TITLE
ASP Conference Series, Vol. **VOLUME**, **PUBLICATION YEAR**
EDITORS

The HI Jodrell All Sky Survey (HIJASS)

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Abstract. We present the first results from the HI Jodrell All Sky Survey (HIJASS). HIJASS provides a northern counterpart to the Southern HIPASS survey, with similar velocity coverage, resolution and sensitivity. HIJASS is now well underway, with several large regions completed. Firstly we report on a blind survey of the M81 group. This is the largest and most sensitive HI survey of the M81 group to date, and provides new clues about the evolutionary history of the galaxies in the group. In addition to the M81 group, an 8 degree strip of sky covering all Right Ascension and centered on +74 degrees Declination has been surveyed. A number of optically faint but HI-rich galaxies were discovered and follow-up observations are underway to determine the nature of these galaxies.

1. Introduction

The HI Jodrell All Sky Survey (HIJASS) is a blind neutral hydrogen (HI) survey of the northern sky, $\delta > 25^\circ$, being conducted on the 76-m Lovell telescope at the Jodrell Bank observatory. HIJASS provides the northern counterpart for HIPASS (see Koribalski 2002). Between them, these surveys will provide HI coverage of the whole sky over the velocity range $\sim -1,000$ km s^{-1} to 10,000 km s^{-1}. HIPASS observations are now finished to the survey limits of $\delta < 25^\circ$, while HIJASS observations are still ongoing with ~ 930 deg^2 surveyed so far.

HIJASS and HIPASS will help to improve models of galaxy formation and evolution by determining the HI mass function and local gas density without being biased by the optical light of the detected galaxies. By surveying the whole sky, the large–scale distribution of HI density with environment will be investigated for the first time. In addition, it will be possible to discover gas–rich low surface brightness galaxies and HI clouds without visible optical counterparts, which would have been missed in optical galaxy surveys. Two HI clouds without stellar emission have already been found in HIPASS (Ryder et al. 2001; Kilborn et al. 2000), and limits on the numbers and HI mass contribution from such clouds will be determined from the full surveys.

HIJASS uses a 4–beam cryogenic receiver (Bird 1997), of a similar design to the Multibeam receiver used for HIPASS. The FWHM beam width of the Lovell telescope is $\sim 12'$, and the survey uses a 64 MHz bandwidth with 1,024 channels. The velocity range covered by HIJASS is $-3,500$ km s^{-1} to 10,000 km s^{-1}. The sky is actively scanned in 8° strips in Declination, at a rate of 1° per minute. Each scan is separated by $10'$, but the sky is scanned eight times which reduces the scan separation to 1.25′. Bandpass calibration is done in real time at the telescope, and for full details of data reductions techniques see Barnes et al. (2001). The data quality of the survey is similar to the of HIPASS – the RMS is on average 15 mJy beam^{-1} compared to the HIPASS RMS of 13 mJy beam^{-1}. The data are gridded into 8° × 8° cubes, with 1,024 channels, and a channel separation of 13.2 km s^{-1}. The HI mass limit for HIJASS is $\sim 10^6 d^2_{\rm Mpc}$ $M_\odot$ for a source with a line–width of 100 km s^{-1}. Table 1 summarises the survey parameters of HIJASS.

Table 1. HIJASS survey parameters

Survey Region	$\delta > 25°$
Number of 8° × 8° cubes in region	236
Lovell Telescope beam FWHM	∼12′
Velocity Range	−3,500 to 10,000 km s^{-1}
Velocity Resolution	18 km s^{-1}
Channel Separation	13.2 km s^{-1}
RMS noise per channel	∼ 15 mJy beam^{-1}
HI mass limit	$\sim 10^6\ d^2_{\rm Mpc}\ M_\odot$

2. Survey Progress and Recent Results

HIJASS is now well underway after two successful observing runs between 1999 and 2001. Two major areas of sky were surveyed - the area encompassing the M81 group, and an eight degree strip around the south celestial pole centred on Declination +74 (the p74 strip). About 6% of the Northern survey has now been completed (∼930 deg^2), with 14 out of the 236 data cubes reduced.

2.1. The M81 group

HIJASS surveyed the region surrounding the M81 group in 2001 January (Boyce et al. 2001). The M81 group consists of the large spiral galaxy, M81, two peculiar galaxies, M82 and NGC3077, two small spiral galaxies, IC2574 and NGC2976, and about 23 dwarf galaxies. The dwarf galaxy population is composed of 12 dIrr's, nine dE's and two blue compact dwarfs (BCDs). A large dynamically complex HI cloud encompasses M81, M82, NGC 3077 and NGC 2976, and a peak intensity HI map of the region can be seen in Figure 1.

All four of the known dwarf irregular galaxies close to M81 are detected in the HIJASS data. The dwarf elliptical galaxy Kar 61 is detected for the first time in HI, and the dE galaxies BK5N and Kar 64 appear to be associated with a spur of HI emanating from M81. This spur can be seen to the south–west of the main HI concentration stretching towards Kar 64, at $\alpha = 10^{\rm h}07^{\rm m}$, $\delta = +67°49'$ (J2000) in Fig. 1. This spur may have formed from a tidal interaction between NGC 3077 and BK5N and/or between NGC 3077 and Kar 64. A continous bridge of HI joins M81 ($\alpha = 09^{\rm h}55^{\rm m}$, $\delta = +69°03'$ (J2000)) and NGC 2976 ($\alpha = 09^{\rm h}47^{\rm m}$, $\delta = +67°55'$ (J2000)), and contains approximately 10^8 $M_\odot$ of HI.

The dIrr galaxy BK3N ($\alpha = 09^{\rm h}53^{\rm m}$, $\delta = +68°58'$ (J2000))was detected unambiguously in HI for the first time. We estimate the galaxy has $\sim 1.8 \times 10^7$ $M_\odot$

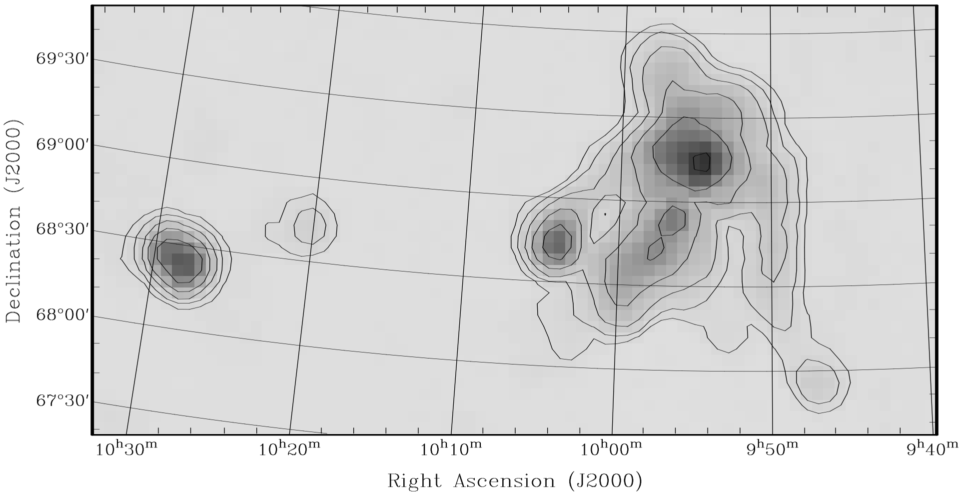

Figure 1. Peak intensity map of the central M81 group region between -270 km s^{-1} and 323 km s^{-1}, but excluding Galactic emission from 20 km s^{-1} to -99 km s^{-1}. The contour levels show 0.1, 0.2, 0.4, 0.8, 1.6 and 3.2 Jy beam^{-1}. For channel maps of the region, see Boyce et al. 2001.

of HI, and it is positioned at the top of a tidal spur near M81 indicating that it may be a tidal dwarf galaxy. Alternatively BK3N may be a preexisting dIrr galaxy undergoing an interaction with M81 (see Boyce et al. (2001) for more details). One possible new M81 group member was found – HIJASS J1021+6840, which can be seen in Figure 1, next to the larger HI concentration from IC 2574 at $\alpha = 10^{\rm h}28^{\rm m}$, $\delta = +68°24'$ (J2000). HIJASS J1021+6840 contains $\sim 2 \times 10^7$ $M_\odot$ of HI, and lies at a velocity of $V_\odot$ = 46 km s^{-1}. There is no corresponding optical counterpart to the new detection, and it is possible that we are seeing the transition of tidal gas from IC 2574 into a dIrr tidal galaxy.

2.2. The p74 Strip

There are 12.5 $8° \times 8°$ cubes in the p74 strip. These cubes have been searched for galaxies visually and using an automated algorithm. $\sim$ 230 galaxies were found in the region during these searches. About 10% of the galaxies are previously uncatalogued, and a further $\sim$20% are detected in HI for the first time. Figure 2 shows two new galaxies that were found in the p74 strip. The images are B-band exposures from the WFC mounted on the INT. HIJASS J1720+7133 shows an interesting morphology indicative of a past interaction, while HIJASS J0349+7146 has a very low optical surface brightness, with $\mu_B \sim 25.5$. In general, the new galaxies found in the p74 strip are typically either low in their surface brightness, or have a compact optical counterpart which has meant they were missed from previous optical searches. B and R–band images are planned for all galaxies without previous photometry in order to determine the contribution of these HI–rich galaxies to the total luminosity density of the local Universe, and to investigate the nature of these objects. In addition, Westerbork synthesis radio telescope (WSRT) observations are underway for all new

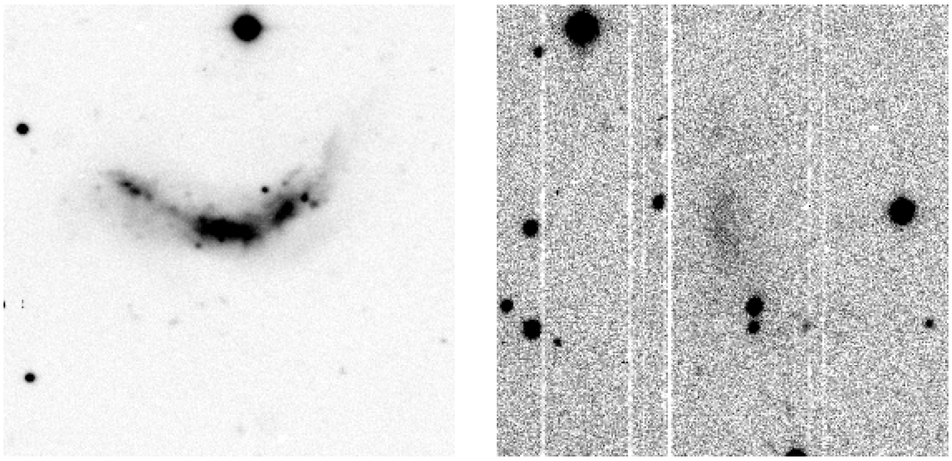

Figure 2. INT B–band mages of two new HIJASS galaxies. HIJASS J1720+7331 (left) shows an interesting morphology indicative of an interaction in the past. HIJASS J0349+7146 has a very low surface brightness ($\mu \sim 25.5$) that has meant it was missed from the cataloguing of previous optical surveys.

galaxies, and also for those with several possible optical counterparts in the 12′ HIJASS beam. These observations will provide high resolution HI images to help determine the optical counterparts of the HI detected galaxies, and will allow the calculation of accurate column densities for the study of star formation in these objects.

3. Acknowledgements

HIJASS has resulted from the work of many people, including Peter Boyce, Mike Disney, Diego Garcia, Marco Grossi, Christine Jordan, Robert Lang, Robert Minchin, various members of the HIPASS working group, and staff at Jodrell Bank observatory and the Australia Telescope National Facility.

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