Radiation Damage Effect on Photodesorption Rates from Astronomical Ices

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Photodesorption from an interstellar CO_2 (ice) analogue at 75K has been studied using Lyman-α (10.2 eV) radiation. We combine quantitative mass spectrometric studies of gases evolved and transmission IR studies of species trapped in the ice. Direct CO desorption is observed from the primary CO_2 photodissocation process which occurs promptly for CO_2 molecules located on the outermost surface of the ice (Process I). As the fluence of Lyman-α radiation increases to $\sim 5.5 \times 10^{17}$ photons cm^{-2}, extensive damage to the crystalline ice occurs, and photo-produced CO molecules from deeper regions (Process II) are found to desorb at a rapidly-increasing rate which becomes two orders of magnitude greater than Process I. It is postulated that deep radiation damage to produce an extensive amorphous phase of CO_2 occurs in the 50 nm ice film and that CO (and CO_2) diffusive transport is strongly enhanced in the amorphous phase. Photodesorption in Process II is a combination of electronic and thermally activated processes. Radiation damage in crystalline CO_2 ice has been monitored by its effects on the vibrational lineshapes of CO_2(ice). Here the crystalline-to-amorphous phase transition has been correlated with the occurrence of efficient molecular transport over long distance through the amorphous phase of CO_2 (ice). Future studies of the composition of interstellar molecular clouds generated by photodesorption from ice layers on dust grains will have to consider the significant effects of radiation damage on photodesorption rates.