

First Results from THINGS: The HI Nearby Galaxy Survey

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Abstract. We describe *The HI Nearby Galaxy Survey (THINGS)*, the largest program ever undertaken at the VLA to perform 21-cm HI observations of the highest quality ($\sim 7''$, $\leq 5 \text{ km s}^{-1}$ resolution) of nearby galaxies. The goal of THINGS is to investigate key characteristics related to galaxy morphology, star formation and mass distribution across the Hubble sequence. A sample of 34 objects with distances between 3 and 10 Mpc will be observed, covering a wide range of evolutionary stages and properties. Data from THINGS will complement SINGS, the Spitzer Infrared Nearby Galaxy Survey. For the THINGS sample, high-quality observations at comparable resolution will thus be available from the X-ray regime through to the radio part of the spectrum. THINGS data can be used to investigate issues such as the small-scale structure of the ISM, its three-dimensional structure, the (dark) matter distribution and processes leading to star formation. To demonstrate the quality of the THINGS data products, we present some preliminary HI maps here of four galaxies from the THINGS sample.

1. Introduction

Studies of the atomic interstellar medium (ISM), through observations of the 21-cm line of atomic hydrogen (HI), have proven to be critical for our understanding of the processes leading to star formation, the dynamics and structure of the ISM, and the (dark) matter distribution; thus touching on major issues related to galaxy formation. In the last decades remarkable progress has been made in these areas. However, the lack of high-resolution HI observations in a representative sample of nearby galaxies precludes a systematic study of the physical characteristics of the atomic ISM.

Here we present first maps of THINGS, ‘The HI Nearby Galaxy Survey’, the largest program ever undertaken at the VLA to perform 21-cm atomic hydrogen observations of the highest quality of nearby galaxies.

The goal of THINGS is to obtain high-quality observations of the atomic ISM (through observations of the 21-cm line of neutral atomic hydrogen) of a

substantial sample of nearby galaxies, covering a wide range of Hubble types, star formation rates, absolute luminosities, evolutionary stages, and metallicities. The database will have homogeneous sensitivity and spatial and velocity resolution at the limit of what can currently be achieved with the Very Large Array. The angular resolution will be $\leq 7''$, and the spectral resolution will be $\leq 5 \text{ km s}^{-1}$. All galaxies will be observed with the VLA B, C and D arrays. A more complete description of THINGS, survey parameters and observational and technical details will be presented in Walter et al. (in preparation). A list of sample targets is given in Table 1. As an example of the high quality of the THINGS data, Figs. 1 and 2 show high-resolution integrated HI column density maps of four galaxies from the sample.

Data from THINGS will complement SINGS, the Spitzer Infrared Nearby Galaxies Survey (Kennicutt et al 2003); hence high-quality observations from the X-ray through the radio will be available at comparable resolution for each galaxy. Data from THINGS can be used to investigate issues such as the small-scale and three-dimensional structure of the ISM, the (dark) matter distribution, and the processes leading to star formation. Furthermore, THINGS will enable studies of the variation of each of these properties as a function of galaxy environment.

2. Scientific Goals

THINGS is designed to address numerous scientific topics, including, but not limited to, the following:

- **Dust – Atomic ISM.** The resolution of the THINGS HI data is similar to that obtained for the intermediate wavelength bands on-board Spitzer. One of the main goals of THINGS is therefore a comparison between the spatial distributions of the HI and dust as measured by Spitzer.
- **Interplay ISM – Star Formation.** THINGS allows studies of the interplay between star formation and the ambient ISM at 100-300 pc resolution over a range of Hubble types. The location and energy input of regions of recent star formation and the impact they have on the structure and dynamics of the HI will be investigated. For example, for the first time a census will be possible of supergiant shells as a function of Hubble type. THINGS data products will enable studies of how these structures form and how they, in turn, might trigger secondary star formation. Using the multi-wavelength data from SINGS a complete energy budget of the ISM can be derived.
- **Global Mass Distribution.** The THINGS data products will enable studies of the dark matter distribution in galaxies at high angular resolution. High resolution data near the centers of galaxies are especially important as this is the regime where differences between the ‘cuspy’ and ‘constant-density’ haloes show themselves most clearly. The data from Spitzer and additional data at other wavelengths will deliver more reliable estimates for the stellar mass-to-light ratio of the disk, obviating the need to resort to the “canonical” maximum disk assumption in order to derive

the properties of the dark matter halo. This study will ultimately shed more light on the validity of the CDM paradigm on scales of individual galaxies and will measure possible trends of the dark matter properties as a function of Hubble type.

- **Star Formation Threshold.** Using THINGS, studies will be performed at high spatial resolution to investigate whether or not there is a ‘universal’ star formation threshold and how, or even if, this is a function of galaxy type. Combinations of THINGS HI surface density maps with CO data will allow one to create total gas surface density maps. Amongst other things, with the velocity dispersion maps and the derived rotation curves, this information can be used to calculate spatially resolved “Toomre- Q ” parameter maps for each galaxy (the Q parameter is a measure for the local gravitational balance, Toomre 1964) as a function of Hubble type. Issues that can be addressed are, e.g., in which regime does ‘ Q ’ break down? What is the importance of local (disk or cloud instability) versus global effects (spiral density waves, tidal forces)?

3. THINGS data products

Observations for THINGS are currently ongoing at the VLA (total observing time: ~ 500 hours, including archival data). The data acquisition will be completed at the end of 2005. Final data products of THINGS will include moment maps (integrated HI distribution, velocity fields, velocity dispersion) as well as the HI data cubes, and will be made available to the community one year after the observations have been completed.

References

- Kennicutt, R.C., et al., 2003, PASP, 115, 928
Toomre, A. 1964, ApJ, 139, 1217

Table 1. Summary of THINGS targets

Name	Alias	Type	RA (2000.0) h m s.s	dec (2000.0) ° ' "	V_{rad} km s^{-1}	W_{20} km s^{-1}	size ' × '	incl °
NGC628	M74	Sc	01 36 41.7	+15 46 59	656	77	10.5 × 9.5	35
NGC925		SBcd	02 27 16.9	+33 34 45	553	217	10.5 × 5.9	61
NGC1569		IBm	04 30 49.0	+64 50 53	-90	83	3.6 × 1.8	68
NGC2366		Irr	07 28 47.6	+69 11 39	99	114	8.1 × 3.3	90
NGC2403		SBc	07 36 51.4	+65 36 09	130	241	21.9 × 12.3	60
HolmbergII	UGC4305	Irr	08 19 04.0	+70 43 09	157	72	7.9 × 6.3	47
M81dwA	PGC23521	Irr	08 23 56.0	+71 01 45	113	33	1.3 × 0.7	–
DDO53	UGC4459	Irr	08 34 07.2	+66 10 54	19		1.5 × 1.3	45
NGC2841		Sb	09 22 02.6	+50 58 35	638	607	8.1 × 3.5	68
NGC2903		SBbc	09 32 10.1	+21 30 04	555	384	12.6 × 6.0	56
HolmbergI	UGC5139	Irr	09 40 32.3	+71 10 56	137	44	3.6 × 3.0	37
NGC2976		Sc	09 47 15.3	+67 55 00	3	135	5.9 × 2.7	61
NGC3031	M81	Sab	09 55 33.2	+69 03 55	-35	442	26.9 × 14.1	59
NGC3077		Sd	10 03 20.6	+68 44 04	13	90	5.4 × 4.5	41
M81dwB	UGC5423	Irr	10 05 30.6	+70 21 52	343	61	0.9 × 0.6	67
NGC3184		SBc	10 18 16.9	+41 25 28	591	151	7.4 × 6.9	24
NGC3198		SBc	10 19 54.9	+45 32 59	662	321	8.5 × 3.3	70
IC2574	UGC5666	SBm	10 28 21.2	+68 24 43	48	109	13.2 × 5.4	75
NGC3351	M95	SBb	10 43 57.8	+11 42 14	778	280	7.4 × 5.0	42
NGC3521		SBbc	11 05 48.6	-00 02 09	809	462	11.0 × 5.1	66
NGC3621		SBcd	11 18 16.0	-32 48 42	726	278	12.3 × 7.1	66
NGC3627	M66	SBb	11 20 15.0	+12 59 30	726	377	9.1 × 4.2	57
NGC4214		Irr	12 15 38.9	+36 19 40	290	86	8.5 × 6.6	42
NGC4449		Irr	12 28 11.2	+44 05 36	202	143	6.2 × 4.4	56
NGC4736	M94	Sab	12 50 53.0	+41 07 14	309	232	11.2 × 9.1	35
DDO154		Irr	12 54 05.2	+27 08 55	373	93	3.0 × 2.2	44
NGC4826	M64	Sab	12 56 43.7	+21 40 52	406	315	10.0 × 5.4	60
NGC5055	M63	Sbc	13 15 49.2	+42 01 49	502	400	12.6 × 7.2	56
NGC5194	M51a	Sbc	13 29 52.7	+47 11 43	463	199	11.2 × 6.9	30
NGC5236	M83	SBc	13 37 00.8	-29 51 59	515	281	12.9 × 11.5	46
NGC5457	M101	SBc	14 03 12.5	+54 20 55	241	188	28.8 × 26.9	22
NGC6946		SBc	20 34 52.3	+60 09 14	51	235	11.5 × 9.8	31
NGC7331		SAb	22 37 04.1	+34 24 56	816	520	10.5 × 3.7	71
NGC7793		Scd	23 57 49.7	-32 35 30	229	192	9.3 × 6.3	53

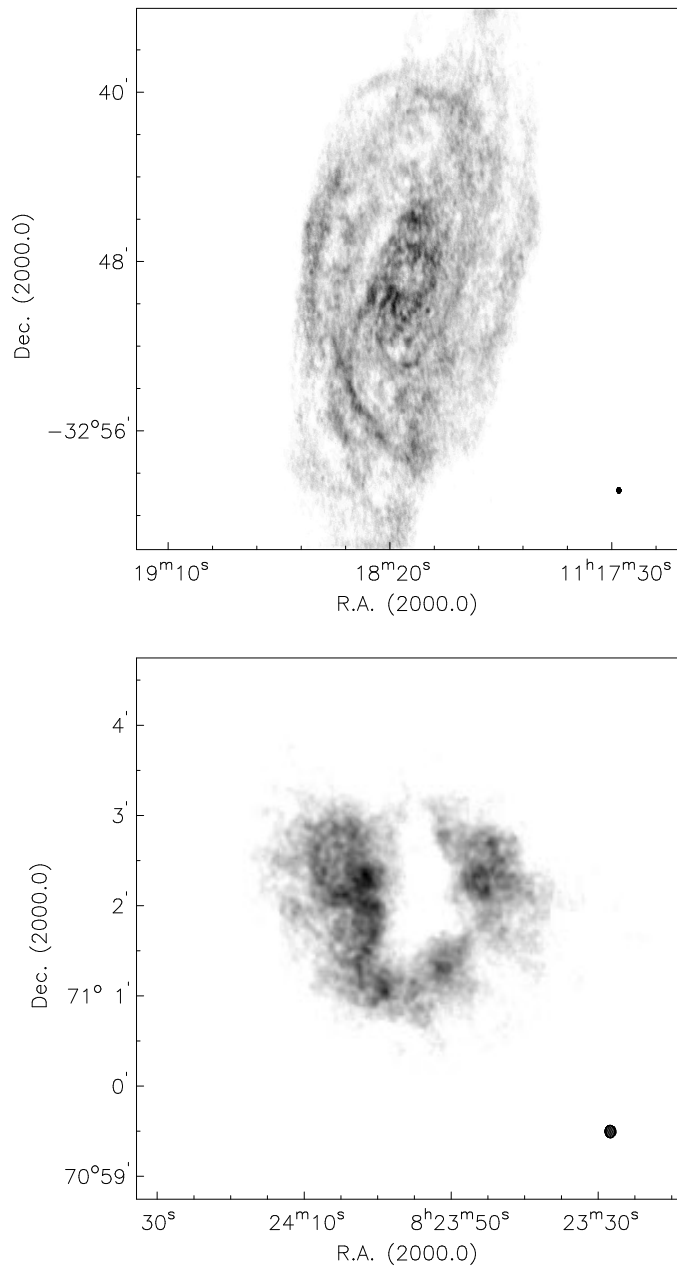


Figure 1. Integrated HI column density maps of N3621 (top) and M81dwA (bottom). Gray-scale levels run from $1.0 \cdot 10^{20} \text{ cm}^{-2}$ (light) to $3.8 \cdot 10^{21} \text{ cm}^{-2}$ (dark) for N3621, and from $1.0 \cdot 10^{20} \text{ cm}^{-2}$ (light) to $1.5 \cdot 10^{21} \text{ cm}^{-2}$ (dark) for M81dwA. The beam is shown in the bottom-right corner

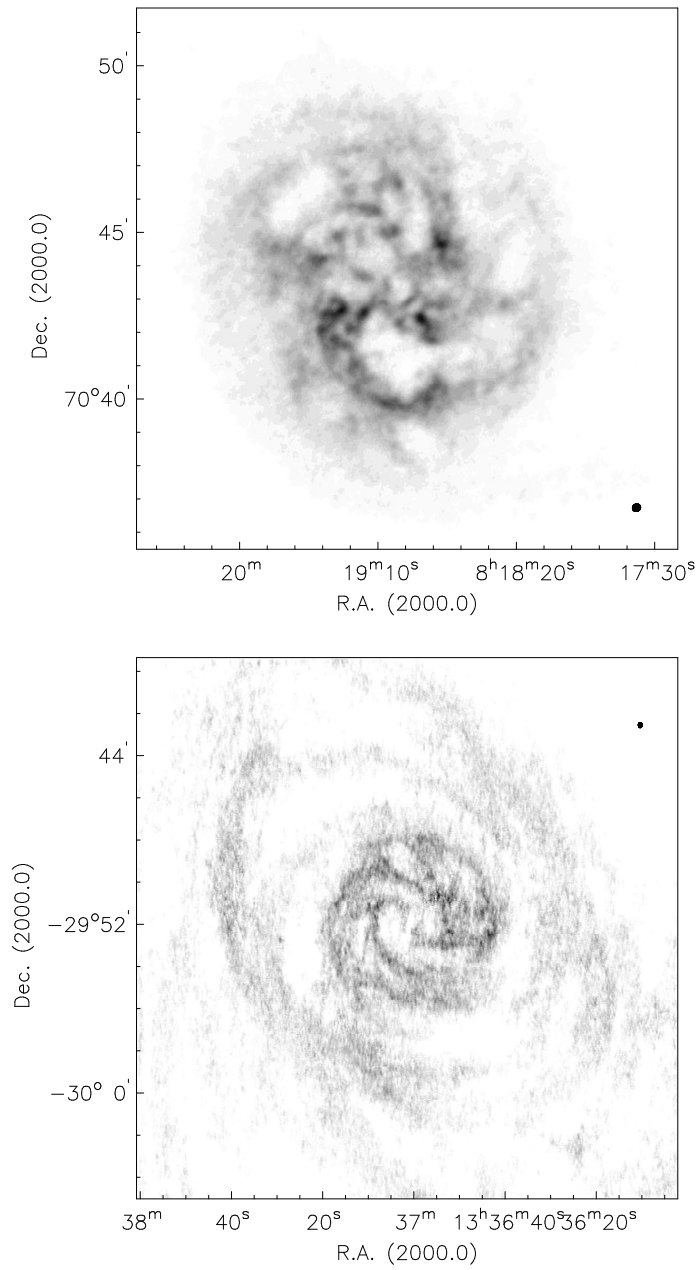


Figure 2. Integrated HI column density maps of Holmberg II (top) and M83 (bottom). Gray-scale levels run from $1.0 \cdot 10^{20} \text{ cm}^{-2}$ (light) to $4.3 \cdot 10^{21} \text{ cm}^{-2}$ (dark) for Holmberg II, and from $1.0 \cdot 10^{20} \text{ cm}^{-2}$ (light) to $3.0 \cdot 10^{21} \text{ cm}^{-2}$ (dark) for M83. The beam is shown in the bottom-right corner for Holmberg II and the top-right corner for M83.