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HI in the Local Universe

Short Communications

Blind H I Survey in the Centaurus and Fornax Clusters

David Barnes

School of Physics, University of Melbourne,
Parkville, Vic. 3052, Australia.
dbarnes@physics.unimelb.edu.au

Abstract: The results of 21 cm H I survey observations are presented for two fields, centred on the Centaurus and Fornax southern galaxy clusters. One previously uncatalogued dwarf galaxy was detected near the southern edge of the Fornax cluster, and is visible on UKST survey plates. Implications for the Parkes Multibeam All Sky Survey are discussed.

1 Introduction

In this paper we present results from a series of 21 cm observations of the Centaurus and Fornax southern galaxy clusters. These observations are part of our continuing program of blind searches for extremely low surface brightness galaxies with H I masses in the range 10^4–$10^{12}\ M_\odot$. In this program, the AT Compact Array is being used to image selected 'blank' fields and probe the H I mass range 10^4– $10^8 M_\odot$, whilst the Parkes radio telescope has been used to search the H I mass range 10^8–$10^{12} M_\odot$.

Searches for nearby galaxies in the 21 cm line of H I had by 1990 covered a total spectral bandwidth of only ~ 350 GHz (Briggs 1990), corresponding to $\sim$2% of the sky to a redshift depth of $z \simeq 0{\cdot}01$. For H I masses greater than $\sim 10^9\ M_\odot$, the contribution of void filling gas clouds to the cosmological density parameter (Ω_0) is probably less than 0·1% (Krumm & Brosch 1984; Fisher & Tully 1981). For H I masses less than $\sim 10^8\ M_\odot$, the contribution of H I clouds to Ω_0 is virtually unconstrained, although Hoffman et al. (1992) find a weak (5% of Ω_0) upper limit for $M_{\rm H\,I} > 5 \times 10^6\ M_\odot$.

Despite the number of surveys for low surface brightness, non-optical H I clouds which have returned null results, a number of very interesting objects have been discovered in H I observations. Such objects include H I 1225 + 01 (Giovanelli & Haynes 1989; the Virgo 'protogalaxy'), the Leo ring (Schneider 1985) and those galaxies found by Szomoru et al. (1993) in the Boötes void. However, there are at present very few candidates for gas clouds which are not associated with some optical emission.

2 Observations and Results

Using the Parkes 64 m radio telescope, we have surveyed the Centaurus and Fornax clusters in the 21 cm line of H I. We observed 512 pointings, each of three minutes duration, in both fields. The pointings were spaced on grids covering 8° × 8° of sky. The observations were made in 1991 March 19–21, 1991 August 13, 1993 June 16–21, 1994 September 15–19, with follow up observations in 1995 September 8–10. The typical spectral RMS noise was 16 mJy, and the velocity resolution $\sim 15\ {\rm km\,s^{-1}}$. Reference spectra were not taken separately from the survey pointings, and instead were obtained individually for a particular spectrum from linear combinations of spectra taken either side of the signal spectrum. All spectra were inspected visually, and the follow up observations were used to confirm detections.

After follow-up observations, 23 detections in the Centaurus field and 9 in Fornax were confirmed and identified with optically catalogued galaxies. Only one survey position showed detectable 21 cm emission, yet had no obvious association with any nearby catalogued galaxy. This galaxy, which we name Wombat I, was found at the nearby southern edge of the Fornax cluster. AT Compact Array observations of Wombat I found the total H I mass of the galaxy to be $8 \times 10^7\ M_\odot$, and at a distance of $8 h_{100}^{-1}$ Mpc, half of the H I gas is contained within 4 kpc. Wombat I is visible on Digitised Sky Survey plates, and appears to be a dwarf irregular galaxy.

3 Analysis

Because no H I gas clouds were detected, it is possible to place limits on the contribution of such clouds to the total mass density in each field. Following the analysis of Shostak (1977) and Fisher & Tully (1981), we obtain $\Omega_{\rm H\,I} <\sim 0{\cdot}01$ for non-optical gas clouds of mass 3×10^8–$3 \times 10^{11} (\delta V/100) h_{100}^{-2} M_\odot$. This upper limit is calculated for a 99% confidence limit, whereas many previous surveys use a 95% confidence limit.

4 Implications for the Parkes Multibeam All Sky Survey

Whilst our observations were centred on cluster environments, the large survey area means that we also probed lower density environments. Taking the Centaurus field as roughly a factor of 10 times overdense, we can expect on the order of one detection per pointing of the Parkes 13 feed array, when the Parkes Multibeam All Sky Survey begins in late 1996. Early estimates suggest that this survey will discover approximately 5000 new galaxies.

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During our survey of the Fornax cluster, a nearby large and bright galaxy, NGC 1365, was detected in two separate pointings of the single beam system. Essentially, one pointing happened to be towards the side of the galaxy rotating towards us, and the other pointing was towards the side of the galaxy rotating away from us, resulting in detections which differed by ~ 90 km s^{-1}. The survey and reduction technique for the All Sky Survey will need to correctly match signals in nearby beams, and indeed should be capable of mapping at moderate resolution such nearby, bright galaxies.

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Galactic H I Mapping and Optical–IR Studies

R. D. Davies

Nuffield Radio Astronomy Laboratories,
University of Manchester, Jodrell Bank,
Macclesfield, Cheshire, SK11 9DL, UK.
rdd@jb.man.ac.uk

Abstract: H I structure is seen at every scale down to the angular resolution limit of all survey telescopes. I present several examples of the structures at high Galactic latitudes with the 12 arcmin beam of the Lovell Telescope, the 2 arcmin resolution of the DRAO synthesis, as well as other indicators of finer scale structure in the interstellar medium (ISM).

1 Introduction

The current widely used all-sky or large-area surveys of the Galactic H I distribution are the Bell Telephone $2^\circ \cdot 5$ resolution survey (Stark et al. 1992) and those at $0^\circ \cdot 6$ using the 25-m telescopes (Weaver & Williams 1973; Heiles & Habing 1974; Hartmann & Burton 1996). These surveys have been used for many purposes including, for example, the calculation of Galactic optical absorption, comparison with IRAS IR distributions and studies of the intermediate scale ISM structure. The benefit of a higher resolution large-area survey at $12'$, as would be produced by the Lovell Telescope at Jodrell Bank using the multibeam system, would be immense. This paper describes some programmes of H I observations at this resolution which address a variety of astrophysical issues.

2 H I-IRAS Comparisons at 12 arcmin Scales

The 60μ and 100μ brightnesses measured by IRAS are known to correlate well with the Galactic H I surface density. However, this correlation is not perfect and reflects a range of physical conditions in the ISM which we have investigated by studying well-defined 100μ clouds at high Galactic latitudes with 100μ surface brightness in the range $0 \cdot 5$ to 5 mJy sr^{-1}. By using adjacent off-cloud references it is possible to establish accurately the ratio of far-infared to neutral hydrogen surface density I_{100}/N(H I) without dependence on the unknown FIR zero level. The individual FIR clouds were directly indentifiable in H I and each has its particular velocity (Malawi & Davies 1996). When the data from the independent observed points in all 12 observed clouds were plotted in the I_{60}/I_{100} vs I_{100}/N(H I) plane, a significant scatter was found. This scatter suggests that the clouds are subject to different interstellar radiation fields and that they consist of different mixes of dust grain sizes. The influence of the radiation field can be seen in the factor 2 difference in I_{100}/N(H I) between the Northern and Southern Galactic pole regions in the sense expected from the Sun's 20 pc offset from the mid-layer of the Galactic disk. Further, no difference was found between the FIR-H I properties of low velocity Galactic disk gas and intermediate velocity clouds (IVCs) at $v(\mathrm{lsr}) \sim -40$ km s^{-1}. It should also be emphasised that stray-radiation corrections are essential in any such intermediate and high latitude studies.

A survey by Willacy et al. (1993) of a $6^\circ \times 2^\circ$ field in the low H I surface brightness region centred on RA $= 10^h07^m$, Dec $= 53^\circ$ has been made with the $12'$ beam of the Lovell Telescope. This map of H I surface brightness was used in a study of the soft X-ray distribution from ROSAT. Again H I features were found on all scales down to the resolution limit of $12'$