SF2A 2008
C. Charbonnel, F. Combes and R. Samadi (eds)

HI KINEMATICS AND DYNAMICS OF M31

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Abstract. We report on final results from recent deep HI observations of M31 obtained with the DRAO aperture synthesis telescope. Many emission lines can be detected along the line-of-sights. The total HI mass is composed by about 70% of a main spectral component attributed to the thin HI disc and 30% of an additional component, Part of this latter additional emission ($\sim$ 70%) is due to a newly discovered gas component, which we refer to as an "anomalous" component similar to the one observed in a few other galaxies. The gas distribution, warp parameters and rotation curve are presented, as well as results from mass distribution models of the rotation curve of M31.

1 Introduction

Mapping the neutral hydrogen in Local Group galaxies is never easy due to the extreme proximity of the galaxies. The main problems are caused by the contamination by the Milky-Way HI and by the difficulty to obtain many field-of-views on telescopes to fully map the galaxies. Nevertheless, the large field-of view, high sensitivity and spectral resolution of the DRAO synthesis telescope are used to obtain the most extended and deepest HI gas distribution of M31.

2 Results

The main results from this HI study of M31 which total integrated emission is shown in Figure 1 can be summarized as follows.

- A large fraction of the field-of-view is filled by several emission lines. Up to five lines can be detected in some spectra, which is more than the two usually known in M31. Two lines are detected in $\sim$65% of the spectra, three lines in $\sim$32% of them, four lines in $\sim$11% of them and five lines in $\sim$2% of them.
- The total HI mass of M31 is 5.1×10^9 $\mathcal{M}_\odot$. The thin HI disc traced by the brightest main spectral component contains 70% of this mass.
- The rotation curve is peculiar, admitting a central velocity dip at 5 kpc in the inner HI ring, two distinct flat parts, the first one at 265 km s^{-1} in the outer HI ring and extending over $\sim$ 9 kpc and the second one at $\sim$ 222 km s^{-1} in the outer disc and extending over $\sim$ 7 kpc (Fig. 1). Except in the perturbed region around $R = 5$ kpc, the axisymmetry of the gas rotation is very good between the two disc halves so that the velocity uncertainties are mostly below 10 km s^{-1}.
- The warp parameters are derived up to 33 kpc. The kinematical major axis is observed to continuously twist as a function of radius from $R = 19$ kpc while the inclination roughly remains constant throughout the HI disc at an average value of $75^{\text{o}} \pm 3^{\text{o}}$.

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- Though its effects in the datacube are spectacular by causing duplicated emission lines, the warp of M31 is thus not strong, contrary to what has been thought for a long time. The wiggles in the inclination profile arising at $R \sim 26$ kpc are fully responsible of the creation of part of the multiple emission lines. The mass attributed to the duplicated emission by the disc warping is small, probably at most $\sim 10\%$ of the total HI mass.

- The remaining 30% of the total HI mass enclosed in all other spectral lines than the rotating disc is thus made of $\sim 30\%$ from the warp contamination and $\sim 70\%$ from additional mechanisms. The latter "anomalous" gas component may have internal (expanding gas clouds in star forming regions) and/or external (extraplanar HI halo, intermediate or high velocity clouds) origins. No forbidden velocities are detected in the datacube, implying that if gas accretion occurs in M31 from extraplanar sources, it is not done from apparent counter-rotating orbits.

- A tight relationship is shown between HI structures and diffuse stellar structures (evidenced in Ibata et al. 2007), the G1 clump and the HI "loop" at the extremity of the SW approaching half. The HI kinematics indicates that the loop is bound to the disc, probably suggesting that the G1 clump is also bound to the disc. To the North-East, a relation between HI spurs and the NE stellar clump is also evidenced.

- Mass-model fittings of the rotation curve are made complicated due to the peculiar shape of the rotation curve. The central dip cannot be modelled in any fittings. The HI data seem to rule out the "universal" Navarro-Frenk-White cusp, which barely coexists with the bulge potential. The best fitted halo shape is for core-dominated or ΛCDM Einasto halos, thus for a constant or slowly decreasing inner mass density profile (Fig. 1).

- A dynamical mass of $\mathcal{M}_{\rm Dyn} = (3.2 \pm 0.3) \times 10^{11}\ \mathcal{M}_\odot$ enclosed within a radius of 33 kpc is derived. An extrapolation to the virial radius of 190 kpc leads to a total mass of $\mathcal{M}_{\rm Vir} \sim 5.0 \times 10^{11}\ \mathcal{M}_\odot$ for M31.

The results and analysis will be presented in Chemin, Carignan & Foster (2008).

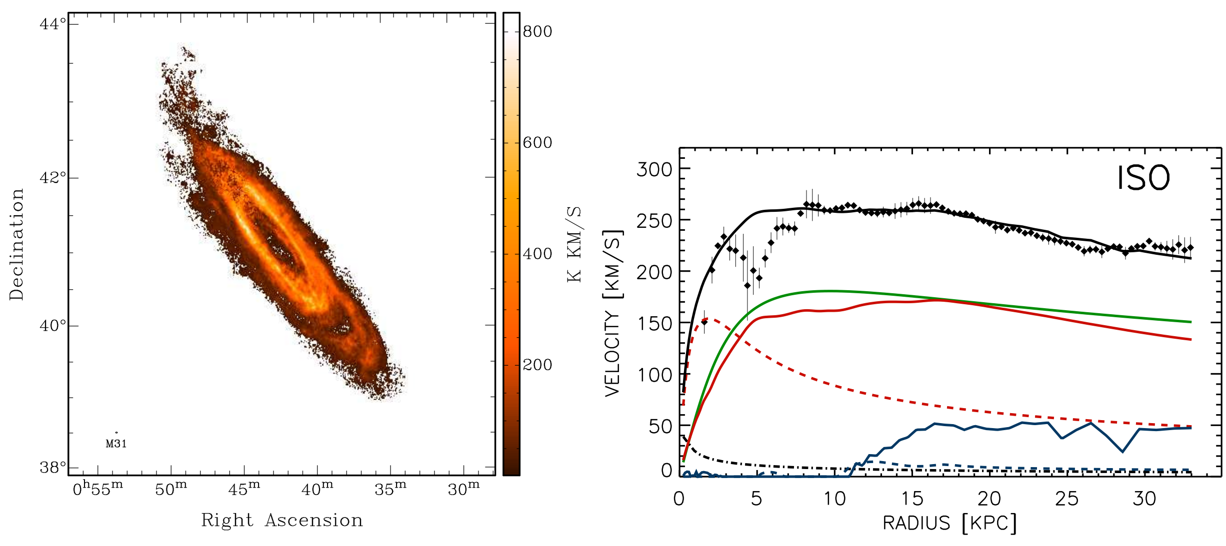

Fig. 1. Total integrated HI emission of M31 (left) and mass distribution models of the M31 HI rotation curve (right). A black dashed-dotted line is for the black hole contribution, blue lines for the neutral and molecular gaseous discs, red lines for the stellar disc and bulge, a green line for the dark matter halo and a black solid line for the overall model.

References

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