Galactic HI mapping and optical–IR studies.

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Abstract

HI 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).

Keywords: The Galaxy: structure— Interstellar medium— Instrumentation: miscellaneous

1 Introduction

The current widely used all–sky or large–area surveys of the Galactic HI distribution are the Bell–Telephone 2°.5 resolution survey (Stark *et al.* 1992) and those at 0°.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 HI observations at this resolution which address a variety of astrophysical issues.

2 HI–IRAS comparisons at 12 arcmin scales

The 60μ and 100μ brightnesses meaured by IRAS are known to correlate well with the Galactic HI 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 0.5 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(HI) without dependance on the unknown FIR zero level. The individual FIR clouds were directly indentifiable in HI 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(HI) 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(HI) 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–HI properties of low velocity Galactic disk gas and intermediate velocity clouds (IVCs) at v(lsr) ~ -40 km s^{-1}. It should also be emphasized that stray–radiation corrections are essential in any such intermediate and high latitude studies.

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

3 Interstellar Medium Physics

The Queen's University Belfast–Jodrell Bank optical–IR programme addresses questions about physical conditions in the ISM. HI emission data are taken alonglines of sight to stars whose absorption spectra are of particular interest, for example lying in the direction of intermediate velocity clouds (IVCs) or high velocity clouds (HVCs). The -71 km s^{-1}IVC/HVC lying in front of the globular cluster M13 has been investigated in this way using Echelle spectra from the NaI D line and Ca II K line observations of stars in M13 along with 12' resolution HI spectra taken with the Lovell Telescope (Shaw *et al.* 1996). N(Na I)/N(HI) ratios in the clouds lying in front of M13 lie in the range $1 - -4 \times 10^{-8}$, while the N(CaII)/N(HI) ratios are $\geq 10^{-7}$. Temperatures in the compact clouds are a few hundred Kelvin while the warmer, more extensive, gas is at $\sim 10^4$ K. Ionization conditions can be determined for the clouds.

Similar investigations have been made of the conditions in the large gas concentration (1300 $M_\odot$), in the direction of Perseus at $l = 150°$, $b = -10°$ (Trapero *et al.* 1995). HI temperatures in this cloud reach as low as 30K. Systematic velocity changes across its surface of several km s^{-1}are found. A distance for the cloud of $\sim$ 100 pc was determined from the presence or not of corresponding absorption features in the spectra of stars lying this direction.

4 Angular structure in HI

Structure in Galactic HI is found on all scales accessible to observation. A good example of this range of structure may be found in the study of the M13 region by Shaw *et al.* (1996). Features are seen with the Lovell Telescope on scales of 12 arcmin and greater. Observations at 2 arcmin resolution with the DRAO Synthesis Telescope show structure on that scale while optical evidence from NaI and CaII spectra, and by implication HI, indicates significant differences in the line of sight to stars $\sim$ 10 arcsec apart. This interstellar material is believed to be at a distance of $\sim$ 100 pc where 1 arcmin corresponds to 0.03 pc.

Radio interferometer data on HI clouds seen in absorption against extragalactic radio sources show structure down to 0.1 arcsec. Davis, Diamond & Goss (1996) find 10–30 percent changes in optical depth over 0.1 arcsec in galactic HI lying in front of the sources 3C138 and 3C147.

5 Conclusions

The evidence presented above shows that Galactic HI occurs on all angular scales down to arcseconds. An all–sky survey of HI at an angular scale of $\sim$ 10 arcmin would provide a rich source of data for many current areas of interest. These include the distribution and kinematics of HI in the Galactic disk, the structure of the nearby ISM from studies of intermediate and high latitude

HI, HVCs and IVCs as well as tidal tails of our own Galaxy and the Magellanic Clouds. The imminent availability of multibeam systems for HI observations makes such large–area surveys a realistic possibility.

The Jodrell Bank multibeam system at present under construction consists of 4 dual–polarized horns at the prime focus of the Lovell Telescope. Each of the 8 receiver systems will operate with a system noise of 25K and feed into a 1024 channel 2–level correlator spectrometer. The system will be used for Galactic and extragalactic studies.

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