WARM, DENSE GAS NEAR THE MASSIVE PROTOSTAR AFGL 2136 IRS 1 AS REVEALED BY ABSORPTION FROM THE ν_1, ν_2, AND ν_3 BANDS OF WATER

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We have identified absorption features due to 47 different ro-vibrational transitions of the ν_1 and ν_3 fundamental and ν_2 overtone bands of H_2O between 2.468 μm and 2.561 μm toward the massive protostar AFGL 2136 IRS 1, and determined column densities in each rotational level. Analysis of the relative level populations indicates the absorption arises in warm ($T \approx 500$ K), very dense ($n_{\rm H} > 10^{10}$ cm^{-3}) gas in local thermodynamic equilibrium, with a total water column density of $N(\rm H_2O) \approx 10^{19}$ cm^{-2}. This gas must be very close to the central protostar, either in the inner envelope or a circumstellar disk/torus. Our findings are consistent with results inferred from 4.7 μm CO observations,[a] 6 μm H_2O observations,[b], and our own 2.5 μm HF observations.[c] This study represents the first extensive use of water vapor absorption lines in the near infrared, and we examine the possibility of using such observations to derive physical parameters in the gas surrounding other protostars.

[a]Mitchell, G. F., *et al.* 1990, ApJ, 363, 554

[b]Boonman, A. M. S., & van Dishoeck, E. F. 2003, A&A, 403, 1003

[c]Indriolo, N., Neufeld, D. A., Seifahrt, A., & Richter, M. J. 2013, ApJ, 764, 188