Thermal Processing of CO_2 Ice Around Massive Young Stellar Objects in the LMC

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Abstract:

We present *Spitzer Space Telescope* IRS spectroscopy of the CO_2 ice absorption feature at 15.2 µm toward ~40 high-mass young stellar objects (YSOs) in the Large Magellanic Cloud (LMC). The ices that create the absorption features reside in the cold outer regions of the massive YSOs' circumstellar envelopes. Observed toward both quiescent dark clouds and active regions of star formation, this particular feature displays an intriguing range of shapes: along lines of sight toward background extincted stars, the band is relatively smooth, however in regions of massive star formation which trace more processed material, the 15.2 µm feature shows a pronounced double peak resulting from a splitting of the bending mode characteristic of pure CO_2 ice. These profile differences are attributed to changes in the inter-molecular interactions between CO_2 and other neighboring molecules in ice mixtures on interstellar grains. Laboratory work has demonstrated that these interactions also have a large dependence on the temperature of the ice. Thus the shape of the CO_2 absorption profile is a measure of both the composition and thermal history of the ice. We have performed a decomposition of the massive YSO spectral profiles to determine the nature of the CO_2 ice mixture. We find that much of the CO_2 is embedded in a polar ice matrix, but that there are variations in the spectral shape which likely arise from the degree of the envelope ices' thermal processing. Results of the decomposition indicate that massive YSOs have warmed a substantially larger fraction of their envelopes than their lower-mass counterparts and that the ices of LMC massive YSOs may be more processed than those within the Milky Way. By comparing the decomposition results to models of circumstellar envelopes, we can make estimates about envelope thermal structure and distribution along with the temperature threshold required to modify the CO_2 ice.