The WSRT HALOGAS Survey: HI Observations of NGC 5055

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Introduction

We present deep neutral hydrogen observations of the nearby spiral galaxy NGC 5055 as part of the Westerbork Hydrogen Accretion in Local Galaxies (HALOGAS) survey currently being performed with the Westerbork Synthesis Radio Telescope (WSRT). See Heald et al. (2011) for a comprehensive overview of the HALOGAS survey.

The galaxy NGC 5055 is a moderately-inclined SAbc galaxy with a large pronounced warp of the extended gaseous disk and a declining rotation curve outside of the optical radius. We present an analysis of new HI data for this galaxy based on modeling of the 3-D HI distribution and kinematics. We also discuss the relation between star formation in the faint outer disk by comparison of the HI with GALEX.

Data and Observations

Figures 1 and 2 show moment maps for the HALOGAS 10×12 hrs observations of NGC 5055. The deepest contour for the moment-0 map corresponds to a column density of 7.8×10^{19} cm^{-2}. The rms noise for these data is 0.16 mJy beam^{-1}, meaning the data is sensitive to a column density of 2.4×10^{19} cm^{-2} at the 3σ level.

We estimate the total HI mass of NGC 5055 corrected for primary beam attenuation to be ~8.5×10^{10} M_☉, assuming a distance of 8.5 Mpc. This is consistent with previous results of Battaglia et al. (2006) and Bosma (1978), corrected for distance.

Discussion

Previously undetected HI clouds providing possible evidence for accretion are encircled in Figures 1 and 2 and in individual channel maps in Figure 3. To the south is a large (~320×13 kpc) filament of mass ~2.7×10^{10} M_☉. To the east are HI clouds suggesting a possible interaction with the galaxy UGC 8365, which was not seen in previous surveys.

Below, Figure 4 shows some anomalous velocity HI in the inner parts of the galaxy, lagging closer to the systemic velocity. This "bead" may signify gas above or below the disk that is rotating more slowly than the disk, as seen in the PV diagrams of, for example, NGC 2403 (Fraternali et al. 2002).

Modeling

We used a tilted-ring modeling software program based on the Groningen Image Processing System (GIPSY) to model the HI. We fit for angle, inclination, rotation velocity, and column density in 40 concentric rings of width 29"=1.2 kpc using the moment maps shown in Figures 1 and 2, and then made adjustments to the model by visual inspection. Figures 5 and 6 show the moment maps for a preliminary model with the same contours as for the data. At a distance of 8.5 Mpc, our model extends to a radius of ~48 kpc.

NGC 5055 has a prototypical Type-I XUV (extended UV) disk (Thilker et al. 2007), with concentrated UV-brightness complexes beyond the radius of expected star formation. The UV emission follows the dense HI gas arms in the disk, however we do not see UV emission in all regions of dense HI. We also do not see UV emission in the outermost HI filaments.

Conclusions

In our new data of the HI for NGC 5055, we find that the HI disk extends to ~48 kpc from the galaxy center, nearly 3.5 R_25. Our preliminary warped disk tilted-ring model nicely explains most features, but there are HI clouds and filaments that cannot be explained by the modeling pointing to a possible external origin. We also find a stream of clouds that may be evidence for an interaction with the galaxy UGC 8365.

Our future work includes a further exploration of the HI model, including the addition of a lagging halo and an in-depth look at the correlation between the HI and the outer disk star formation.

References


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for the data (left) and model (right). In the data, the moving left (left half) shows HI at lower velocities and the approaching (right) half shows HI at higher velocities. This may indicate a lagging halo. Adding a lag term to the model may be an improvement.
The WSRT HALOGAS Survey: HI Observations of NGC 4258

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Introduction
In this slide we present an initial model for the neutral hydrogen disk of NGC 4258 based on preliminary HALOGAS survey 4x12 hr data. We follow the same method as described in the previous slide.

The galaxy NGC 4258 (also M106) is a moderately inclined SABbc galaxy with a star formation rate of \(1.7 \text{ M}_\odot \text{yr}^{-1}\). We adopt a distance of 7.6 Mpc. NGC 4258 has the unique characteristic of having anomalous spiral arms seen in both x-ray and radio continuum (blue and purple in the image below).

Data and Observation
Figures 1 and 2 show moment maps for the HALOGAS 4x12 hrs observations of NGC 4258. The deepest contour for the moment-0 map corresponds to a column density of \(3 \times 10^{20} \text{cm}^{-2}\). The full data set should be sensitive down to \(\sim 10^{18} \text{cm}^{-2}\).

We estimate the total HI mass of NGC 4258 corrected for primary beam attenuation to be \(6.5 \times 10^9 \text{M}_\odot\), assuming a distance of 7.6 Mpc. This is consistent with previous results of van Albada (1980), corrected for distance.

Discussion
These observations show an HI cloud to the north of the galaxy, encircled in the moment maps and shown in the corresponding channel maps of Figure 3. At \(\approx 850 \text{km/s}\), also interesting is the large HI filament extending from the southeastern end of the galaxy to the north. Below Figure 4 shows some anomalous velocity HI, lagging closer to the systemic velocity, a beard similar to that of NGC 5055 shown in the previous slide. The beard gas is prevalent enough to have caused an offset in our derived rotation velocity input for the preliminary model. It is likely that this model would be improved with a simpler rotation curve and the possible addition of a vertical decrease in velocity.

Conclusions
This first model, though not without obvious problems, is a good representation of the main features of NGC 4258. The full observations (10x12 hrs) will push the sensitivity down two orders of magnitude in column density. It will be interesting to see whether more HI clouds and filaments will become obvious.

Our main goal in improving the model will be to address the asymmetries in the data and see whether or not this can be recreated in an improved model.

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References