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MUSE-DARK: Dark matter halo properties of intermediate-z star-forming galaxies

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Disk-halo decompositions of star-forming galaxies (SFGs) at redshifts $z > 1$ typically focus on massive galaxies with stellar masses exceeding log(M⊠/M⊠) > 10.
In this study, we analyse the dark matter (DM) halo properties of 127 intermediate-redshift ($0.3 < z < 1.5$) SFGs down to low stellar masses (7 < log(M⊠/M⊠) < 11). To do so, we use integral field unit observations from the MUSE Hubble Ultra Deep Field Survey, as well as photometry from the Hubble Space Telescope and James Webb Space Telescope.
We employ a 3D forward modelling approach to analyse the morpho-kinematics of our sample, enabling us to measure individual rotation curves extended up to 2 − 3 times the effective radii. We performed a disk-halo decomposition with a 3D parametric model, which includes stellar, DM and gas components, as well as corrections for pressure support. Our methodology was validated using mock data cubes generated from idealised disk simulations. The DM halo was parameterised using six different density profiles, including the Navarro-Frenk-White, and the generalised profile of Di Cintio et al. (2014) (DC14). We use a Bayesian model comparison to select the best-fitting model.
Our Bayesian analysis suggests that the mass-dependent density profile of DC14, which accounts for the response of DM to baryonic processes such as stellar feedback, performs as well as or better than the other six halo models in ⊠ 65% of the sample. We performed consistency checks for DC14 and found that the stellar masses obtained from the disk-halo decomposition agree with the values inferred from the spectral energy distributions, and the recovered DM inner slopes, γ, agree with the theoretical expectations. For 72% of the SFGs, we infer $\gamma < 0.5$, indicating cored DM density profiles, however, we do not find any correlation between γ and the star-forming activity of the sample. We find that 89% of the galaxies have DM fractions larger than 50%, similar to what is observed in the local universe. The stellar–halo mass and concentration-halo –halo mass relations inferred from our 3D modelling align well with the theoretical expectations, but with larger scatter. Our results confirm the anticorrelation between the halo scale radius and DM density with a slope of ~ −1. We find tentative evidence of an evolution of the DM density with z, which suggests that the DM halos of $z \sim 0.85$ systems are denser than those of their local counterparts. In contrast, the halo scale radii are z-invariant. For the first time, we explore the Radial Acceleration Relation (RAR) at intermediate redshifts and uncover an offset from the $z = 0$ relation, with an a_0 value higher than that inferred for the local SPARC sample. Therefore, our results suggest that the RAR evolves with redshift, which is in qualitatively good agreement with ΛCDM simulations. Furthermore, an examination of individual RAR tracks uncovers a non-monotonic relationship between a_tot(r) and a_bar(r), which Modified Newtonian Dynamics theories do not predict, but which naturally arises in ΛCDM. Specifically, galaxies with cored dark matter density profiles exhibit downward-bending "hooks," while those with cuspy profiles display upward-bending "hooks".
In conclusion, our results support baryonic feedback-induced core formation in the context of ΛCDM.

Author: CIOCAN, Bianca-Iulia (Centre de recherche astrophysique de Lyon (CRAL))

Presenter: CIOCAN, Bianca-Iulia (Centre de recherche astrophysique de Lyon (CRAL))

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