Preliminary Master Thesis Abstract

Revealing the Circumgalactic Medium with an Einstein Cross: A Tomographic Study of KIDS J2329

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The circumgalactic medium (CGM) plays a fundamental role in the baryon cycle, acting as the interface between inflows, outflows, and metal recycling around galaxies (Tumlinson et al., 2017; Peroux & Howk, 2020). However, its low density makes it difficult to observe directly, and most studies rely on MgII absorption detected in background sources to trace the cool gas component of the CGM. In my MSc thesis, I apply a tomographic approach developed by the **ARCTOMO** collaboration (Lopez et al., 2018, 2020) to study the cool phase of the CGM using the unique geometry of an Einstein Cross (EC) system, KIDS J232940–340922. This system consists of four images of a compact, star-forming *blue nugget* at $z_s = 1.59$, lensed by a galaxy at $z_l = 0.38$, with an intervening absorber galaxy (G1) at $z_{abs} = 1.27$. We used VLT/MUSE data cubes along with VST/OmegaCAM *gri* and Magellan/IMACS *i*-band images to study this system.

I developed a detailed model of the EC components using BUDDI, allowing me to subtract the light from the lens and isolate the spectra of both the blue nugget and the absorbing galaxy. The residuals confirm that the sources are compact and comparable to those used in quasar-based absorption studies, providing an intermediate case between quasar and arc tomography. From the MUSE data, I extracted clean spectra for the four lensed images and for G1, detecting strong MgII absorption in the blue nugget images and DtB absorption in G1. The detection of [OII] emission identifies G1 as a star-forming galaxy.

Using GALFIT and GALPAK3D, I derived G1's morphological and kinematic parameters, finding consistent results that describe a face-on disk galaxy with $n \approx 1.0$, $M_\star \approx 10^{10}\,M_\odot$, and SFR $\approx 3\,M_\odot\,\mathrm{yr}^{-1}$. These properties place it on the star-forming main sequence near the cosmic noon. The MgII equivalent widths range from 1–2 Å, with impact parameters between 10–30 kpc, probing the inner CGM. These values are consistent with previous quasar and lensing studies (Chen et al., 2014; Nielsen et al., 2018; Tejos et al., 2021). Analysis of fractional EW differences shows that the absorbing gas is relatively homogeneous at these small scales, in agreement with previous studies based on quads (Rubin et al., 2018; Okoshi et al., 2021).

Finally, I built an extended rotating disk (ERD) model using the [OII] kinematics to compare with the MgII absorption velocities. The model reproduces the observed trends, suggesting that the cool CGM gas is co-rotating with the galaxy's ISM, while the detected DtB absorption may trace outflowing gas. The remaining discrepancies can be attributed to model uncertainties. These results establish KIDS J2329 as a key system bridging quasar and arc tomography, offering new insights into the structure and kinematics of the cool CGM at $z \approx 1.3$, and highlighting the potential of this type of objects for extended mapping of the spatial distribution of the gas.

References

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