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 ($\sim 7''$, $\leq 5$ 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 $\leq 5$ 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 reso-
lution. High resolution data near the centres 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: $\sim 500$ 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 completed.

References

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

Figure 1. Integrated HI column density maps of N3621 (top) and M81dwA (bottom). Grayscale levels run from $1.0 \times 10^{20}$ cm$^{-2}$ (light) to $3.8 \times 10^{21}$ cm$^{-2}$ (dark) for N3621, and from $1.0 \times 10^{20}$ cm$^{-2}$ (light) to $1.5 \times 10^{21}$ cm$^{-2}$ (dark) for M81dwA. The beam is shown in the bottom-right corner.
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    | Bm      |      | 04 30 49.0          | +64 50 53         | –90                  | 83                  | 3.6 × 1.8  | 68    |
| NGC2346    | Irr     |      | 07 28 47.6          | +69 11 39         | 99                   | 114                 | 8.1 × 3.3  | 90    |
| NGC2403    | Sb      |      | 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 33 12.1          | +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          | +70 05 00         | 3                    | 135                 | 5.9 × 2.7  | 61    |
| NGC3031    | M81     |      | 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     |      | 10 43 57.8          | +11 42 14         | 778                  | 280                 | 7.4 × 5.0  | 42    |
| NGC3521    | SBbc    |      | 11 05 48.6          | –90 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     |      | 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     |      | 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     |      | 12 56 43.7          | +21 40 52         | 406                  | 315                 | 10.0 × 5.4 | 60    |
| NGC5055    | M63     |      | 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 2. Integrated HI column density maps of Holmberg II (top) and M83 (bottom). Grayscale levels run from $1.0 \times 10^{20}$ cm$^{-2}$ (light) to $4.3 \times 10^{21}$ cm$^{-2}$ (dark) for Holmberg II, and from $1.0 \times 10^{20}$ cm$^{-2}$ (light) to $3.0 \times 10^{21}$ cm$^{-2}$ (dark) for M83. The beam is shown in the bottom-right corner for Holmberg II and the top-right corner for M83.
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