Poster contribution to IAU Symposium 170, *CO: Twenty-five Years of Millimeter-wave Spectrocopy*, 29 May – 2 June 1995, Tucson, Arizona

# Molecular Absorption Toward the Low-Latitude Radio Source 2023+336

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We have conducted millimeter-wave and centimeter-wave absorption observations toward the low-latitude radio source 2023+336 ($l$ = 73°, $b$ = -2°) in order to search for cold molecular gas, to compare directly the optical depths of the cool atomic and molecular phases of the ISM, and to characterize the chemical composition of molecular clouds in the Galaxy.

## Results

- We find multiple-component, translucent CO, HCN, HCO+ absorption in the inner Galaxy near 6 km $s^{-1}$ (Fig. 1) presumably associated with molecular clouds in the Cygnus Rift, $\sim$ 0.7 kpc away.
- There is only marginal ($3\sigma$) evidence for cold gas (CO absorption without emission) in the Galaxy near -55 km $s^{-1}$ (Fig. 1 and Kobulnicky, Dickey & Akeson 1995). This stands in contrast to two other lines of sight where absorptions at outer Galaxy velocities suggested that cold molecular gas might be abundant at large Galactic radii (Lequeux *et al.* 1993.) However, the number of lines of sight sampled in molecular absorption is small, and there could exist a population of subthermally excited molecular gas not detected in emission surveys (de Geus & Phillips 1995.)
- CO absorption line widths are as broad as the corresponding emission lines, even though the emission beam diameter subtends 0.2 pc and the absorption column subtends $\sim$ 1 AU! We conclude that the emission preferentially arises in denser clumps with small filling factor while the absorption comes from more diffuse regions of subthermal excitation; A similar situation has been noted toward BL LAC in CO (Marscher *et al.* 1991) and HCO+ (Lucas & Liszt 1993).

- $^{12}$CO absorption and emission spectra indicate low CO excitation temperatures of 4 to 6.0 K (Fig. 2).
- The CO absorption implies an optically thin line of sight, whereas $^{12}$CO/$^{13}$CO emission ratios of 13:1 imply a higher optical depth. One resolution to this apparent discrepancy would be that the background source happens to be seen through a "hole" in the molecular clouds so that our measured absorption optical depth is lower than the emission beam average. This solution demands even lower CO excitation temperatures. The alternative solution is a non-standard $^{12}$CO/$^{13}$CO ratio.

We also present the discovery of OH, HCN and HCO+ absorption toward another low-latitude continuum source, 2021+317, adding another interesting line of sight to the small but growing number of millimeter-wave absorption experiments (Fig. 3).

**References**


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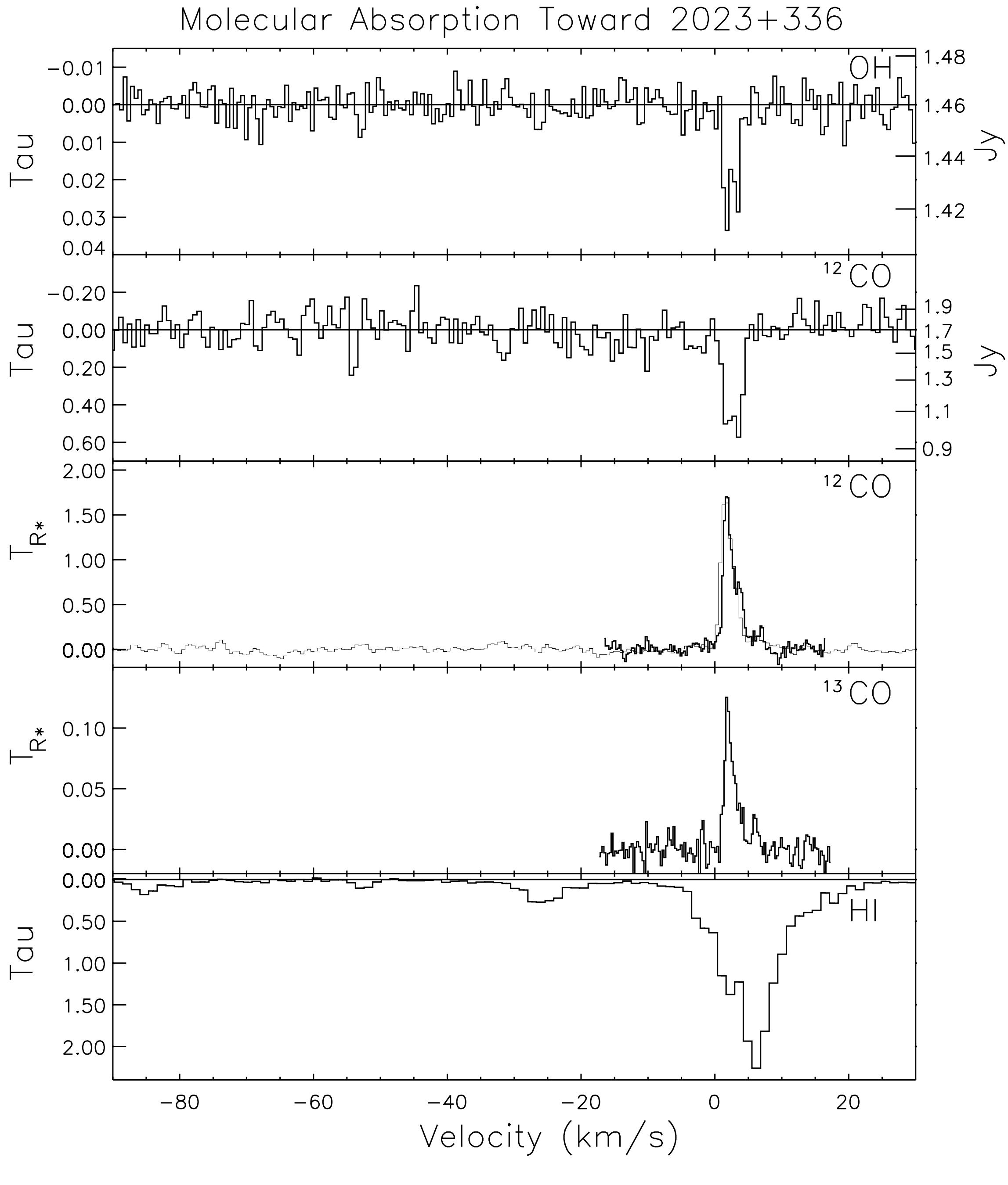


Figure 1: Molecular absorption and emission spectra toward the low-latitude radio source 2023+336 covering a wide range of Galactic velocities. The obvious features near 5 km $s^{-1}$ have a (somewhat uncertain) kinematic distance of 0.7 kpc, and presumably originate in the molecular clouds affiliated with the Cygnus Rift. We find a marginal (3 $\sigma$) CO, OH, and HI absorption feature near -55 km $s^{-1}$ which has no associated CO emission and has a kinematic distance of 11 kpc. The CO absorption profile is as broad as the CO emission profile, despite that the CO emission beam samples $10^8$ times more volume! Note the broad HCO+ emission near 6 km $s^{-1}$ corresponding to weak $^{12}$CO and $^{13}$CO emission, but there is no sign of CO absorption near 6 km $s^{-1}$. The HCN absorption near 6 km $s^{-1}$ is a hyperfine component of the main line at 2 km $s^{-1}$. Also of interest is the relatively low HCN optical depth of component B compared to CO and HCO+.

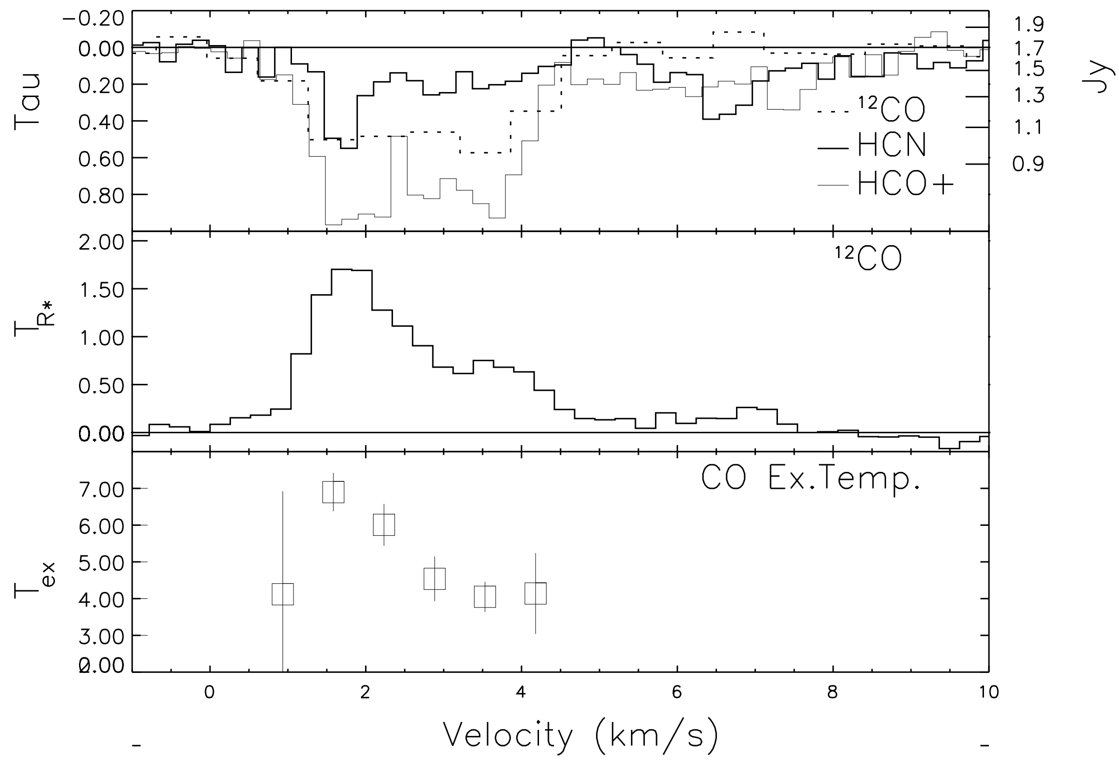


Figure 2: An enlarged view of Fig. 1. CO excitation temperature ($T_{ex}$) across the line profile is displayed along with an enlarged view of the mm-wave absorption lines and the $^{12}$CO emission data used to calculate $T_{ex}$. The gas is rotationally quite cold, having excitation temperatures only 1-3 degrees above the 2.7 K background.

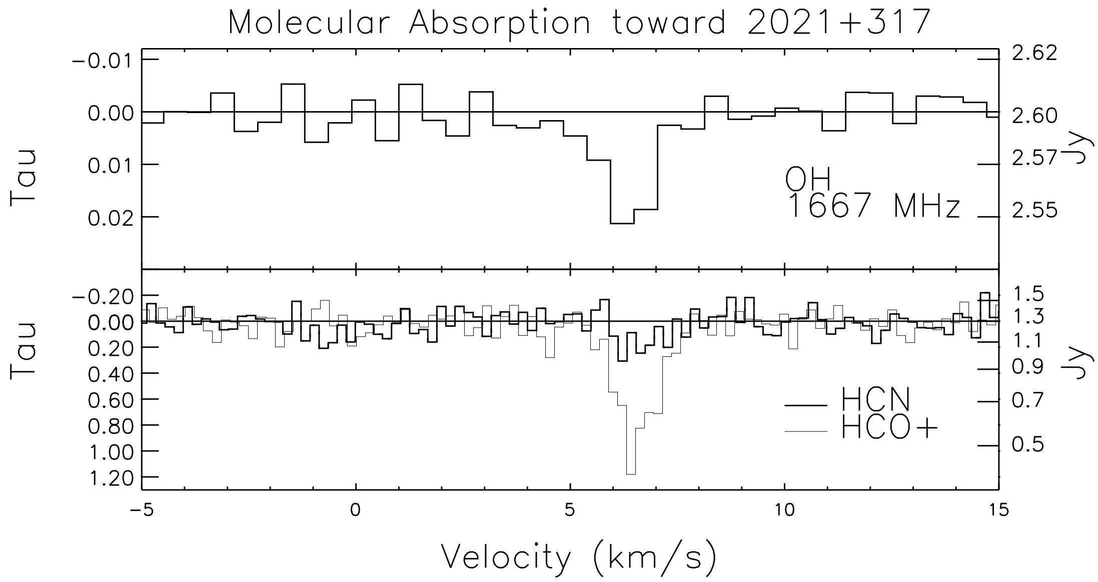


Figure 3: OH, HCO+ and HCN absorption toward 2021+317.