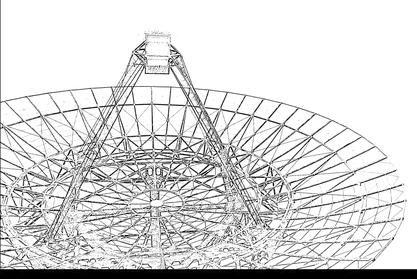

The WSRT HALOGAS Survey: HI Observations of NGC 5055

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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 **P246.19 (Heald et al.)** 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.

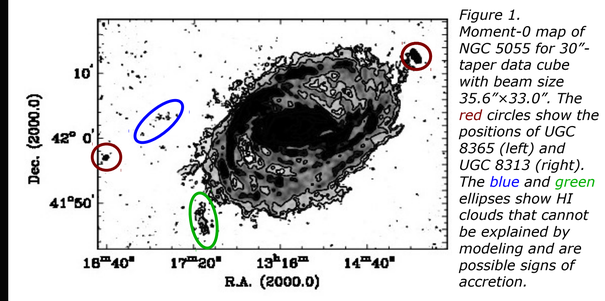


Figure 1. Moment-0 map of NGC 5055 for 30"-taper data cube with beam size 35.6"×33.0". The red circles show the positions of UGC 8365 (left) and UGC 8313 (right). The blue and green ellipses show HI clouds that cannot be explained by modeling and are possible signs of accretion.

Contours: 1.9x2ⁿ mJy/beam

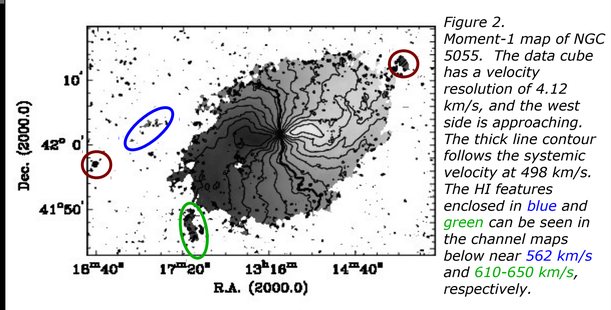


Figure 2. Moment-1 map of NGC 5055. The data cube has a velocity resolution of 4.12 km/s, and the west side is approaching. The thick line contour follows the systemic velocity at 498 km/s. The HI features enclosed in blue and green can be seen in the channel maps below near 562 km/s and 610-650 km/s, respectively.

Contours: Δ30 km/s from 270 to 780 km/s

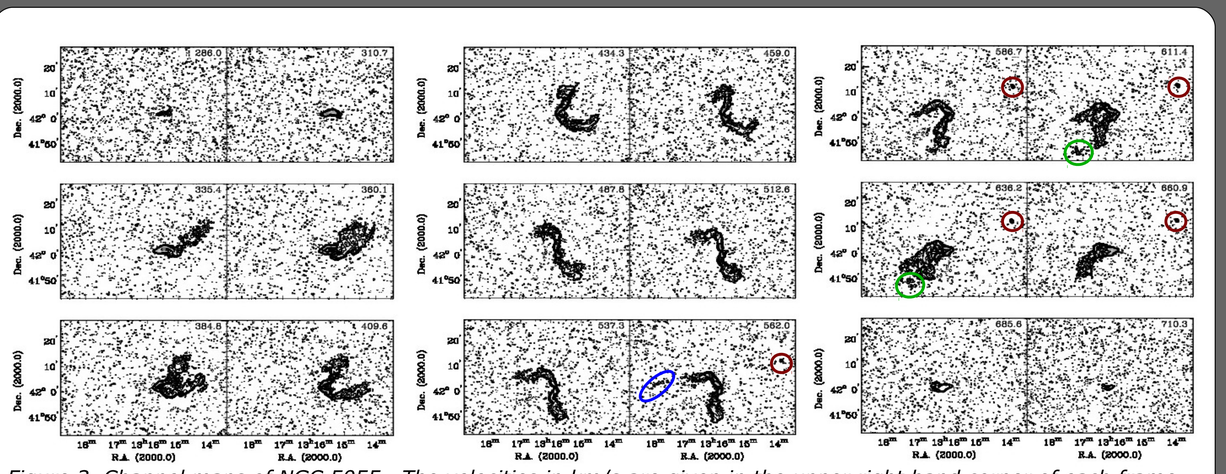


Figure 3. Channel maps of NGC 5055. The velocities in km/s are given in the upper right hand corner of each frame. The blue and green ellipses show the positions of the corresponding filaments in Figs 1 and 2. The red circles show UGC 8313.

Contours: 0.36x2ⁿ mJy/beam

Data and Observations

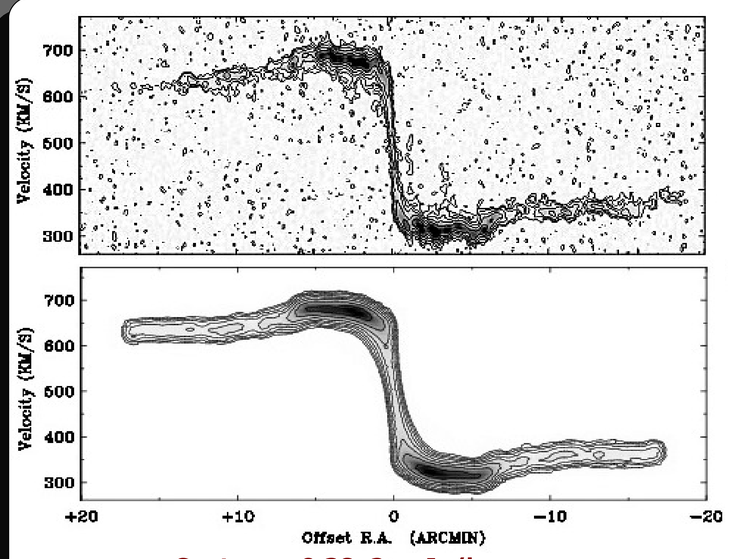
Figures 1 and 2 show moment maps for the HALOGAS 10×12 hrs observations of NGC 5055. The deepest contour for the moment-0 map corresponds to a column density of 5.0×10^{18} cm^{-2}. The rms noise for these data is 0.18 mJy beam^{-1}, meaning the data is sensitive to a column density of 2.1×10^{18} cm^{-2} at the 3σ level.

We estimate the total HI mass of NGC 5055 corrected for primary beam attentuation to be ~8.5×10^{9} $M_{\odot}$, 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^{7} $M_{\odot}$. To the east are HI clouds suggesting a possible interaction with the galaxy UGC 8365, which was not seen in previous observations.

Below, Figure 4 shows some anomalous velocity HI in the inner parts of the galaxy, lagging closer to the systemic velocity. This "beard" 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).



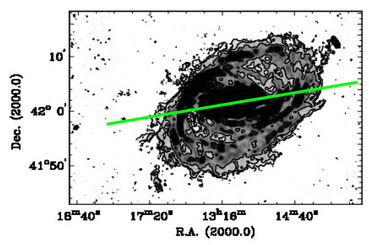


Figure 4. Position-velocity diagrams of NCG 5055 sliced along the optical major axis, as shown above. Top left shows the data. Bottom left is a slice through our preliminary model. At a distance of 8.5 Mpc, 1' = 2.5 kpc.

Contours: 0.38x2ⁿ mJy/beam

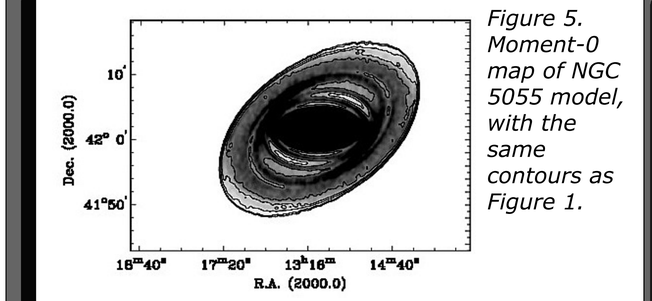


Figure 5. Moment-0 map of NGC 5055 model, with the same contours as Figure 1.

Contours: 1.9x2ⁿ mJy/beam

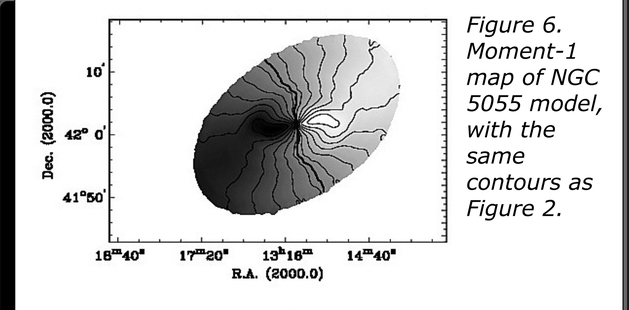


Figure 6. Moment-1 map of NGC 5055 model, with the same contours as Figure 2.

Contours: Δ30 km/s from 270 to 780 km/s

Modeling

We used a tilted-ring modeling software program based in the GIPSY (Groningen Image Processing SYstem) to model the HI. We fit for initial input parameters such as position angle, inclination, rotational 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. Figure 7 shows channel maps of the model for comparison to the data. In both the moment maps and the channel maps can be seen HI clouds and filaments outside of the disk that cannot be explained by our model. Figure 8 shows our basic input parameters for the model.

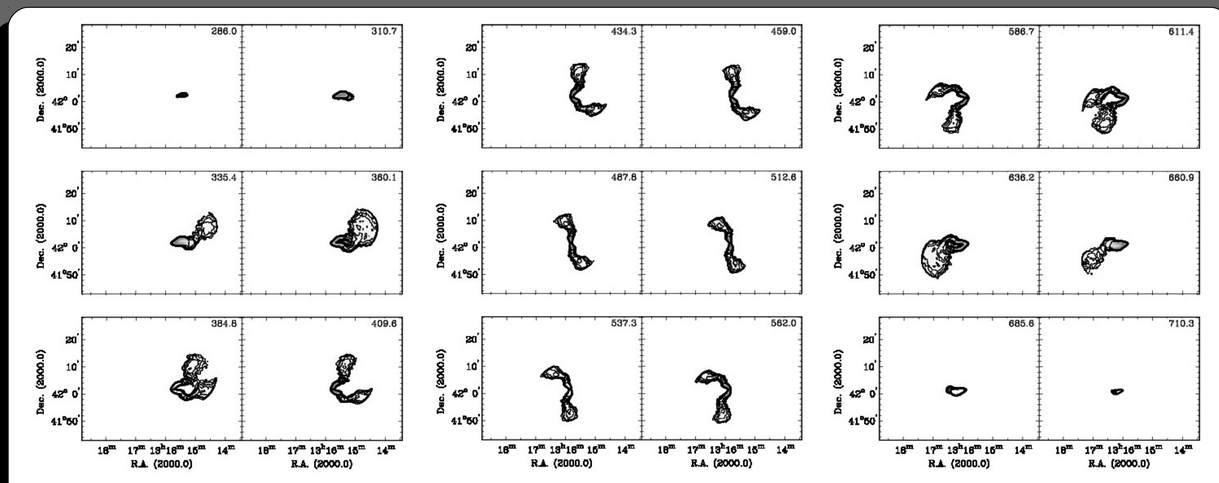


Figure 7. Channel maps of NGC 5055 model. The velocities in km/s are given in the upper right hand corner of each frame. The contours are the same as in Figure 3.

Contours: 0.36x2ⁿ mJy/beam

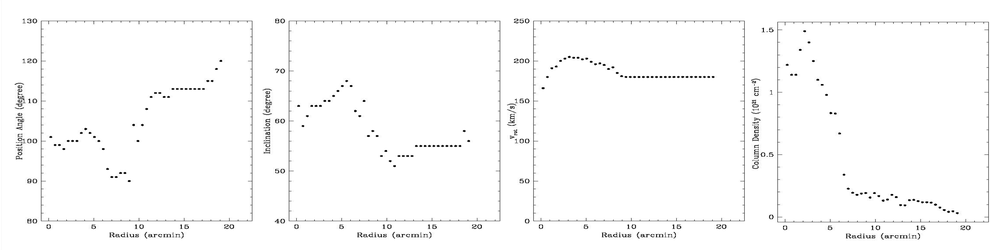


Figure 8. Input parameters for a tilted-ring model of the HI in NGC 5055. We used 40 rings of width 29", corresponding to a width of ~1.2 kpc at a distance of 8.5 Mpc for a total HI extent of ~48 kpc.

GALEX

NGC 5055 has a prototypical Type-I XUV (extended UV) disk (Thilker et al. 2007), with concentrated UV-bright complexes beyond the radius of expected star formation. The UV emission follows the dense HI spiral 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.

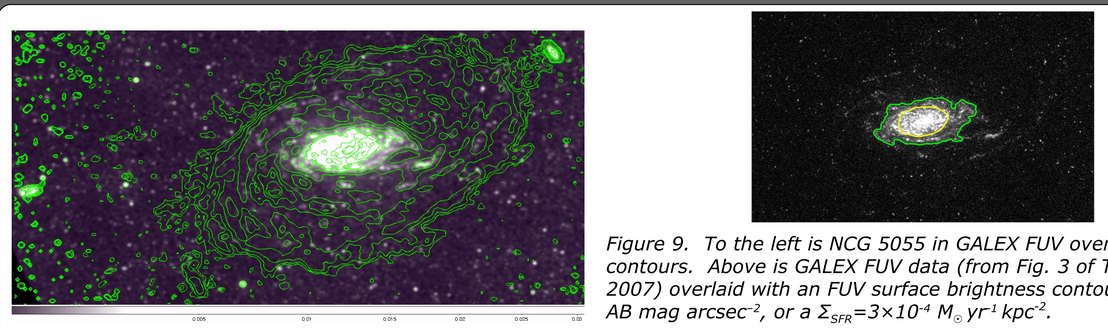


Figure 9. To the left is NCG 5055 in GALEX FUV overlaid with HI contours. Above is GALEX FUV data (from Fig. 3 of Thilker et al. 2007) overlaid with an FUV surface brightness contour at 27.25 AB mag arcsec^{-2}, or a $\Sigma_{SFR}=3\times10^{-4}$ $M_{\odot}$ yr^{-1} kpc^{-2}.

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 multiple disk component models and an in-depth look at the correlation between the HI and the outer disk star formation.

Acknowledgments

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