Kinematics of Diffuse Interstellar Clouds in the Galaxy

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Certificate:

This is to certify that the thesis entitled “Kinematics of Diffuse Interstellar Clouds in the Galaxy” submitted by Rekhesh Mohan for the award of the degree of Doctor of Philosophy of Jawaharlal Nehru University is his original work. This has not been published or submitted to any other University for any other Degree or Diploma.

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Declaration:

I hereby declare that the work reported in this thesis is entirely original. This thesis is composed independently by me at Raman Research Institute under the supervision of Dr. K. S. Dwarakanath. I further declare that the subject matter presented in this thesis has not previously formed the basis for the award of any degree, diploma, membership, associateship, fellowship or any other similar title of any university or institution.

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A summary of the new results

Speak the truth, then leave quickly.

—Serbian Proverb

HI 21cm-line absorption in diffuse clouds which had earlier been detected in optical absorption

- We have carried out sensitive HI 21cm-line absorption observations using the GMRT toward radio sources located at small angular separation from bright O and B stars whose spectra reveal the presence of intervening high random velocity CaII absorbing clouds, hitherto undetected in HI 21cm-line. ***In 5 out of the 14 directions searched, we detect HI 21cm-line absorption features from these clouds.***
- ***These are the first detections of HI absorption from high random velocity clouds.***
- ***The mean optical depth of these detections is $\sim$ 0.09, consistent with absorption arising from the cold neutral medium.***

A high Galactic latitude HI absorption survey

- We have conducted a sensitive high Galactic latitude HI absorption survey using the GMRT to obtain an independent dataset to compare with the existing optical absorption line data.
- ***With a mean rms sensitivity of $\sim$0.003 in HI optical depth, this is the most sensitive HI absorption survey so far.***
- ***We detected approximately 120 absorption features.***

- ***Of these, 13 are at random velocities greater than 15 km s^{-1}.***
- ***We find that the higher random velocity absorptions have smaller optical depths, as suspected by Rajagopal et al. (1998b), however the estimated spin temperatures are similar to that of the standard clouds.***
- ***We find the histogram of radial velocities to have two gaussian components, one with a dispersion $\sim$7 km s^{-1} and the second one with a dispersion $\sim$20 km s^{-1}.***
- ***While the significance of the wider gaussian component is not clear, it is consistent with the recent discovery of a population of HI clouds in the lower Galactic halo.***

Observation towards the Galactic Center and Anticenter

- Early HI 21cm-line absorption measurements towards the Galactic Center using the Parkes interferometer suggested the existence of a low optical depth ($\tau_{peak} \sim 0.3$), broad ($\sigma_v \sim 35$ km s^{-1}) feature centered at zero LSR velocity, and was attributed to a population of high random velocity diffuse HI clouds.
- However, later observations carried out using the WSRT did not confirm this.
- We have made fresh observations to resolve this longstanding and important issue.
- ***We see clear evidence for the presence of a wide HI absorption feature, with a peak optical depth τ_{HI} $\sim$0.31 and a dispersion σ_v $\sim$50 km s^{-1}.***
- ***We conclude that the Westerbork observations failed to detect this feature due to the insufficient bandwidth used in their observations.***
- ***No such feature was detected towards the Galactic Anticenter down to a 3σ limit of 0.006 in optical depth.***

HI absorption in the Intercloud medium

- The intercloud medium, also known as the Warm Neutral Medium (WNM), remains the least understood among the different phases of the interstellar medium.
- The spin temperature of the WNM and its filling factor are important parameters with implications on the models of the ISM, but only two measurements of HI absorption from the WNM exist till date.

- ***We have detected HI 21cm-line absorption in the Warm Neutral Medium of the Galaxy towards 3 more directions. The measured HI optical depth is in the range 0.0014 to 0.004.***
- ***The estimated spin temperature varies from $\sim$2500K $-$ 1400 K. We obtained a lower limit of $\sim$ 5200K towards the fourth line of sight.***
- The spin temperatures derived from our observations agree with the predictions of the two phase models of the ISM.
- ***We have also detected HI absorption in the high velocity gas in the Outer Arm Complex towards one line of sight. The inferred spin temperature is $\sim$ 450K.***
- ***In addition, we have also detected an unusual HI absorption feature ($\tau \sim$ 0.0009), the position and width of which seem to be correlated to a low T_B ($\sim$ 0.1K) wide ($\sigma_v \sim$ 66 km s^{-1}) HI emission feature in the Leiden Dwingeloo Sky survey, which are known as the large velocity dispersion (LVD) HI gas.***
- If confirmed, this will be the first observational evidence for HI absorption in the LVD HI gas, previously seen only in HI emission. The inferred spin temperature is ~ 100 K.

Acknowledgments

"The time has come" the walrus said, "to talk of many things"...
—Lewis Carroll, Through the looking glass

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One of the well known books in astrophysics begins with a quote, “Oh traveller, there are no paths, paths are made by walking”. But the initial mystery that attends any journey is: How did the traveller reach the starting point in the first place? Everything begins at home. I must thank my parents for their encouragement and continuing support, with apologies for not being there when they needed me the most. My girl friend, who walked in to my life while I was writing this thesis, thank you for everything. Last but, definitely not the least, I wish to thank my grandma, Lakshmi. I have been out of home for more than seven years now and my lifestyle has changed beyond recognition, but nothing could prepare me for her loss.

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Once again, I thank everyone.

R.M.

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