IS WATER ICE THE PRECURSOR TO OH^+ AND H_2O^+ IN ORION KL?

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The reactive ions OH^+ and H_2O^+ have been observed in an outflow in front of the Orion KL region at significant column densities of $\sim 10^{13}$ cm^{-2} with the Heterodyne Instrument for the Far Infrared (HIFI) on the Herschel Space Observatory. No H_3O^+ was observed, establishing an upper limit of $\approx 10^{12}$ cm^{-2}. This is unexpected, because both OH^+ and H_2O^+ react with molecular hydrogen to form H_3O^+. The primary destruction of H_3O^+ is by recombination with electrons.

We explore the low velocity Orion KL outflow with a gas-grain PDR model where UV radiation, cosmic rays, X-rays, and temperature depend on both depth into the cloud and time. The model starts with cold core conditions and a radiation field of $\chi = 1$ and $\zeta_{\rm H2} = 5 \times 10^{-17}$ s^{-1} at the edge. Water ice collects on the grains at this time, and then as stars form, χ increases to 10^4 and $\zeta_{\rm H2}$ becomes 5×10^{-15} s^{-1} at the edge. At all times, temperature is calculated via thermal balance using the Meudon PDR code. At $A_{\rm V} < 4$ into the cloud the water desorbs off grains and becomes ionized by cosmic rays and X-rays, and dissociated by UV photons, increasing the rates of OH^+ and H_2O^+ formation. On the other hand, the increased electron fraction depletes the H_3O^+. The results of this model agree to within a factor of 5 with observation, and place the H_3O^+ column at $\approx 5 \times 10^{11}$ cm^{-2}. We will discuss the model and its results for the OH^+ and H_2O^+ ions as well as predicted abundances for other species.