First Mass Model of ESO 418- G 006 using MeerKAT HI Line Observations

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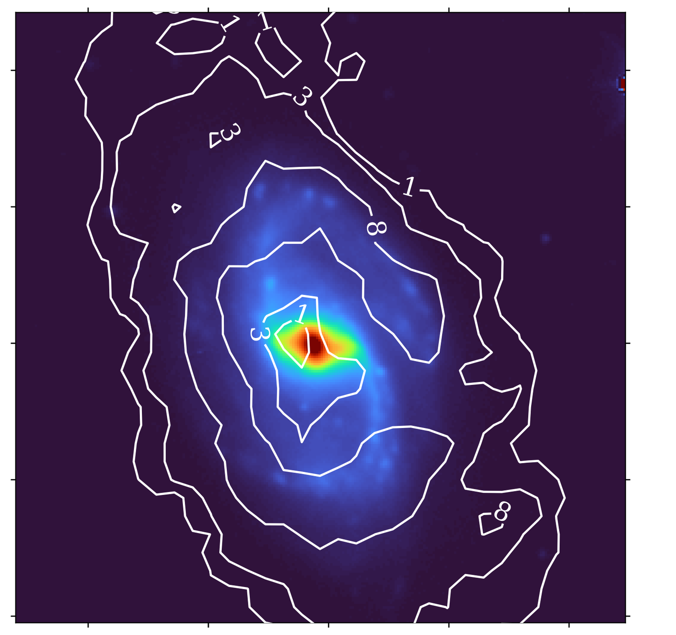

1. Introduction

This work aims to generate a dynamical mass model of galaxy ESO 418- G 006 ($z = 0.0379$) and thus constrain the radial distribution properties of its dark matter (DM) content..

The LADUMA [1] L band detection of this galaxy constitutes its first HI interferometric observation.

Since HI is an excellent tracer of a galaxy's gravitational potential, observations of the HI emission line enable us to derive rotation curves out to very large radii [2].

Moreover, these rotation curves can be used as a direct tool for constraining a galaxy's mass distribution - far beyond the edge of its stellar disk.

The data used in this study of ESO 418- G 006 is in the form of an HI data cube. This data cube has a spatial resolution of 10" and a spatial resolution of ~ 22 km.s^{-1} The various data products produced from this cube are displayed in Figure 1.

The optical i-band image of this galaxy, obtained from DECaLS, is used to supplement the HI data. This image is displayed in the top right of the poster.

2. Methodology

At a given galactocentric radius R , the total rotation velocity of the galaxy (V_{obs}) is determined by the gravitational contribution from the galaxy's various mass components:

$$V^2_{obs}(R) = V^2_{gas}(R) + V^2_{disk}(R) + V^2_{bulge}(R) + V^2_{DM}(R)$$

We use ^{3D}Barolo [2] to fit tilted-ring models [3] to the HI data cube of this galaxy and thus obtain a measurement of V_{obs}.

^{3D}Barolo replicates the input HI data cube and produces a model version of it. Comparing the input data cube to the model cube (Figure 2) indicates how well the tilted-ring model has been fitted.

The baryonic contribution (gas, stellar disk and stellar bulge) to V_{obs} can then be calculated from the HI total intensity map (Panel 1 of Figure 1) and optical image respectively and subtracted from V_{obs} . In this way, the DM contribution to the total rotation velocity can be obtained.

3. HI Data Products

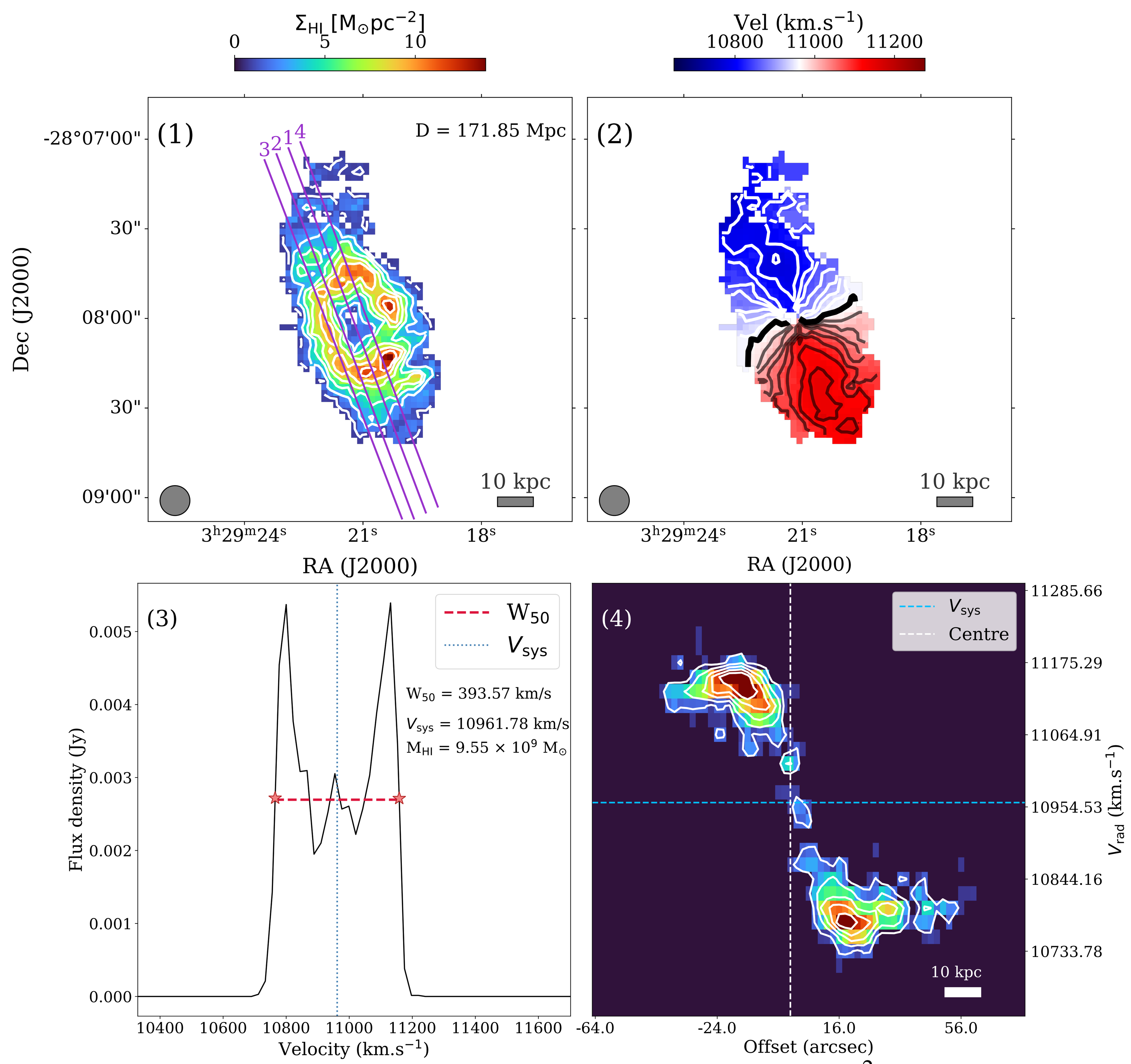

Figure 1: **Panel 1**: HI total intensity map (mom0) - down to a level of 1M$_\odot$pc^{-2}. This map indicates that this galaxy contains an HI hole in its centre. The purple diagonal lines numbered 1-4 indicate the positions at which the position-velocity (p-v) slices displayed in Figure 2, are extracted. **Panel 2**: Intensity-weighted mean velocity field (mom1). This map shows the galaxy to be in regular circular rotation. **Panel 3**: HI global profile. This profile exhibits the double-horned shape, typical of spiral galaxies. **Panel 4**: Major-axis p-v slice. The position at which this slice is extracted is indicated by purple line 1 from Panel 1. This slice also shows that this galaxy exhibits regular rotation with no clear sign of anomalous kinematics.

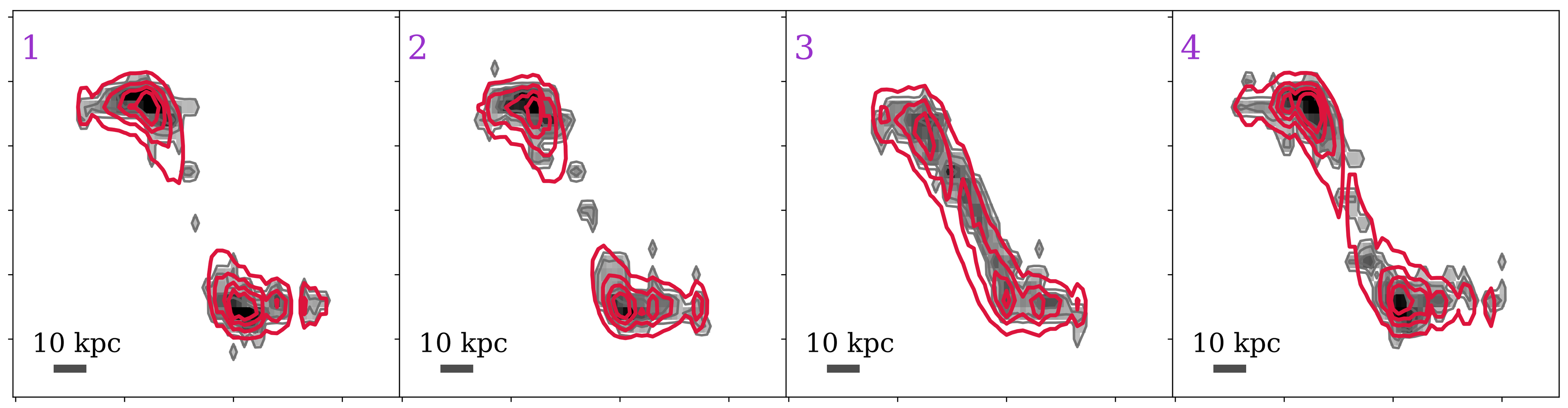

Figure 2: The p-v slices of the input HI data cube of ESO 418- G 006 overlaid with the contours of the model p-v slices - shown in red. These slices are extracted parallel to the major axis of this galaxy - indicated by the purple diagonal lines in Figure 1. From this comparison it is evident that the ^{3D}Barolo model matches the data well - indicating that the tilted-ring fit from which we obtain V_{obs}, can be regarded as reliable.

4. Results

V_{obs} (Figure 3) is found to be declining, which is unusual for spiral galaxies, such as this one.

The DM halo of a galaxy is known to be described by two well known contrasting profiles: pseudo isothermal (ISO) sphere & NFW.

ISO: suggests that the DM halo consists of a constant mass-density inner core. NFW: mass density sharply increases towards the centre of the DM halo, giving rise to a cusp

We fit both of these profiles to V_{DM}. In doing so we find that the ISO profile best describes the DM halo of ESO 418- G 006.

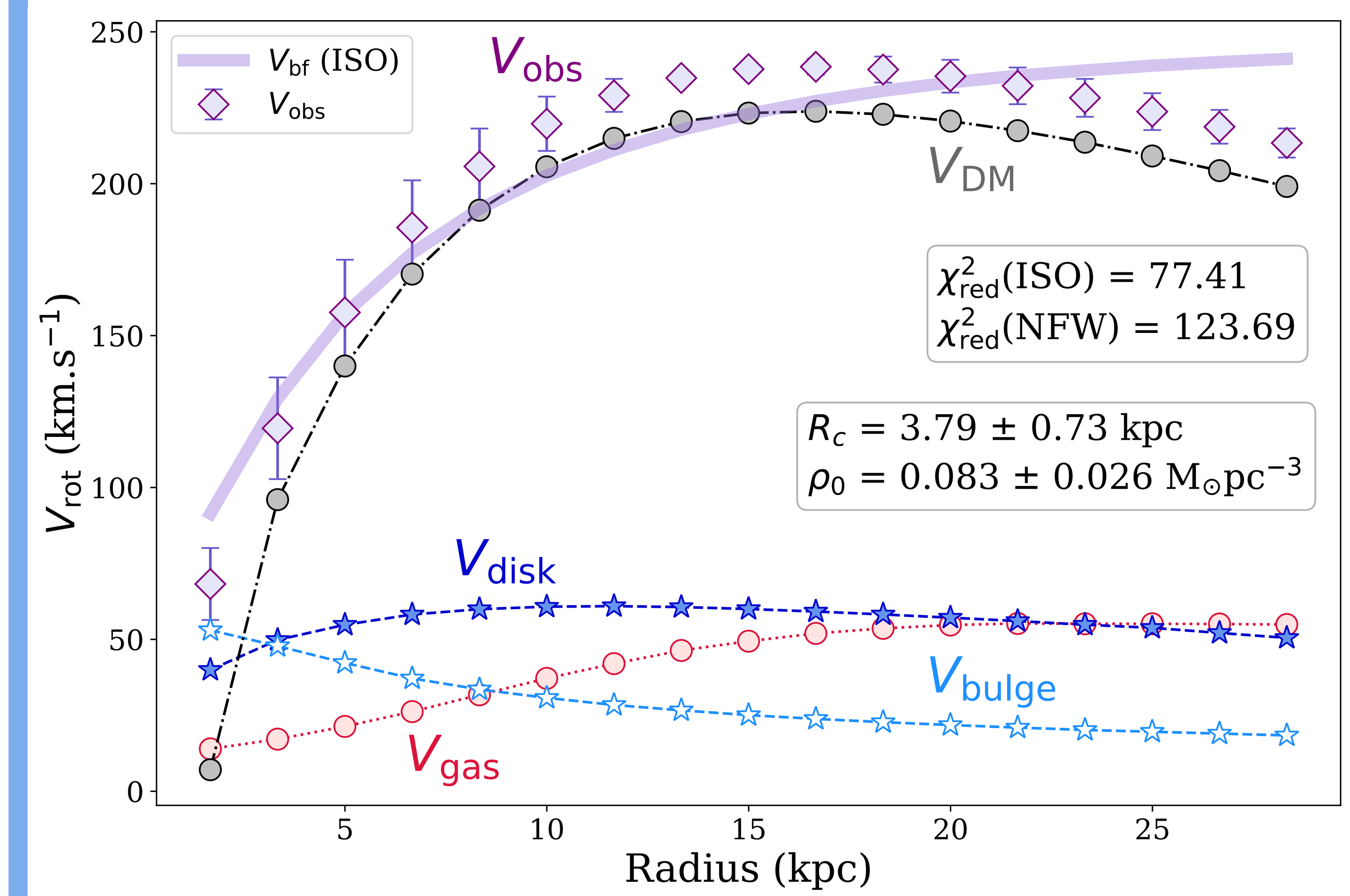

Figure 3: The resulting mass-model of ESO 418- G 006 . The thick purple line indicates the best-fit rotation velocities (V_{bf}) resulting from the sum of the rotation velocities of the baryonic component and the rotation velocities of the fitted ISO halo model to V_{DM}. The NFW counterpart is excluded here for the sake of clarity. The χ^2_{red} values, resulting from the comparison of V_{obs} to V_{bf}, indicate that the DM halo of this galaxy is more likely to consist of an inner-density core, rather than a so-called cusp. The high χ^2_{red} values are due to both ISO and NFW profiles failing to fit V_{DM} well at large radii. This is because V_{DM} decreases at large radii, mirroring the decline observed in V_{obs}. The best-fit values of the core radius (R_c) and core density (ρ_0) of this ISO model are displayed in the figure.

References

[1] Blyth, S., et al. (2016). *Proceedings of Science*
[2] Di Teodoro, E.M. and Fraternali, F. (2015). *MNRAS*, 451(3):3021-3033.
[3] Rogstad, D., et al. (1974). ApJ, 193: 309-319