Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias, 60, 208-209, (2026)

OPEN ACCESS https://doi.org/10.22201/ia.14052059p.2026.60.181

Parametric strong-lensing analysis of a high-disturbance galaxy cluster

C. Cornil-Baïotto[1], V. Motta[1], G. Mahler[2,3,4], M. Limousin[5] and E. Jullo[5]

[1] *Instituto de Física y Astronomía, Universidad de Val- paraíso, Gran Bretaña 1111, Valparaíso 2360102, Chile.*
[2] *Institut d'Astrophysique et de Géophysique, Université de Liège, Quartier Agora, Allée du 6 Août 19c, Liège, Belgium.*
[3] *Centre for Extragalactic Astronomy, Durham University, South Road, Durham DH1 3LE, UK.*
[4] *Institute for Computational Cosmology, Durham University, South Road, Durham DH1 3LE, UK.*
[5] *Aix Marseille Université, CNRS, CNES, LAM, F-13388 Marseille, France.*

Keywords: *gravitational lensing: strong*

This contributed talk presented the method to model with Lenstool the strong lensing effect observed in the core of the massive galaxy cluster MACS J0159.0-3413 (hereafter M0159) at $z = 0.419 \pm 0.001$ (MUSE).

Strong lensing has become a prime tool for mapping the mass distribution of galaxy cluster cores. In the central regions of a galaxy cluster, the geometry of multiple-image systems and the distribution of the cluster members provide information on the priors for the matter distribution (Kneib & Natarajan, 2011). It is therefore more appropriate to use so-called parametric models.

To identify the cluster member galaxies (CMGs), a point source classification (Leauthaud et al., 2007) is done using the dual mode of the software SourceExtractor (Bertin & Arnouts, 1996) on the five HST filters of the cluster core. Then, the CMG candidates were selected by identifying the Red Sequence (RS) on a galaxy color-magnitude diagram (Gladders & Yee, 2000). CMGs are part of the RS, which has a width of (0.15 ± 0.05) mag. After a visual selection, 74 CMGs were included in the lensing potential. The lens redshift was identified from public MUSE data (ID 0100.A-0792, ESO-VLT-U4) with a M0159 BCG-centered FOV of $1' \times 1'$. Two multiple-image systems (8 multiple images) are visually identified by their color and morphology. The M0159 lens models done in this work are based on a previous model (Livermore et al., 2012), and were performed using the publicly available software lenstool (Kneib et al., 1996; Jullo et al., 2007). Image position predictions using lenstool was also done to confirm the presence of the lensed system 2 (see Fig. 1) for which we could not identify the redshift in the MUSE data.

In the lens models explored, each mass component is described by the dual Pseudo Isothermal Elliptical mass distribution (dPIE) (Limousin et al., 2005; Elíasdóttir et al., 2007):

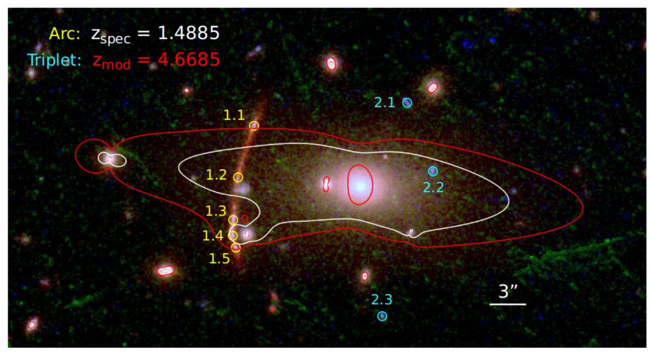

Figure 1. MACS J0159.0-3413 inner core. HST WFC3/IR F110W, F140W & F160W, and UVIS F606W & F814W. The circles show the positions of the multiple images. The white critical curve is computed at the spectroscopic redshift of the giant arc (z =1.4885, MUSE), while the redshift of the red critical line is a model's free parameter.

$$\rho(r) = \frac{\rho_0}{(1 + r^2/r_c^2)(1 + r^2/r_s^2)} \qquad (1)$$

where $\rho(r)$ describes the mass distribution of a spherical system with central mass density ρ_0, core radius r_c, and scale radius r_s. The number of free parameters is constrained by the limited number of spectroscopically-confirmed multiple images (five in this work). Thus, we cannot fit the parameters for each CMG individually. We do it instead for a typical $L^\star$ galaxy at the cluster redshift ($m_0^\star = 19.91$ in HST/WFC3 F814W), and the CMG parameters are assumed to scale relative to $L^\star$. Fig. 1 presents one of the lens models performed in this work.

We successfully map the mass distribution within the M0159 core, reproducing reasonably the observations. The model-predicted high-ellipticity of the central dark matter halo is assumed to be an artifact introduced by not

"XVII LARIM", Montevideo, Uruguay, November 27 - December 1, 2023.Volume Editors: Gonzalo Tancredi, Cecilia Mateu & Juan José Downes

considering in the models the merger-turbulence observed in optical, X-ray, and radio wavelengths (Cornil-Baïotto et al., in prep).

References

Bertin, E., & Arnouts, S. 1996, A&AS, 117, 393, doi: 10.1051/aas:1996164

Elíasdóttir, Á., Limousin, M., Richard, J., et al. 2007, arXiv e-prints, arXiv:0710.5636, doi: 10.48550/arXiv.0710.5636

Gladders, M. D., & Yee, H. K. C. 2000, AJ, 120, 2148, doi: 10.1086/301557

Jullo, E., Kneib, J.-P., Limousin, M., et al. 2007, New Journal of Physics, 9, 447, doi: 10.1088/1367-2630/9/12/447

Kneib, J.-P., Ellis, R. S., Smail, I., Couch, W. J., & Sharples, R. M. 1996, ApJ, 471, 643, doi: 10.1086/177995

Kneib, J.-P., & Natarajan, P. 2011, A&A Rev., 19, 47, doi: 10.1007/s00159-011-0047-3

Leauthaud, A., Massey, R., Kneib, J.-P., et al. 2007, ApJS, 172, 219, doi: 10.1086/516598

Limousin, M., Kneib, J.-P., & Natarajan, P. 2005, MNRAS, 356, 309, doi: 10.1111/j.1365-2966.2004.08449.x

Livermore, R. C., Jones, T., Richard, J., et al. 2012, MNRAS, 427, 688, doi: 10.1111/j.1365-2966.2012.21900.x

“XVII LARIM”, Montevideo, Uruguay, November 27 - December 1, 2023.Volume Editors: Gonzalo Tancredi, Cecilia Mateu & Juan José Downes