A PRECISE CN MEASUREMENT OF THE MICROWAVE BACKGROUND AT 1.32 mm

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ABSTRACT. We present very high signal-to-noise observations of the (1,0) and (0,0) vibrational bands of interstellar CN near 3580 and 3874 Å toward HD 21483. Corrected for saturation with a derived b-value of 1.29±0.05 km s^{-1}, these CN line strengths yield excitation temperatures of 2.83±0.09 and 2.76±0.07 K for the J=1-2 and J=0-1 rotational transitions at 1.32 and 2.64 mm. In the absence of local CN excitation, these values represent the brightness temperature of the cosmic microwave background (CMB) radiation at these wavelengths. Millimeter observations have revealed no CN emission at 2.64 mm toward HD 21483 and allow us to set a 2σ upper limit of 0.11 K on the contribution of local processes to the J=0-1 excitation. Considering this limit and the lesser likelihood of local J=1-2 excitation, our observations indicate a CMB temperature of 2.83±0.09 K at 1.32 mm.

1. INTRODUCTION

Optical absorption-line observations of the J=0-1 rotational excitation of interstellar CN have traditionally provided independent measures of the CMB temperature at 2.64 mm that have rivaled the best direct observations in accuracy (Thaddeus 1972; Meyer and Jura 1984, 1985; Crane et al. 1986). Such measurements of stars like ζ Oph have been made by comparing the CN J=0 and J=1 populations indicated by the R(0), R(1), and P(1) line strengths of the (0,0) vibrational band. Due to the extreme weakness of the R(2) and P(2) absorption ($W_\lambda < 0.1$ mÅ) arising from the CN J=2 level, these diffuse lines of sight are not as well suited for an accurate measurement of the CMB flux responsible for the J=1-2 rotational excitation at 1.32 mm. In this paper, we report a new CMB measurement at 1.32 mm based on very high signal-to-noise observations of the CN (0,0) R(2) and P(2) absorption in the CN-rich line of sight toward the star HD 21483.

2. OBSERVATIONS

The observations presented here were obtained in October, 1988, with the echelle spectrograph and TI2 charge-coupled device on the 4 m telescope at Kitt Peak National Observatory. The spectrograph was configured to observe the echelle orders covering the CN (1,0) and (0,0) bands simultaneously at a spectral resolution of 0.1 Å (3.4 pixels). A total of twelve 1 h exposures of HD 21483 were summed to produce net (1,0) and (0,0) spectra characterized by pixel-to-pixel S/N ratios of 500 and 1000. Our (0,0) spectrum is illustrated in Figure 1. We measure equivalent widths of 44.13±0.32, 23.31±0.31, 13.69±0.23, 1.04±0.15, and 0.72±0.15 mÅ for the CN (0,0) R(0), R(1), P(1), R(2), and P(2) lines, respectively. The CN (1,0) R(0), R(1), and P(1) line strengths are 7.89±0.27, 2.48±0.24, and 1.24±0.24 mÅ.

3. RESULTS

Our sensitive measurement of the optically thin (1,0) R(0) line toward HD 21483 allows us to confidently correct the CN lines for saturation using the Franck-Condon factors calculated by

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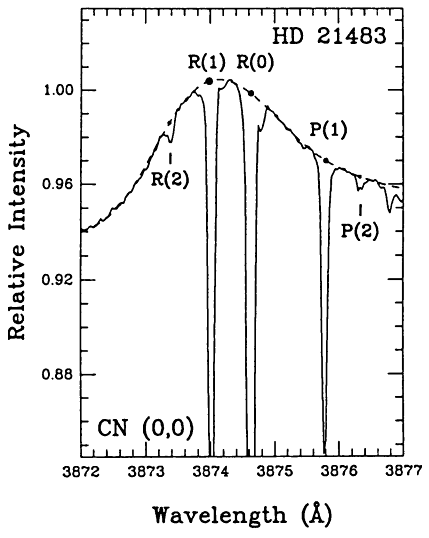

Figure 1. The (0,0) vibrational band of interstellar CN observed toward HD 21483. The broad continuum structure is due to the rotationally broadened photospheric lines of HD 21483 and the narrow feature at 3876.7 Å is instrumental in origin. The dashed curve represents our continuum fit and the diameters of the filled circles correspond to our $\pm 1\sigma$ estimates of the continuum placement errors for each line.

Dwivedi et al. (1978) and empirically verified by Meyer and Roth (1989, submitted). Assuming a standard single-component Gaussian line profile, the resulting b-value of 1.29±0.05 km s^{-1} leads to J=1-2 and J=0-1 excitation temperatures of 2.83±0.09 K(T_{12}) and 2.76±0.07 K(T_{01}). The accuracy of T_{12} is limited solely by the R(2) and P(2) measurement uncertainties.

If local processes such as electron collisions contribute to the CN excitation, their effect can be evaluated through direct observations of the CN emission at 2.64 mm (Penzias, Jefferts, and Wilson 1972; Crane et al. 1988). Consequently, we obtained millimeter observations of CN toward HD 21483 in March, 1988, using the National Radio Astronomy Observatory 12 m telescope at Kitt Peak. The resulting spectrum allows us to place a 2σ upper limit of 0.04 K on the antenna temperature (T_A) of the strongest CN J=1-0 hyperfine component at 113490.94 MHz. This constraint corresponds to a 2σ upper limit of 0.11 K on the contribution of local excitation to T_{01}. Considering this limit, the agreement of T_{01} with previous CN measurements of the CMB, and the lesser likelihood of local J=1-2 excitation, our observations indicate a CMB temperature of 2.83±0.09 K at 1.32 mm. This value is a factor of two improvement over the best previous 1.32 mm CN measurement (2.76±0.20 K; Meyer and Jura 1985) and consistent with the Matsumoto et al. (1988) rocket measurement of 2.799±0.018 K at 1.16 mm.

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