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COLD ATOMIC HYDROGEN IN THE INNER GALAXY

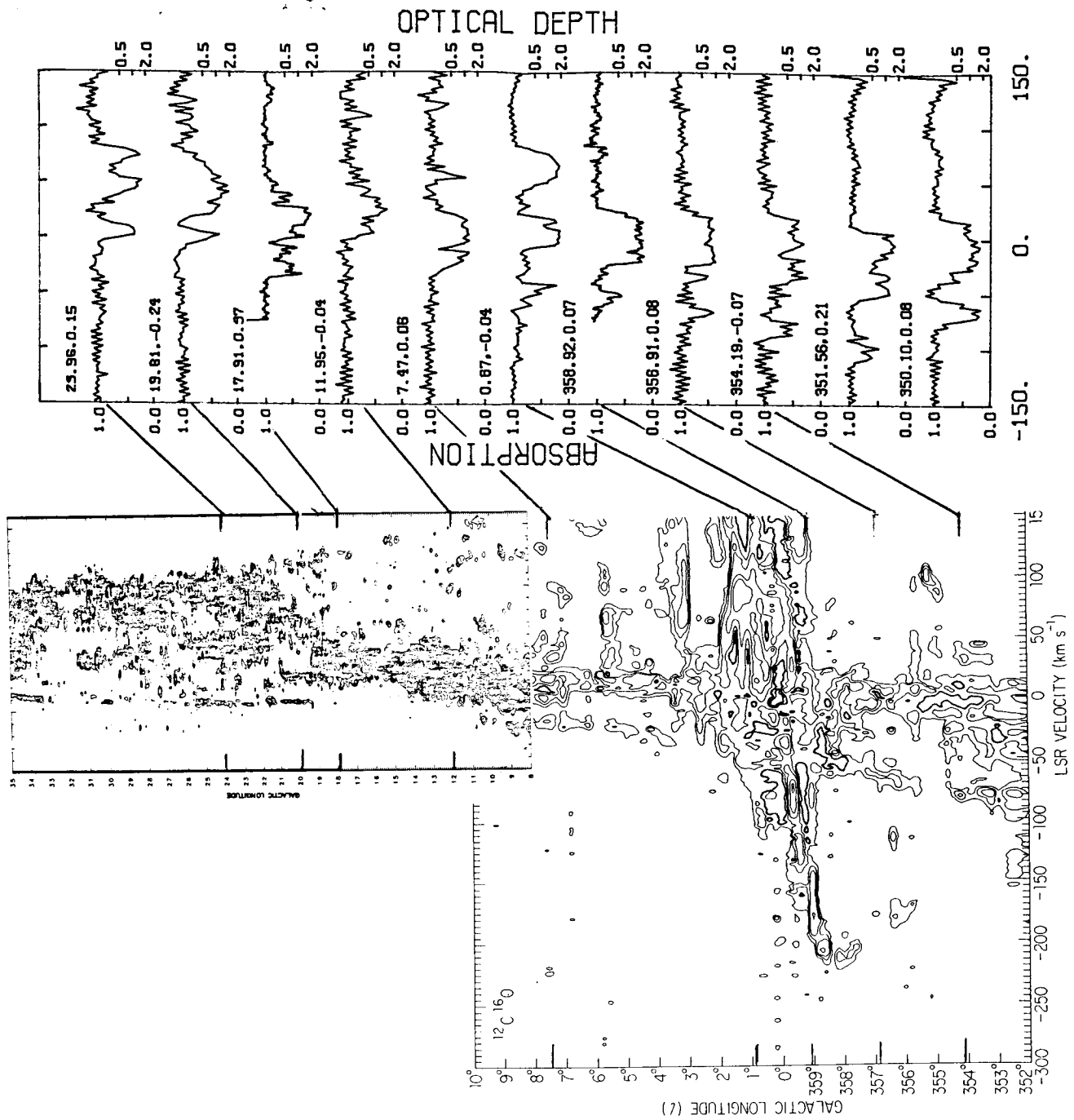
John M. Dickey and R. W. Garwood, University of Minnesota

Abstract : We have used the VLA to measure 21 cm absorption in directions with $|b| < 1^\circ$, $|l| < 25^\circ$ to probe the cool atomic gas in the inner galaxy. We detect abundant H I absorption; typical lines are deep and narrow, sometimes blending in velocity with adjacent features. Unlike 21 cm emission not all allowed velocities are covered : large portions of the l-v diagram are optically thin. Although not similar to H I emission, the absorption shows a striking correspondance with CO emission in the inner galaxy : essentially every strong feature detected in one survey is seen in the other. Our provisional conclusion is that in the inner galaxy most cool atomic gas is associated with molecular cloud complexes. There are few or no cold atomic clouds devoid of molecules in the inner galaxy, although these are common in the outer galaxy.

Background : In spite of many low latitude surveys of 21cm emission our knowledge of the detailed distribution of atomic hydrogen in the inner galaxy is not complete. The problem is the blending of the two phases of atomic gas. The warm gas (10 to 20 km/s linewidths) fills in the emission spectra to cover all velocities allowed by galactic rotation, while the cool phase is often optically thick and selectively obscures background gas. The fundamental question of how the cool atomic phase is distributed in the inner galaxy has remained unanswered, in spite of our growing understanding of the distribution of cold molecular clouds through surveys of CO. In this project we are studying the cool phase directly through a 21 cm absorption survey of the galactic plane.

Observations : Unfortunately in absorption we cannot observe a regular lattice of points and construct a map as in emission surveys. We first had to survey in continuum with the VLA to find background sources. We have made a catalog complete to 50 mJy of compact ($< 30''$) continuum sources at low latitudes (Garwood et al, in preparation). From the hundreds of sources discovered we selected nine to study in absorption with the VLA in "phased-up" mode (Dickey et al 1984, Ap. J. Supp. 53, 591). The high resolution of the B array (4'') avoids confusion due to emission structure. The spectra obtained cover -150 to +150 km/s with 2.6 km/s channels. The rms noise in optical depth ranges from 0.03 to 0.1.

Results : The figure shows a composite of the observed spectra arranged by longitude. Galactic coordinates (l,b) are given in the upper left of each spectrum. For comparison the longitude-velocity diagram of CO from Bania (1977, Ap. J. 216,381) and Clemens et al (1986 Ap. J. Supp. 60, 297) is shown. By tracing the longitudes of our sources horizontally across the l-v diagram one can see the correspondance between spectral features in CO and H I absorption, which is almost perfect. On the other hand, there is very little correspondance between absorption features and 21 cm emission lines; in emission the H I is largely saturated, and many clouds along the line of sight blend in velocity. In absorption there are narrow, distinct clouds, separated by velocities with no detected optical depth at all.



Conclusion : There is a one-to-one correspondance between features in the spectra of H I absorption, and the CO emission in the inner galaxy. This suggests that the cool diffuse phase of the interstellar medium is confined to the vicinity of molecular clouds. The atomic gas may be mixed with the molecules, or in a halo around and between molecular clumps. This situation is different from the solar neighborhood (observed at high latitudes) where many cool atomic clouds are seen with little or no molecular emission. The implication is that in the inner galaxy the role of the cool atomic phase is different from that in the outer galaxy. Whereas locally diffuse clouds are common (mean free path ~ 300 pc) and giant molecular clouds are much less common, in the inner galaxy these two phases may be intimately associated.