

Galaxy Groups in the Local Volume: An HI Perspective

Bärbel S. Koribalski

Australia Telescope National Facility, CSIRO, P.O.Box 76, Epping, NSW 1710, Australia. Baerbel.Koribalski@csiro.au

Summary. The ‘Local Volume HI Survey’ (LVHIS; Koribalski et al.) is a large project to obtain high-resolution and high-sensitivity HI and 20-cm radio continuum observations of all nearby ($D < 10$ Mpc) galaxies that are detected in the HI Parkes All-Sky Survey (HIPASS). We will obtain detailed maps of the HI distribution, kinematics and environment of all target galaxies, and derive their rotation curves, orientation parameters and star formation rates. By using independent distances we will be able to derive HI mass functions and local star formation densities for the Local Volume as well as nearby galaxy groups such as the Cen A and Sculptor groups. A complementary H -band survey will also allow us to analyse the (baryonic) Tully-Fisher relation.

The ‘Local Volume’ (the sphere of radius ~ 10 Mpc centered on the Local Group) includes at least 500 known galaxies, many of which congregate in well-known groups like the Local Group, the relatively loose Sculptor Group and the more compact Centaurus A group. Now that accurate distances for many of these nearby galaxies are becoming available (see Karachentsev et al. 2004, 2006), it is possible to define a complete distance-limited galaxy sample and study: the true Tully-Fisher relation; the reality of the supposedly quiet Hubble flow in the local Universe; galaxy spin vector alignments; the faint end of the HI mass; the local star-formation rate; and the unbiased properties of the faintest galaxies.

The first catalog of galaxies within 10 Mpc was compiled by Kraan-Korteweg & Tammann (1979); it contained 179 galaxies. Huchtmeier & Richter (1986, 1988) obtained Effelsberg HI measurements for almost all non-elliptical galaxies in the sample and presented global parameters, including the Tully-Fisher relation. Following numerous updates, the latest catalog of Local Volume (LV) galaxies was presented recently by Karachentsev et al. (2004); it contains 451 galaxies. About 85% of the LV population are dwarf galaxies which contribute about 4% to the local optical luminosity density and roughly 10–15% to the local HI mass density. Independent distances currently exist for more than half of the LV population within 8 Mpc, either from the luminosity of Cepheids, the tip of the red giant branch (TRGB), or surface brightness fluctuations (SBF).

Fig. 1 shows the correlation between Local Group velocity, v_{LG} , and distance, D , for ~ 400 galaxies as obtained from the LV catalog compiled by Karachentsev et al. (2004) and additional HIPASS data. The uncertainties of Cepheid, TRGB, and SBF distances are typically around 10%. The Local Group (LG; $D < 1$ Mpc), which consists of two subgroups centred around the Milky Way and Andromeda spirals, has a velocity dispersion similar to that of other nearby groups such as the Cen A/ and M 83 subgroups at ~ 3.6 and ~ 4.6 Mpc, respectively. We note that Centaurus A itself is the most prominent elliptical galaxy in the Local Volume.

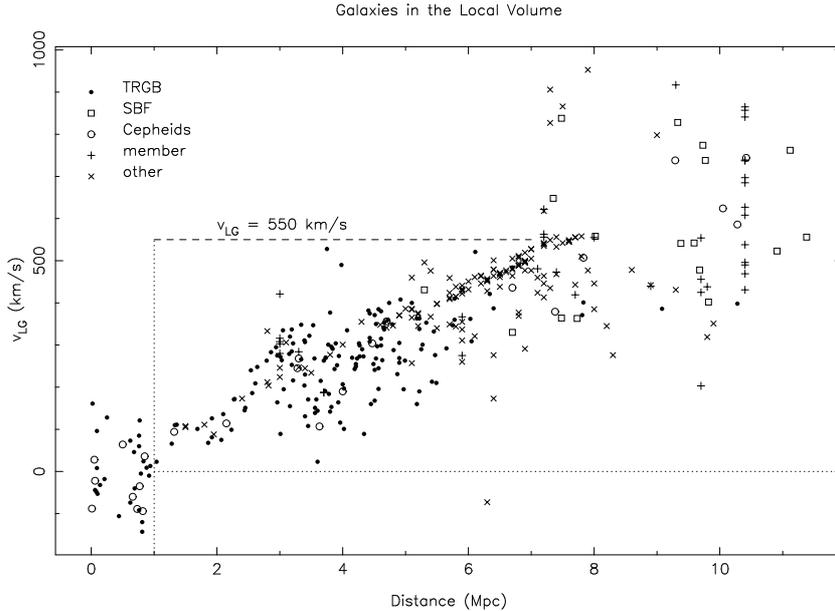


Fig. 1. Local Group velocity, v_{LG} (km s^{-1}), versus independent distance, D (Mpc), for all catalogued galaxies in the Local Volume. The different symbols denote the methods by which the distances were determined.

Beyond ~ 6 Mpc we currently lack reliable distances, but many efforts are underway to remedy the situation. While membership distances can be useful in the overall picture, independent distances are needed for all galaxies to determine group memberships and study their 3D distribution as well as their orientation and kinematics with respect to each other.

Fig. 2 shows the distribution of Local Volume galaxies on the sky, with symbols indicating distance ranges. There is no doubt that most galaxies live in groups, but the compactness or density of groups varies enormously, with strong implications as to the evolution of individual members and groups

as a whole. Through sensitive HI observations we have clear evidence for interactions between close neighbours. The Magellanic Bridge and Stream are the most nearby indicators of strong interactions between the Magellanic Clouds and the Milky Way (Putman et al. 2000). The network of HI streams and filaments in the M81–M82–NGC 3077 group (Yun et al. 1994) is one of the most spectacular examples of nearby interacting galaxies. And recent HI observations of the giant spiral galaxy M83 reveal a prominent tidal arm to the east (Koribalski et al. 2006), clearly indicating previous and on-going tidal interactions with its neighbouring dwarf galaxies.

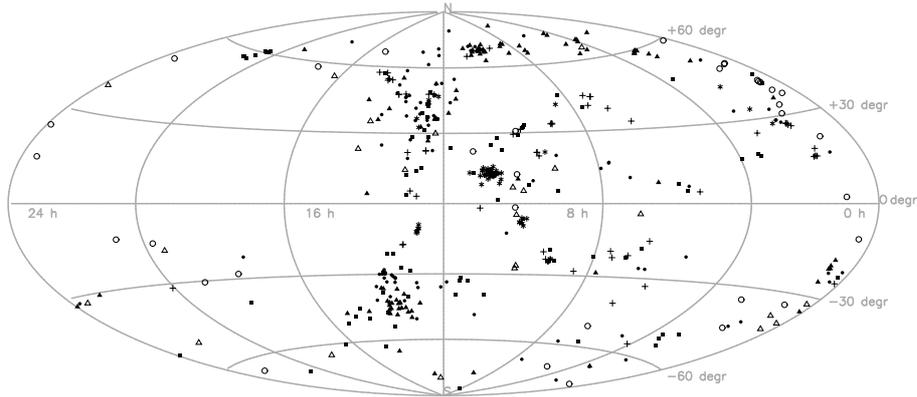


Fig. 2. Distribution of Local Volume galaxies on the sky. The symbols denote the following distance ranges: < 1 Mpc (open circle), $1 - 2.5$ Mpc (open triangle), $2.5 - 4$ Mpc (filled triangle), $4 - 5.5$ Mpc (filled circle), $5.5 - 7$ Mpc (filled square), $7 - 9$ Mpc (plus sign), and > 9 Mpc (star). In the southern sky, the Cen A group stands out as the densest concentration of galaxies (see also Fig. 3).

Several large surveys of nearby galaxies have recently been carried out or are in progress. Most importantly, ‘*The HI Nearby Galaxy Survey*’ (THINGS; Walter et al. 2005; de Blok et al. 2005), which aims at high-resolution ($7''$) HI imaging of initially 36 galaxies with $\delta > -30^\circ$, has just been completed at the Very Large Array. The THINGS sample is targeting LV galaxies from ‘*The Spitzer Nearby Galaxies Survey*’ (SINGS, Kennicutt et al. 2003).

Using the Australia Telescope Compact Array (ATCA) we have obtained sensitive HI distributions, velocity fields and 20-cm radio continuum maps for a complete sub-sample of ~ 70 southern, gas-rich LV galaxies. These data form part of the ‘Local Volume HI Survey’ (LVHIS¹; Koribalski et al.). The initial sample lies south of declinations -30° and contains all LV galaxies detected in the HI Parkes All-Sky Survey (HIPASS). The HIPASS Bright Galaxy

¹ The LVHIS webpages are at: www.atnf.csiro.au/research/LVHIS.

Catalog (BGC, Koribalski et al. 2004), which contains the 1000 H I-brightest galaxies in the southern sky, includes 80 galaxies with $v_{LG} < 550 \text{ km s}^{-1}$. Of these, 54 lie south of declination -30° . To this sample we added fainter HIPASS galaxies from the catalogs of Banks et al. (1999; Cen A group) and Meyer et al. (2004; HICAT). — We have now observed each galaxy in our sample for 12-h using either the ATCA EW352-m or the EW367-m array and are on track to obtain further full synthesis (12-h) observations in each of the ATCA 750-m and 1.5-km arrays. Our aim is to complete the survey by the end of 2007. In addition, we mosaic galaxies with very extended H I envelopes (such as the prominent Sculptor spirals) in the ATCA H75 array.

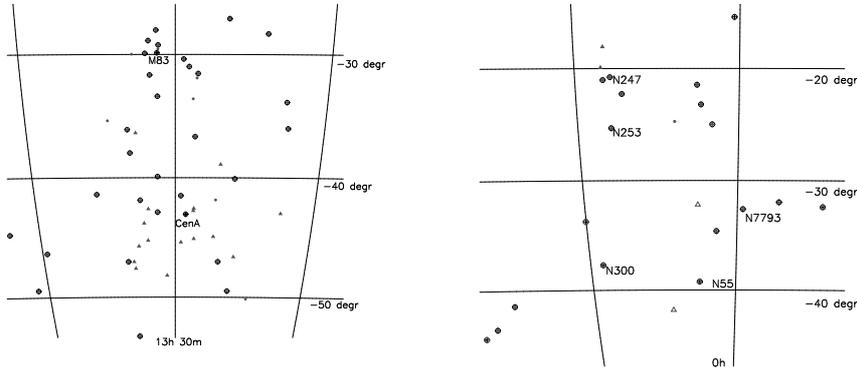


Fig. 3. The two most prominent southern groups are the relatively compact Cen A & M83 groupings (left) and the loose Sculptor group (right). Galaxies that are known to contain H I emission are marked with an open circle.

Fig. 3 shows the distribution of galaxies in the two southern groups, Cen A/M83 and Sculptor. While M83 is a giant H I-rich galaxy surrounded by numerous dIrr galaxies, the galaxies around Cen A are predominantly of earlier type. The ATCA H I velocity fields of some of the irregular galaxies near Cen A are shown in Fig. 4. The Sculptor Group, which is dominated by five bright gas-rich spiral galaxies, stretches over a relatively large range of distances and is much less compact than the Cen A/M83 group. It is often considered to be a filament or loose group. While there are signs of disturbances in individual galaxies, no tidal streams have so far been detected in the Sculptor group. All of the H I-rich galaxies in these groups are being studied in detail as part of the LVHIS project.

My collaborators in the LVHIS project are Lister Staveley-Smith, Jürgen Ott, Erwin de Blok, Helmut Jerjen, Igor Karachentsev and Katie Kern. Our ATCA H I survey of gas-rich galaxies in the Local Volume is a major and very timely contribution to the on-going multi-wavelength campaign to characterise the Local Universe.

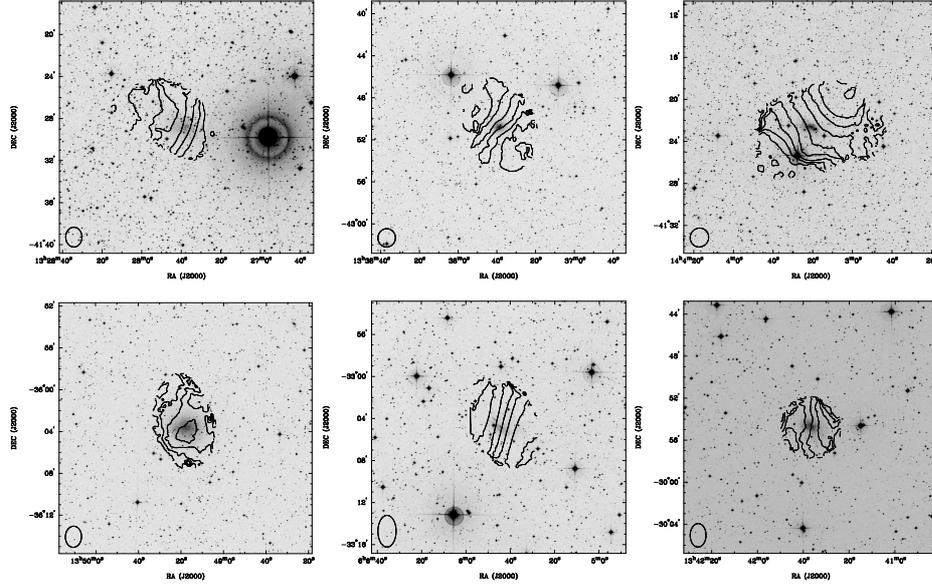


Fig. 4. HI mean velocity fields (contours) of some irregular galaxies in the Local Volume, as obtained from archival ATCA data. Top (left to right): ESO324-G024 (3.73 Mpc), NGC 5237 (3.40 Mpc), and NGC 5408 (4.81 Mpc). Bottom (left to right): ESO383-G087 (3.45 Mpc), ESO364-G?029 (7.7 Mpc), and NGC 5264 (4.53 Mpc). The ATCA synthesized beam is indicated at the bottom left of each panel. The HI velocity fields are overlaid onto *R*-band images from the Digitised Sky Survey (greyscale).

References

1. G.D. Banks et al.: *ApJ* **524**, 612 (1999)
2. W.J.G. de Blok et al.: *ASPC* **329**, 265 (2005)
3. W.K. Huchtmeier & O.-G. Richter: *A&AS* **63**, 323 (1986)
4. W.K. Huchtmeier & O.-G. Richter: *A&A* **203**, 237 (1988)
5. I.D. Karachentsev et al.: *AJ* **127**, 2031 (2004)
6. I.D. Karachentsev et al.: *AJ* **131**, 1361 (2006)
7. R. Kennicutt et al.: *PASP* **115**, 928 (2003)
8. B.S. Koribalski et al.: *AJ* **128**, 16 (2004)
9. B.S. Koribalski et al.: *MNRAS*, in prep. (2006)
10. R. Kraan-Korteweg & G.A. Tammann: *AN* **300**, 181 (1979)
11. M. Meyer et al.: *MNRAS* **350**, 1195 (2004)
12. M.E. Putman et al.: *Nature* **394**, 752 (1998)
13. F. Walter et al.: *ASPC* **331**, 269 (2005)
14. M.S. Yun, P.T. Ho, K.Y. Lo: *Nature* **372**, 530 (1994)