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INCLINATION OF THE HCO^+ TORUS IN THE NGC7027 MOLECULAR ENVELOPE

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ABSTRACT We have determined the inclination of the axis of the HCO^+ torus in NGC 7027 to the line of sight, based on interferometric observations and model calculations. We found that the deduced inclination of the HCO^+ torus is misaligned with the inclination of the major axis of the ionized core. The result may imply the precession of the axis of the axisymmetric mass loss.

NGC 7027 is a well studied young planetary nebula with a thick circumstellar envelope around visible ionized core of the size of about 10". Masson (1989) deduced the distance to the nebula as 880 pc by the VLA observations of the ionized core. Interferometric observations in the CO $J = 1 - 0$ line (Masson et al. 1985; Bieging et al. 1991) revealed that the CO envelope extends to about 70" diameter. Deguchi et al.(1990) detected strong HCO^+ line in this nebula. Interferometric observations with Nobeyama Millimeter Array in the same line (Deguchi et al.1992) with a beam size of 4.3" $\times$ 3.2" (HPBW) revealed that HCO^+ emission arose from a torus of the size of about 15". Recent observations by Likkel (1992) confirm the presence of HCO^+ torus, although the emission size is slightly larger than the size derived by Deguchi et al. (1992). The velocity channel maps [FIGURE I (left)] show that the torus is tilted to the line of sight. We attempt to determine the inclination of the axis of the HCO^+ torus by model fitting, based on the observations by Deguchi et al.(1992).

Model calculations by Deguchi et al.(1992) are improved, taking into account the effect of the inclination. We first determine the density distribution by fitting CO $J = 1 - 0$ observations (Bieging et al. 1991). The abundance of CO molecule is supposed to be uniform in the envelope. The temperature gradient in Deguchi et al. (1990) is adopted in the calculations. The ionized core is approximated as an elongated ellipsoidal shell, inclined 30° to the line of sight (Masson 1989). In the next step, we vary the distribution of HCO^+ and inclination of the torus, and search for the best fit model.

The fitting results are shown in FIGURE I (right). The best fit model shows that the HCO^+ ions are more concentrated in the torus than CO. Inclinations of the axis of the HCO^+ torus to the line of sight determined by the model fitting is $60° - 70°$. We also examine for CO envelope and get 55°. Masson (1989) has

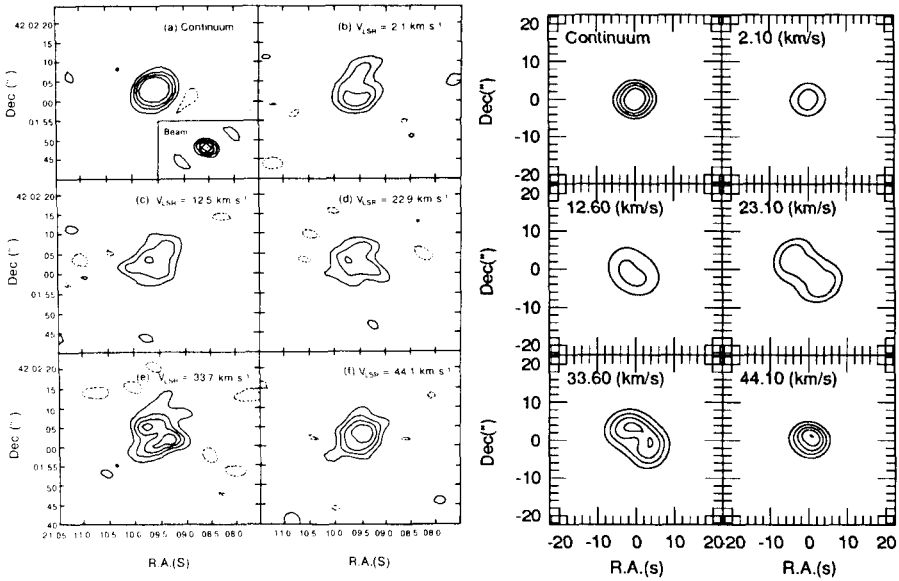

FIGURE 1 Observed(left) and calculated(right) velocity channel maps of HCO^+ in NGC 7027. The contour levels are $-0.4, -0.2, 0.2, 0.4, 0.6, 0.8$ and 1.0 of 0.784 Jy beam^{-1} for continuum and 1.04 Jy beam^{-1} for HCO^+ emission, respectively. Both continuum and HCO^+ emission are included.

derived the inclination of the ionized core as about 30° by VLA observations. Atherton et al. (1979) and Scott (1973) also deduced the inclination of the ionized region as 34° and 30°, respectively. Both the inclination HCO^+ and CO torus determined in the present study are completely different with these values. The reason of this misalignment has not been clarified. One possible explanation is that the precession of the axis of the axisymmetric mass loss at the last stage of the mass-losing phase. Observations with higher resolutions may resolve this puzzle (Guilloteau 1992).

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