A Multi-line aperture synthesis study of Orion-KL

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ABSTRACT

We have mapped the Orion-KL region in 28 transitions of 16 molecular species (H_2CO, DCN, HDO, CH_3CH_2CN, HC_3N, SO_2, OCS, ^{29}SiO, SiO, SO, $H^{13}CN$, HCN, HCO^+, CH_3CN, CH_3OH, CO) near 3 millimeters wavelength using the BIMA array. The maps have $1'' - 6''$ angular resolution and $0.3 - 4$ km s^{-1} velocity resolution.

The images show two principal molecular concentrations in a ridge of dense gas, one toward the Kleinmann Low Nebula (KL), the other approximately $25''$ to the northeast, toward dust continuum source CS1. The "hot core", "compact ridge", and "plateau" spectral features all are associated with KL. This region has broad linewidths, high excitation emission, and unusual chemical abundances; it is associated with luminous infrared sources, masers, and a powerful bipolar outflow from at least one embedded young stellar object. By contrast, CS1 has narrower linewidths, lower temperatures, and only weak indications of star formation.

The maps provide evidence that the outflow from KL impacts and heats the southern edge of CS1. CH_3OH and CH_3CN emission peaks and a cluster of H_2O masers are seen here. The outflow may also be responsible for the velocity divergence of the ridge gas seen toward KL.

At $1''$ angular resolution the hot core appears as a chain of dense clumps offset approximately $1''$ east of radio continuum source I (IRc2). The HC_3N vibrational excitation temperature in the hot core is inferred to be 335 K.

The high abundance of HDO, DCN, and other deuterated species in the hot core indicates evaporation of icy grain mantles. CH_3OH, prominent in the compact ridge, appears to be liberated from the grain mantles at a lower temperature than H_2O, perhaps indicating that it is selectively evaporated from mixed molecular ices at ~ 120 K.

The "plateau" spectral feature looks quite different in different molecular tracers. Bright SiO v=0 emission appears to define a 1000 AU diameter flared disk around radio source I; weaker, thermal SiO emission appears to fill the infrared cavity around source I. SO and SO_2 form a shell of expanding gas, probably where the outflow shocks dense clumps along the periphery of the cavity. High velocity HCN and HC_3N emission seems to trace material ablated from these clumps.

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The high velocity outflow probably originates from source I. It does not appear to be well-collimated, but instead expands in a wide angle cone. The outflow appears to be partially blocked to the southeast by the hot core clumps.

In an appendix, we present a table of column densities for each observed molecular species at 9 positions across the source, for comparison with chemical models. All the maps discussed in this paper are available in FITS format from the NCSA digital image library.

Subject headings: interstellar: molecules — stars: formation — nebulae: Orion nebula