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# The Local Volume H I Survey (LVHIS)

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**Abstract.** The 'Local Volume H I Survey' (LVHIS)[1] is a large project comprising deep interferometric H I line and 20-cm radio continuum observations of all nearby, gas-rich galaxies and their surroundings. For each galaxy we study their gas distribution and kinematics as well as their global and local star formation properties. We explore how galaxy properties (such as diameter, mass, star formation rate and mass-to-light ratio) behave as a function of environment, from the most isolated galaxies to the centres of galaxy groups. Complementary surveys of the galaxies' H$\alpha$, $UV$, $IR$ and CO properties are invaluable for the project. — As examples we briefly discuss (a) the relatively isolated galaxies ESO215-G?009 and ESO223-G009, both of which have extended H I envelopes but display very different kinematics in their outer disks, and (b) the large spiral galaxy M 83 which has a very large, asymmetric H I disk and tidal arm, while being surrounded by a large number of dwarf galaxies.

## 1 Introduction

The Local Volume (LV) – defined as the sphere of radius 10 Mpc centred on the Local Group – contains a diverse selection of galaxies which can be studied in greater detail than any other galaxies. While poor in ellipticals, the Local Volume is rich in spiral and dwarf galaxies of all types. The observed H I sizes range from ∼1 to 100 kpc, while H I masses range from $\lesssim 10^5$ to over $10^{10}$ M$_\odot$. By far the largest and most powerful LV galaxy is Centaurus A (NGC 5128, HIPASS J1324–42, $D$ = 3.8 Mpc) whose enormous radio lobes extend over ∼10 degr. Together with the spiral galaxy M 83 (HIPASS J1337–29, $D$ = 4.5 Mpc), it dominates the Cen A galaxy group. While the influence or impact of Cen A's giant radio lobes on the environment, esp. its neighboring galaxies, is not discussed here, we do briefly discuss the M 83 galaxy group.

Focussing on the Local Volume allows us to, for example, study the faint outer gas envelopes of nearby galaxies as well as their large-scale environment, and detect small, low-mass galaxies that remain elusive at larger distances. — Karachentsev et al. (2004, AJ 127, 2031) noted that ∼85% of the galaxies in the Local Volume are dwarf galaxies contributing ∼4% to the local optical luminosity density and ∼10–15% to the local H I mass density. — The Local Group contains only two large (spiral) galaxies, our Galaxy and Andromeda, and 40+ dwarf galaxies. While the Milky Way may, in some circumstances, be considered an *'isolated'* galaxy, nobody would classify any of the neighboring dwarf galaxies as isolated. Thus, the meaning of the term *'isolated'* depends on the

[1] Project webpage: www.atnf.csiro.au/research/LVHIS

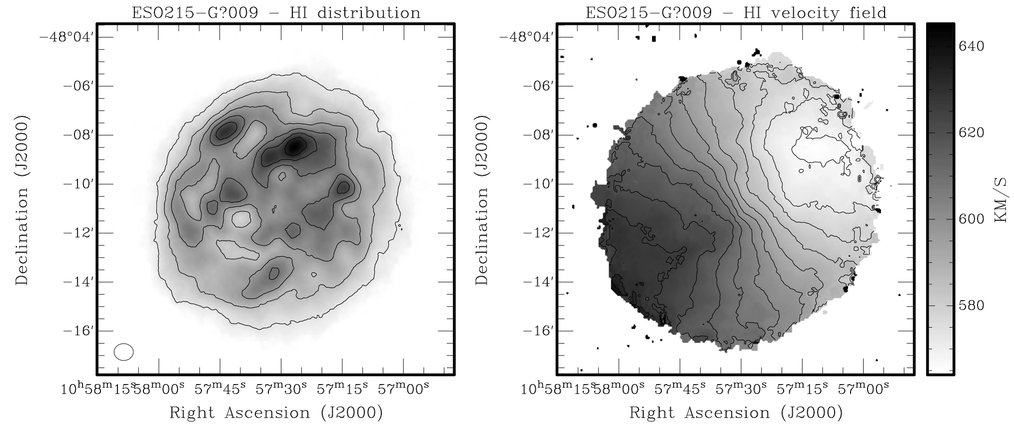


Figure 1. The dwarf irregular galaxy ESO215-G?009 (HIPASS J1057–48). The ATCA H I distribution (left) and velocity field (right) reveal a regularly rotating disk with a near circular H I envelope. Warren, Jerjen & Koribalski (2004, AJ 131, 2056) found its H I extent to be six times larger than the optical Holmberg diameter and determined $M_{\rm HI}/L_{\rm B} = 22 \pm 4\ M_\odot/L_{\odot,\rm B}$ ! The nearest known neighbours to ESO215-G?009 lie about 10 degr to the north.

question being asked. There is no doubt that the Milky Way is gravitationally interacting with, for example, the Magellanic Clouds. A broad band of gas – the Magellanic Stream – connecting both is an obvious tell-tale sign (Putman et al. 1998, Nature 394, 752). **The 21-cm line of neutral atomic hydrogen (H I) is an excellent tracer of galaxy interactions**, revealing not only the location but also the kinematics of stripped and/or accreted material, manifesting as tails/streams/plumes, etc. Without H I observations, the environment of a galaxy cannot be fully characterised. Noteworthy examples are the one-sided H I tail/plume attached to the galaxy IC 2554 (Koribalski et al. 2003, MNRAS 339, 1203), the massive, intergalactic H I cloud HIPASS J0731–69 located at a projected distance of 250 kpc from NGC 2442 (Ryder et al. 2001, ApJ 555, 232), the partial H I ring associated with NGC 5291 (Malphrus et al. 1997, AJ 114, 1427), the *Vela Cloud* in the NGC 3256/3263 galaxy group (English et al. 2009, AJ, in press), and the 2XH I envelope of the galaxy NGC 1512 (Koribalski & López-Sánchez 2009, MNRAS, in press).

The Milky Way (H I diameter $\sim$ 120 kpc) is not only surrounded by a large number of dwarf galaxies but also by extended stellar streams, probably resulting from the accretion and disruption of small, nearby companions. This agrees with the fact that the majority of gas-poor dwarf spheroidal neighbours are located within 130 kpc (their gas has been stripped), while gas-rich dwarf irregulars are mostly found further out ($>$ 400 kpc; Tolstoy et al. 2009, A&AR, in press). Stellar streams are also observed around other galaxies, such as the edge-on galaxies NGC 5907 and NGC 4013, and are likely connected to the severe warping of their gas layers. Slow accretion of H I gas to the outermost regions of rotating disk galaxies could lead to extended, non-planar gas layers that are warped (and twisted) with respect to the inner disk.

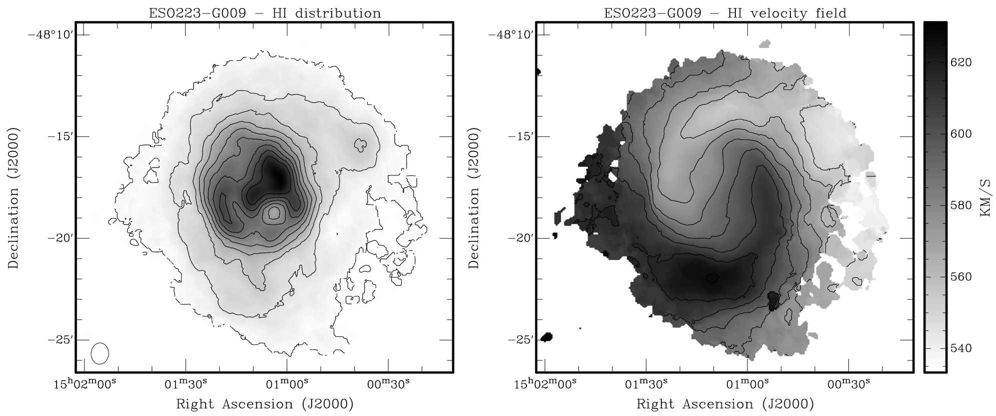


Figure 2. The dwarf irregular galaxy ESO223-G009 (HIPASS J1501–48). The ATCA H I distribution (left) and velocity field (right) reveal a peculiar looking velocity field and near-circular disk. Koribalski et al. (2009, in prep.) explain both with a warped and twisted, nearly face-on disk. The nearest known neighbour to ESO223-G009 is the large, edge-on galaxy ESO274-G001 (HIPASS J1514–46) at a projected distance of $160'$ or 300 kpc.

## 2 The Local Volume H I Survey (LVHIS)

All LV galaxies detected in the H I Parkes All Sky Survey (HIPASS; Koribalski et al. 2004, AJ 128, 16), and with declinations $\delta \lesssim -30°$, were observed with the Australia Telescope Compact Array (ATCA). We accumulated ∼3000 hours of observing time and reach an H I mass limit of $3 \times 10^4$ $D^2$ $M_\odot$. Similar H I surveys have been carried out (or are under way) with the VLA, WSRT and GMRT. Together, this adds up to about 300 LV galaxies being studied in detail with existing radio interferometers. LVHIS delivers (1) high-resolution H I data cubes of gas-rich galaxies imaged on all scales, this includes H I intensity distributions (→ galaxy diameters, asymmetries, tidal tails and companions), H I velocity fields (→ rotation curves, orientation parameters as a function of radius, and dynamical masses), H I velocity dispersions (→ multiple components, line broadening), and (2) deep 20-cm radio continuum imaging (→ star formation rates and efficiencies). For a summary of the science goals see Koribalski et al. (2008, in 'Galaxies in the Local Volume', Springer Astrophysics & Space Science Proceedings., eds. Koribalski & Jerjen, p. 41).

Figures 1 and 2 show two particularly interesting LVHIS galaxies, ESO215-G?009 ($D$ = 5.3 Mpc) and ESO223-G009 ($D$ = 6.5 Mpc). They are relatively isolated dwarf irregulars with H I masses of 0.4 and $1.0 \times 10^9$ $M_\odot$, respectively. Their H I diameters are 20–30 kpc. While ESO215-G?009 displays a straight line of nodes and a mild warp, ESO223-G009 has a highly twisted and warped velocity field. The H I velocity dispersions in both galaxies reach maxima around 12 km s$^{-1}$. The peculiar H I velocity field of ESO223-G009 shows some similarity to those of the spiral galaxies NGC 628 (Kamphuis & Briggs 1992, A&A 253, 335), NGC 3642 (Verdes-Montenegro et al. 2002, A&A 389, 825), IC 10 (Manthey & Oosterloo 2008, in 'Galaxies in the Local Volume', p. 303) and the lenticular galaxy ESOO381-G047 (Donovan et al. 2009, AJ 137, 5037). The common feature of these rather different galaxies is their warped, nearly face-on H I disks. Koribalski et al. (2009) explore gas accretion, e.g. in form of a dwarf irregular galaxy, as one possibility to create a warped (and twisted) outer gas layer. The shape and longevity of a galaxy's warp would then depend on the rate of infall and momentum of the accreted gas. The different perspectives provided by both edge-on and face-on galaxies are advantageous for this study.

The spiral galaxy M 83 (H I diameter $\sim$ 80 kpc) also appears to grow by regularly accreting neighboring dwarf galaxies. We observe clear signatures of interaction and accretion, such as several faint stellar streams and a one-sided outer H I arm. M 83's closest neighbour is the dIrr galaxy NGC 5264, located just east of the outer arm. The overall shape of M 83, with the eastern side appearing rather fluffy compared to the sharp western edge, suggests that ram pressure stripping by the intragroup medium may also play a role. A detailed study of M 83 and its companions is under way as part of the LVHIS project; for preliminary results see Koribalski (2005, PASA 22, 333).

## 3 Future H I surveys and Conclusions

Future, large-scale H I surveys with the Square Kilometre Array (SKA) and SKA Pathfinders (such as ASKAP) are essential to study the evolution of galaxies as a function of redshift and of their environment. WALLABY, the *'Wide-field ASKAP L-band Legacy All-sky Blind SurveY'*, is one of the highly ranked ASKAP Science Survey Projects (PIs: Koribalski & Staveley-Smith). This large-scale 20-cm (1.4 GHz) survey will deliver H I line and radio continuum data. The plan is to spend one year surveying 1.5 hemispheres ($\delta = -90°$ to $+30°$) over a velocity range of –2,000 to +70,000 km s$^{-1}$ ($z < 0.25$) using focal plane array technology. An integration time of 8 hours per field is expected to result in an rms of 1.5 mJy beam$^{-1}$ and detect around 500,000 gas-rich galaxies (resolution: 30″, 4 km s$^{-1}$). The LVHIS project has provided comparable data, but only for the targeted, nearby galaxies and their immediate neighbourhood.

There are no isolated galaxies! Every galaxy has neighbours: some are large and massive, causing major disruptions, others are small and potentially less influential. The outermost gas envelopes of galaxies, which are best studied in the 21-cm line of neutral hydrogen (H I), are highly sensitive to external forces (e.g., tidal interactions, gas infall, and ram pressure stripping) as well as internal forces (e.g., the dark matter potential, resonances, and density waves) and can be used to study galaxy assembly and evolution. A statistical analysis of the H I properties of LV galaxies as a function of environment is under way.

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