

Detection of HCO⁺ emission toward the PN K 3-35

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Abstract. Here we are reporting the detection of HCO⁺ ($J = 1 \rightarrow 0$) emission as well as weak emission of CO ($J = 1 \rightarrow 0$) toward the planetary nebula (PN) K 3-35 as a result of a molecular emission survey carried out toward this source. K 3-35 is remarkable because it is one of the two PNe that are known to exhibit water maser emission. In this nebula, the emission is present in the central region as well as at a distance of $\simeq 5000$ AU away from the center. The presence of molecular emission reveals some clues that could lead to the understanding of the persistence of water molecules in its envelope. We also report new spectra of the CO ($J = 2 \rightarrow 1$) transition. From the CO emission we have obtained a value for the excitation temperature of the molecular gas of $\simeq 20$ K. Using this result, we have estimated a molecular mass for the envelope of $\simeq 0.017 M_{\odot}$, and that the abundance for the HCO⁺ is 6.1×10^{-7} .

Keywords. Planetary Nebula — Stars: individual (K 3-35) — Radio lines: molecules — Stars: circumstellar matter

1. Introduction

K 3-35 is one of the two planetary nebulae (PNe) that have been found to harbor water maser emission (Miranda *et al.* 2001). Water-vapor masers that are detected in the envelopes of red giants (Elitzur 1992; Habing 1996) and also in some proto-PNe (Likkell & Morris 1988; Imai *et al.* 2002), are not expected to persist in the PN phase where the envelope begins to be ionized (Gómez *et al.* 1990). Therefore, the presence and persistence of water molecules in this PN is puzzling, probably related to some shielding mechanism due to the presence of high density molecular gas that protects water molecules against the ionizing radiation of the central star. A full understanding of this shielding mechanism requires first the characterization of the physical conditions of the molecular gas around the planetary nebula together with detailed modeling studies. Any information about the chemistry and physical parameters of the gas in K3-35 is very important to understand the characteristics of such a particular object. In order to find some clues that might help to better understand this object, we carried out a survey for molecular emission having as a result the first detection of the HCO⁺ ($J = 1 \rightarrow 0$) line emission toward this young planetary nebula.

2. Observations and Results

The survey for molecular lines toward the young planetary nebula K 3-35 was carried out using the Onsala 20 m telescope in Sweden (OSO), the 45 m Nobeyama telescope in Japan and the IRAM 30 m telescope in Spain and included the following molecules: SiO, HCO⁺, H¹³CO⁺, HNC, HCN, HC₅N, HC₃N, CS, CN, CH₃OH, CO and ¹³CO. We succeeded in detecting for the first time weak emission of HCO⁺ ($J = 1 \rightarrow 0$) with the 20 m Onsala telescope (HPBW=44''). Figure 1a shows the continuum subtracted spectrum in main beam brightness temperature. CO ($J = 1 \rightarrow 0$) emission also was detected for the first time using the Nobeyama 45 m telescope (HPBW=16'', lower panel of Figure 1b). Finally, we detected CO ($J = 2 \rightarrow 1$) emission toward K 3-35 using the IRAM 30 m telescope (HPBW=12'', upper panel of Figure 1b).

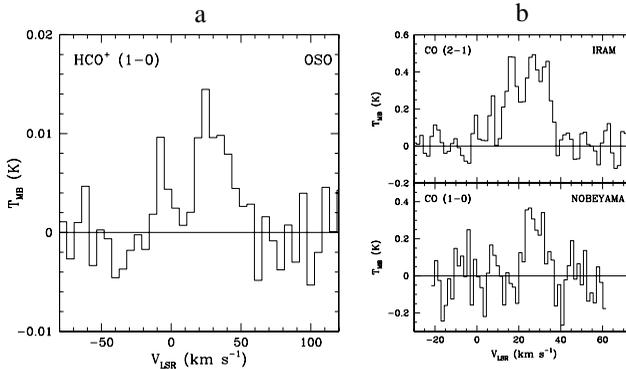


Figure 1. Left: Onsala telescope HCO⁺ ($J = 1 \rightarrow 0$) spectrum. Right (upper): CO ($J = 2 \rightarrow 1$) spectra obtained with the IRAM 30 m telescope. Right (Lower): CO ($J = 1 \rightarrow 0$) spectra obtained with the Nobeyama 45 m telescope.

In order to determine the physical parameters of the K 3-35 envelope it is necessary to determine the excitation temperature (T_{ex}). In trying to improve previous results, we used our CO observations and derived a value of 20 ± 6 K for this temperature. For this value of T_{ex} , we estimated that the column densities of CO and HCO⁺, averaged over their respective beams, are: $N(\text{CO}) = 4.95 \times 10^{15} \text{ cm}^{-2}$ and $N(\text{HCO}^+) \simeq 6.95 \times 10^{11} \text{ cm}^{-2}$. This results in a total molecular mass for the K 3-35 envelope of $M_{\text{mol}} \simeq 0.017 M_{\odot}$, and an abundance for the HCO⁺ of $X_{\text{HCO}^+} = 6.1 \times 10^{-7}$.

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