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Dark matter distribution in Milky Way-analog galaxies

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In this work, we combine HI spectroscopy with mid-infrared (mid-IR) imaging to investigate the dark matter (DM) distribution within Milky Way-analog galaxies. For that, our methods revolve in a three-dimensional dynamical modeling of atomic hydrogen (HI) data cubes to construct HI rotation curves (RC) and analyze the spatial distribution of the DM component. We then use an MCMC-based approach to separate the DM contribution and estimate the local DM density – an important value for DM direct detection experiments.

Our current understanding of how DM is distributed within the Milky Way (MW) halo, particularly in the solar neighborhood, is based on either careful studies of the local stellar orbits, model assumptions on the global shape of the MW halo, or from direct acceleration measurements. We here set out to use external galaxies in an attempt to go around some of these challenges.

Our MW-analog sample is comprised of 5 galaxies. Our galaxies were selected based on their HI velocity (200-280 km s^{-1}), morphology (typical Hubble T-type in the range of 2.0–3.0) and inclination ($35° < i < 75°$). We build RCs for each galaxy in our sample based on publicly available HI data from the THINGS and VIVA surveys (Walter et al., 2008; Chung et al., 2009) by using the three-dimentional dynamical modeling ^{3D}BAROLO (Di Teodoro & Fraternali, 2015). Our ^{3D}BAROLO run takes as free parameters the RC, velocity dispersion and position angle along the galaxy. With the aim of analyzing separately the DM and baryonic components, we further exploit available mid-IR data from the S^4G survey (Sheth et al., 2010). To separate the DM contribution from the RC and estimate the DM halo mass, M_{200}, and the halo concentration, c, we

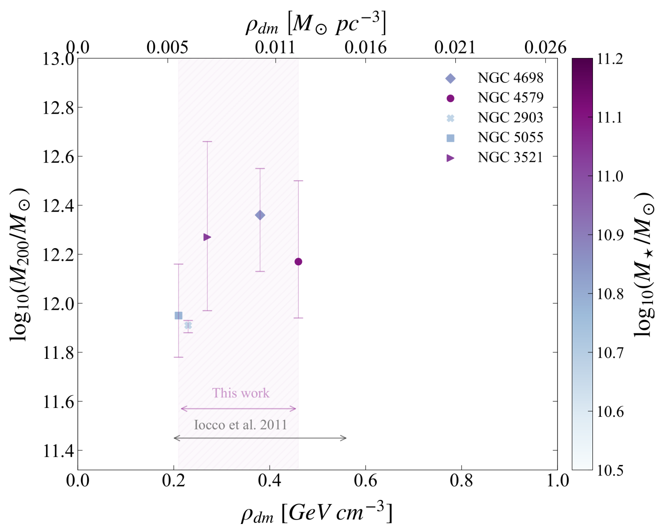

Figure 1. DM density estimates at the corresponding Sun's location (r/R_{25}=0.6) for our MW-analog sample. The error bars correspond to the 16th and 84th percentiles of the probability distribution function. Galaxies are colour-coded by their stellar mass. A complete description of this figure can be found in Gomes-Oliveira et al. (2023).

use an MCMC routine in PYTHON using 50 walkers and 30 000 iterations for each run.

We measure the DM density at $r/R_{25} \sim 0.6$ (corresponding position of the solar neighborhood in external galaxies) for each galaxy in our sample. With values in the range of 0.21–0.46 GeV cm^{-3}, our estimates for the local DM density (ρ_{dm}) are in agreement with those from previous works in the literature with a focus on MW (see Table 3 of Gomes-Oliveira et al. (2023)). We show these values in Figure 1 as a function of the host DM halo masses.

By drawing a parallel with our own MW, this distinct approach based on external galaxies provides a potentially useful insight to the range of valid values for the local DM density. For a detailed look at this and other relevant results, we encourage readers to take a deeper look at Gomes-Oliveira et al. (2023).

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