RADIO DETECTION OF AMMONIA IN IRC+10216

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1. INTRODUCTION

IRC+10216 (CW Leo) is a carbon star surrounded by an expanding circumstellar envelope which is rich in molecules. Recently, Betz *et al.*[1] reported the detection of rotation-vibration transitions of NH_3 (ν_2 band) in absorption against the infrared continuum of circumstellar dust. We now report the detection of the (1,1) and possibly the (2,2) inversion transitions of (para) NH_3, the first radio detection of ammonia in a star. This information can be used to determine the thermal structure of the envelope of IRC+10216.

2. OBSERVATIONS

The observations were made in May & June 1979 using the 46-meter telescope of the Algonquin Radio Observatory.* The telescope has a beamwidth of 1'.4 and an estimated beam efficiency $\eta_B \approx 0.28$ at 23.7 GHz. A cooled parametric amplifier with $T_S \approx 230$K was used with a very wideband (90 MHz) 100-channel filter spectrometer[2]. All observations were made using a new technique designed to provide a stable baseline over the wide observing window. The technique has previously been used successfully at the Algonquin Radio Observatory and is described by Bell[3]. The data were corrected for the variations in antenna gain and atmospheric attenuation with zenith angle, and the averaged spectrum was then smoothed by taking a running mean over two channels.

3. RESULTS

The radio spectrum of IRC+10216 is shown in Figure 1. In addition to the (1,1) and (2,2) inversion lines of NH_3 (para), we also

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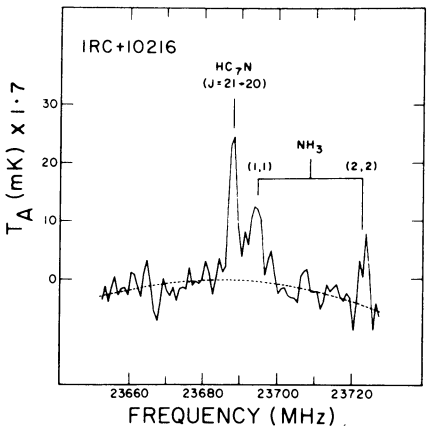

Fig. 1. Spectrum of IRC+10216

find the J=21→20 rotational transition of HC_7N, previously detected in IRC+10216 by Winnewisser and Walmsley[4]. The values of peak antenna temperature, T_A^*, corrected to outside the atmosphere and for the estimated beam efficiency at 23.7 GHz, are 27±5 and 16±5 mK, respectively, for the (1,1) and (2,2) lines of ammonia.

4. DISCUSSION

IRC+10216 is believed to be a late-type star undergoing extensive mass loss. If the ammonia molecules are manufactured in the outer atmosphere of the star and subsequently expelled in the form of a stellar wind, the higher rotational states will gradually become depopulated as the molecules move out to where the gas temperature is lower due to adiabatic expansion. Results of our observations are consistent with the (2,2) state being populated only within ~30" of the star, and with a gas temperature distribution of the form $T \approx 350(r/2\times10^{15}\text{cm})^{-0.6}$K, i.e. they are consistent with CO observations (cf. ref. 5). Because the (1,1) and (2,2) states have widely different excitation requirements, ammonia can be a very effective probe of the thermal structure of circumstellar envelopes. Assuming a mass-loss rate[5] of $2\times10^{-5}M_\odot\ yr^{-1}$, the abundance ratio of NH_3 (para) to H_2 is found to be 2×10^{-8}, which is similar to the total abundance ratio of $\sim10^{-7}$ reported by Betz *et al.*[1].

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