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Molecular Line Emission from the Young Planetary Nebula NGC 7027

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NGC 7027 has been observed in eleven molecular species (in seventeen transitions) in the 200 and 300 GHz bands with the James Clarke Maxwell Telescope (Hasegawa & Kwok 2001). The results include a first detection of C_2H in this source. The observed spectra of HCO^+, $H^{13}CO^+$, HCN, CN, C_2H, and CO^+ show line widths larger than that of bulk CO emission but coincident with the full width at detection limit of weak wings in CO spectra. The sizes of the HCO^+, HCN, and CN emitting regions are $13''$ in diameter at half-peak level, significantly smaller than that ($60''$) of the CO emitting region. The emission of all the observed molecules other than CO and ^{13}CO must originate from a very small volume compared with the entire CO envelope of NGC 7027. Since the central $10''$ region is an ionized region, the molecular emission region (except CO) must be geometrically thin ($\Delta R = 1'' - 2''$) and must be close to the ionization front.

Excitation analyses on six molecules with electron and neutral collisions at an assumed gas temperature of 800 K yield similar density estimates ranging from 1.3 to 5 $\times 10^5$ cm^{-3} (Hasegawa & Kwok 2001). The similar density estimates are consistent with the picture that various molecular lines originate from the same gas in the photodissociation region in NGC 7027. Estimated column densities for HCO^+, HCN, CN, CO^+, and C_2H are in good agreement with predictions from the chemical model for the photodissociation region in NGC 7027 by Hasegawa, Volk & Kwok (2000).

The isotopomer ratio, $HCO^+/H^{13}CO^+$, is 40 in NGC 7027. HCO^+ is mostly formed *and* destroyed by chemical reactions, whereas CO and ^{13}CO are mostly photodissociated in planetary nebulae. Since ^{13}CO could be selectively photodissociated, $CO/^{13}CO$ ratio may not reflect the carbon isotope ratio $^{12}C/^{13}C$. Thus, $HCO^+/H^{13}CO^+$ should better reflect the carbon isotope ratio than $CO/^{13}CO$.

References

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