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STUDYING THE GAS CONTENT OF LOW SURFACE BRIGHTNESS GALAXIES

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Abstract. In this contribution, we present some preliminary results about the Meerkat HI profile of a diffuse galaxy undergoing ram-pressure stripping in the Virgo cluster. We discuss the importance of HI observations to constrain the evolution of such galaxies, but also to discover new giant low surface brightness gas disks.

Keywords: galaxies

1 Introduction

Low Surface Brightness Galaxies (LSBs) have been gaining a strong interest in the last years, notably with the coining of the term "Ultra Diffuse Galaxies" (UDGs) by van Dokkum et al. (2015), followed by the finding of many such galaxies in clusters (e.g. Koda et al. 2015). They have joined a rich population of galaxies with central surface brightness well below the canonical value 21.65 mag arcsec^{-2} of Freeman (1970), including "giant LSBs". Giant LSBs are defined by Sprayberry et al. (1995) as large disk galaxies, with a larger "diffuseness" (combining central surface brightness and radial scale length) than "regular" galaxies. Giant LSBs are often also defined with additional criteria on their size or mass (Saburova et al. 2023; Zhu et al. 2023). Extended UV galaxies (XUVs) are also galaxies with faint surface brightness extended disk but found at ultraviolet (UV) wavelengths. Bernaud et al. (2025) showed that while some XUVs are also diffuse when observed at the optical wavelengths, they represent a very mixed bag.

With Rubin, and Euclid, stellar populations are becoming visible at faint surface brightness for an extremely large number of galaxies. However, a crucial piece of information concerning the evolution of such galaxies is their gas content. Giant LSBs have been found to be extremely massive in HI (Matthews et al. 2001; Pickering et al. 1997; Lelli et al. 2010). UDGs are usually gas-poor in clusters but the existence of blue, gas-rich UDGs has also been confirmed (Leisman et al. 2017; Prole et al. 2020).

In the following, we comment on the information gained from the study of the gas of UDGs and GLSBs, before discussing the progresses that can be expected from SKAO in the future.

2 Meerkat observations of a diffuse galaxy

The Virgo cluster has been extensively studied at many wavelengths. Among the most recent data set, a noticeable one is the HI-blind survey performed with Meerkat (de Gasperin et al. 2025). While lots of science cases can be pursued with such data, we focus here on a HI detection (preliminary data) in a diffuse galaxy that may be undergoing ram-pressure according to the study of multi-wavelength profiles (u,g,r,i,z,FUV,NUV,Hα) by Junais et al. (2022).

We show in Fig 1-left the HI contours on top of a NGVS composite. The model of Junais et al. (2022) for this galaxy predicted a low amount of gas, as Ram Pressure Stripping (RPS) has already removed a significant part of the gas (Fig. 1-right). In comparison, the amount of observed gas is larger than in this model (but lower than the model for the same galaxy in the absence of RPS).

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This underlines the importance of gas constraints for such studies, as it might indicate that the RPS in this case has not been as efficient as in the models, or that the RPS event is only beginning, and the age derived from the previous profiles is inexact. This will be investigated by constraining the models by including the final HI profile. In a next phase, we will also investigate the gas properties (or upper limits) with these data for all the galaxies studied by Junais et al. (2022) on the basis of the stellar and Hα emission.

3 The gas in giant disks

Early on, HI measurements have played an important role in investigating the rotation curve of galaxies, and in giant LSBs in particular (Matthews et al. 2001; Pickering et al. 1997; Lelli et al. 2010). The Gas content is also paramount to know how efficient is star formation in the outer very diffuse regions (see Junais et al. 2024, using MUSE to trace star formation in Malin 1). However, the data for giant LSBs are limited in number and relatively old (limited in resolution and sensitivity). We stress the importance to re-observe such galaxies with modern facilities. Such data will help us to constrain their dark matter content, dynamics, star formation efficiency, and the environment of such galaxies with its possible role in shaping these extremely large galaxies.

4 Perspectives with SKAO

For both diffuse galaxies, and massive giant LSBs, SKA will bring invaluable information. For diffuse galaxies, Junais et al. (2022) predicted gas masses around 10^6 $M_\odot$ or 10^9 $M_\odot$ depending if UDGs have or have not undergone RPS. The surveys performed with SKA could detect the field UDGs (not having undergone RPS) up to redshift 0.2 or so. They will provide upper limits for the nearby cluster gas-poor UDGs or detect the remaining gas for those that only started the interaction.

For giant discs, the prospects are even more amazing. Recently O'Neil et al. (2024) found in the nearby universe a massive (10^9 $M_\odot$) HI disk without any known stellar counterparts by looking at a random place in the sky*. Performing blind surveys with SKAO will allow the discovery of new galaxies detected from their gas content. Giant LSBs similar to Malin 1 will be found up to redshift 1, and a 10^9 $M_\odot$ disk similar to the one found by chance and by O'Neil et al. (2024) will be detectable at redshift 0.2 (Acero et al. 2017).

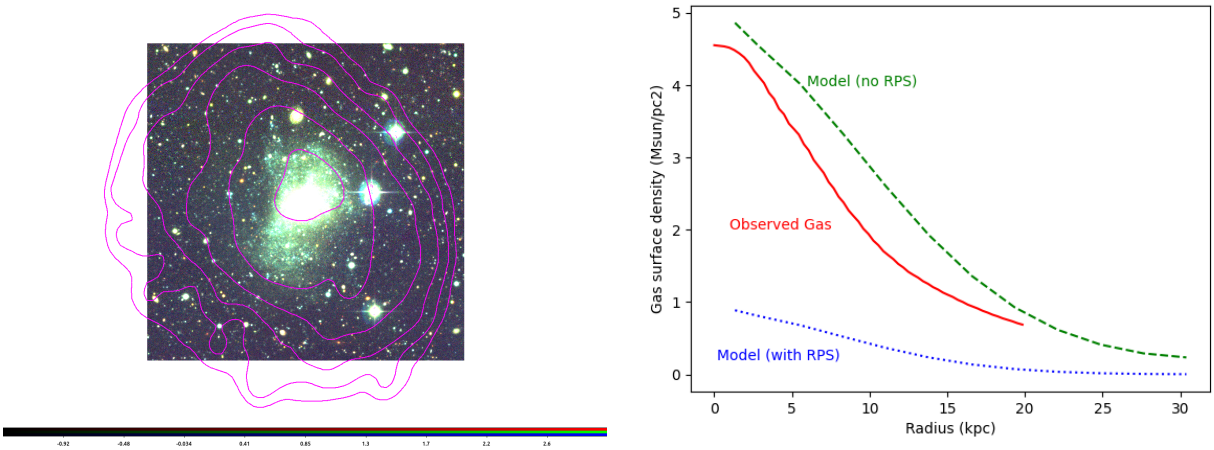

Fig. 1. Left: Meerkcat HI contours (preliminary) on top of NGVS image. Levels are corresponding to HI densities of 0,25 to 8 $M_\odot$ pc^{-2}, doubling between each contours inwards (not corrected for inclination). **Right:** Gas profile (in red, preliminary, corrected for inclination and for the He contribution). The dashed green (dotted blue) lines show the model predictions of Junais et al. (2022) without (and with) ram pressure, convolved at the resolution of the observations.

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*I apologize for the illustration of the work of Karen O'Neil with a picture of totally unrelated Jack O'Neill during the conference.

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