaxies (e.g. bulges and disks). We address the problem by considering a powerful diagnostic tool for this purpose which is to measure the curvature brightness profile $\varkappa(R)$. Our rationale comes from previous works on concentration of light C and Single Sérsic fits (effective Séric index) for multicomponent galaxies. We base our analysis on measurements accomplished with the MORFOMETRYKA algorithm. Our results showed that the curvature is a procedure capable to identify galaxy multicomponents.

New Insights

Concentration C_{ij}

The concentration of light (Kent, 1985) is defined as $C_{ij} = \log_{10}(R_i/R_j)$, where R_i and R_j are elliptical radii containing the fraction i (inner) and j (outer) of the total flux of the galaxy.

The curvature $\varkappa(R)$

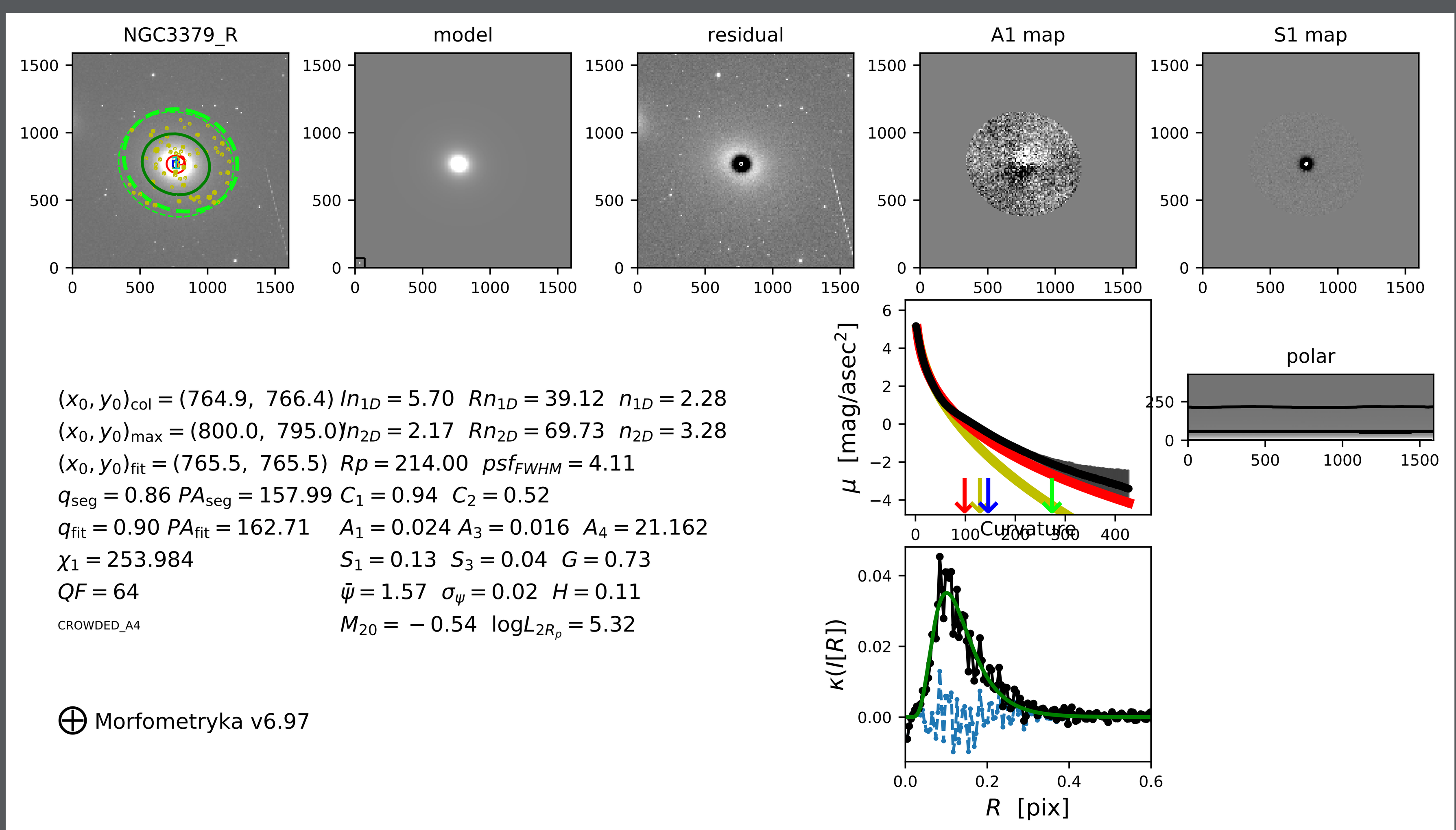
It measures how a curve (or a surface) deviates from being a straight line (a flat plane). We use it to measure the curvature of the light profile $I(R)$ of a given galaxy.

Entropies (future work)

Quantify the information of the pixel distribution of a galaxy image.

MORFOMETRYKA

Measures morphometry reliably and automatically. (Ferrari et al., 2015).



Effective Sérsic index and Concentration Paradigm: Misclassification of spirals

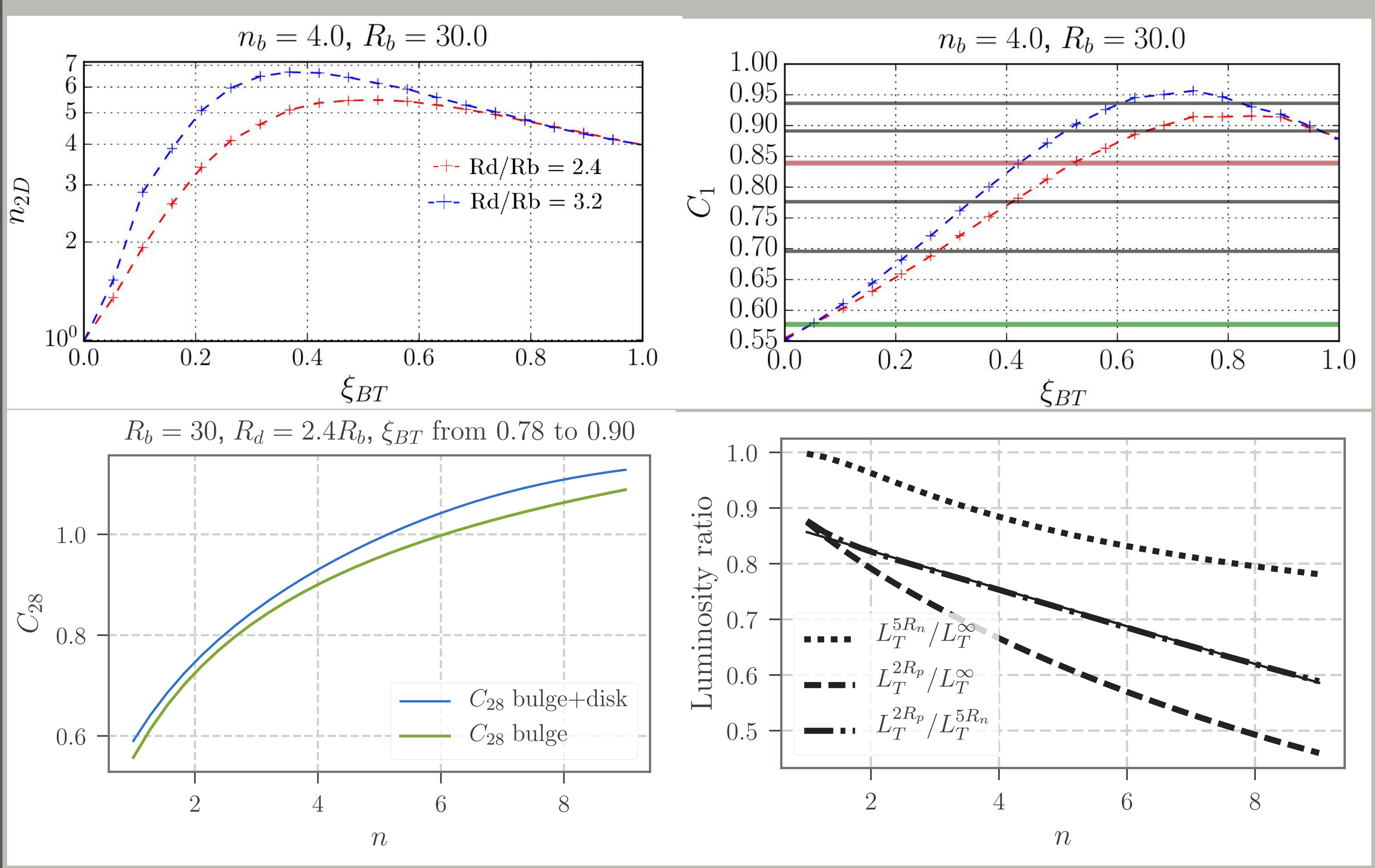
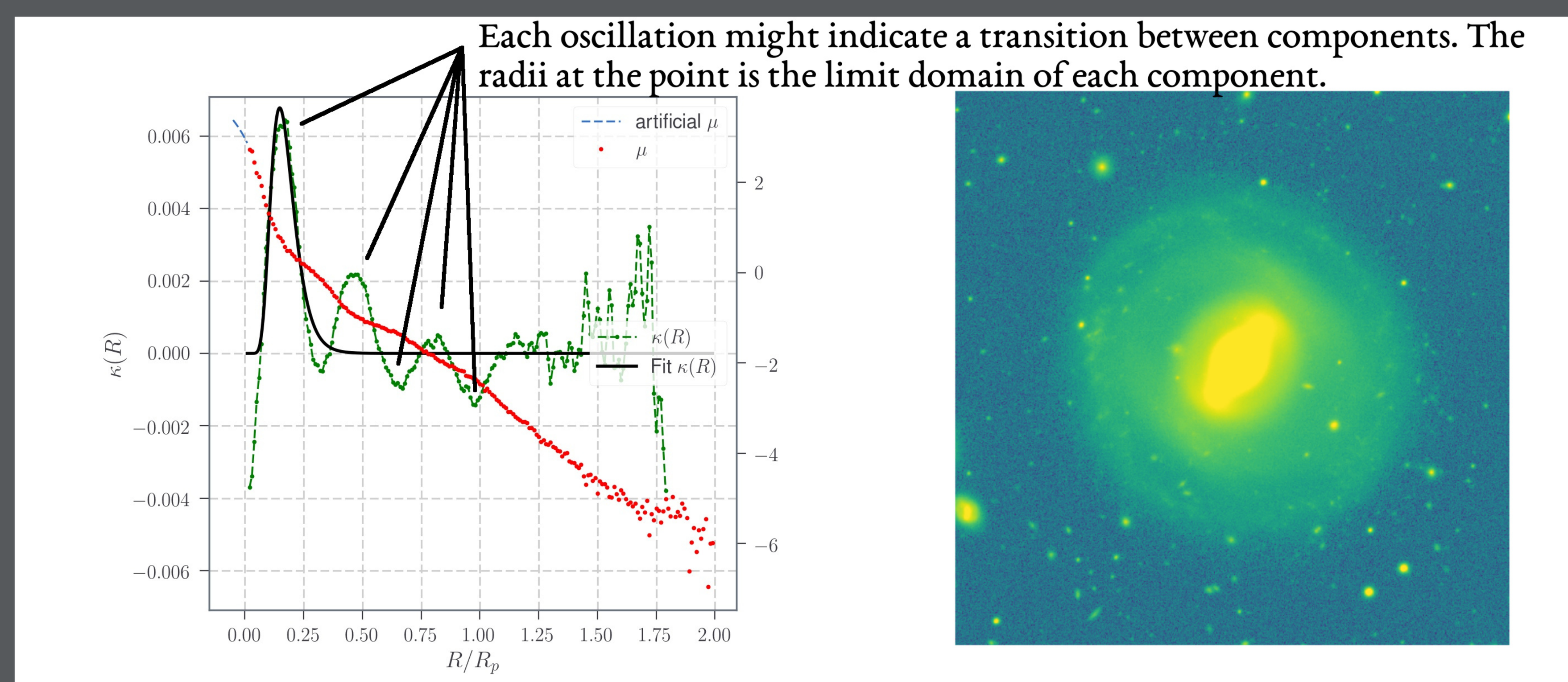


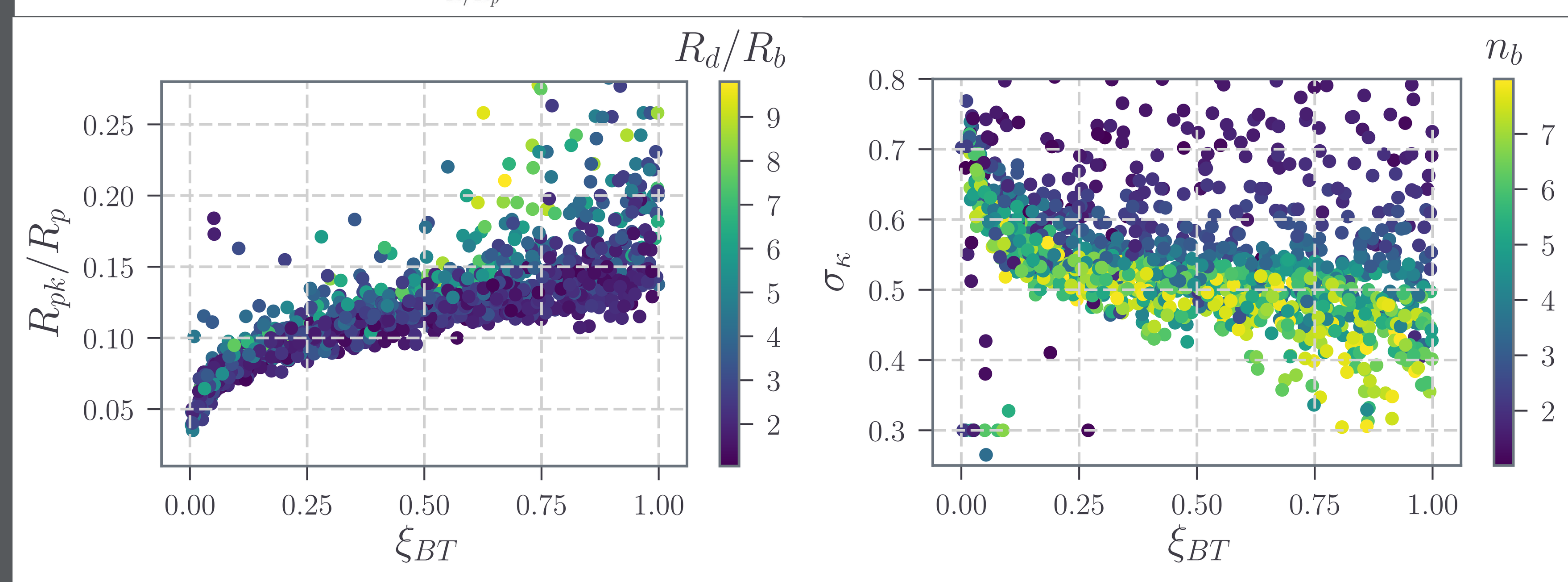
Figure: Top left: Effective Sérsic index n_{eff} refers to a galaxy fit profile $I_{eff}(R)$ that contain more than one component (in most cases two, bulge+disk, $I_D(R) + I_B(R)$). In the graph we have this fit for a range $[0, 1]$ of bulge-to-disk ratio ξ_{BT}. Note that n_{eff} can be higher than the Sérscic index of the bulge n_b (see this effect in (Gadotti, 2009)). Top-right: concentration index. In a intermediary region C is bigger than a pure bulge, multiple components acts to increase C. Bottom-left: Numerical calculation for C. Bottom-right: fraction of total luminosities calculated at different galaxy extension radial points, $L_T(5R_n)$, $L_T(2R_p)$ and $L_T(\infty)$, measuring L_T is a very sensible task because C might be strongly affected (see (Graham et al., 2005)).

Curvature $\varkappa(R)$

$$\varkappa(R) \equiv \left\{\frac{1}{I(R)}\frac{d^2I(R)}{dR^2} - \left[\frac{1}{I(R)}\frac{dI(R)}{dR}\right]^2\right\}\left\{1 + \left[\frac{1}{I(R)}\frac{dI(R)}{dR}\right]^2\right\}^{-3/2}. \qquad (1)$$

- identifies whether a galaxy is bulge or disk;
- indicates the separation region between both and/or other components;
- is related to the log-normal distribution $f(x; I_0, \sigma, \mu)$;





Conclusions and future perspectives

- concentration is a robust index however is degenerate and may misclassifying spiral galaxies as ellipticals or bulge;
- Sérsic fits should be calculated more carefully;
- $\varkappa(R)$ distinguishes bulge/ellipticals from disks/spirals;
- next steps:
  - → improve $\varkappa(R)$ calculations and automation in order to work with all peaks/valleys;
  - → apply non-extensive information theory to image processing and galaxy morphometry;

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References

Davari, R., Ho, L. C., and Peng, C. Y. (2016). On the limits of measuring the bulge and disk properties of local and high-redshift massive galaxies. *The Astrophysical Journal*, 824(2):112.

Ferrari, F., de Carvalho, R. R., and Trevisan, M. (2015). Morfometryka – A New Way of Establishing Morphological Classification of Galaxies. *The Astrophysical Journal*, 814:55.

Gadotti, D. A. (2009). Structural properties of pseudo-bulges, classical bulges and elliptical galaxies: a Sloan Digital Sky Survey perspective. *Monthly Notices of the Royal Astronomical Society*, 393:1531–1552.

Graham, A. W., Driver, S. P., Petrosian, V., Conselice, C. J., Bershady, M. A., Crawford, S. M., and Goto, T. (2005). Total Galaxy Magnitudes and Effective Radii from Petrosian Magnitudes and Radii. *The Astronomical Journal*, 130:1535–1544.

Kent, S. M. (1985). CCD surface photometry of field Galaxies. II - Bulge/disk decompositions. *Astrophysical Journal Supplement Series*, 59:115–159.

Sérsic, J. L. (1968). *Atlas de galaxias australes.*

Trujillo, I., Graham, A. W., and Caon, N. (2001). On the estimation of galaxy structural parameters: the Sérsic model. *Monthly Notices of the Royal Astronomical Society*, 326:869–876.

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