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A desorption mechanism of water following vacuum-ultraviolet irradiation of amorphous solid water

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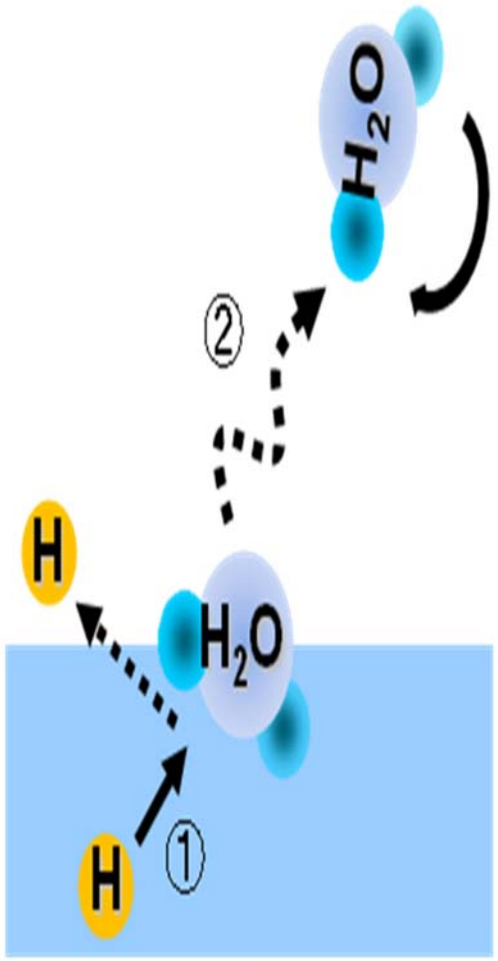

Figure 1 Schematic illustration for photodesorption of H_2O molecule from amorphous solid water via "kick-out" mechanism by a hot H atom released from phtodissociation of amorphous water ice. The numbers dedicate for sequence of the reaction.

Water ice is the major solid component in a variety of astrophysical environments, ranging from cold and dense molecular clouds, the small solar system objects such as Kuiper Belt objects, comets, to icy satellites in the outer solar system. In such cold regions where the thermal evaporation of ice is negligible, photodesorption plays a dominant role in consuming ice. Several experimental studies of the photodesorption of H_2O molecules from ice surfaces have been performed. However, these studies did not reveal the desorption mechanism or the energy partitioning of photodesorbed H_2O molecules, which is important for detailed modeling of gas-ice surface interactions, and/or as possible observational signatures of photodesorption.

In this study, photodesorption of H_2O molecules from amorphous solid water at 90 K has been investigated, in order to probe the photodesorption mechanism. Using resonance-enhanced multiphoton ionization technique, we have measured the translational and rotational energy distributions of photodesorbed H_2O molecules following vacuum-ultraviolet (VUV) laser irradiation of amorphous solid water.

The measured translational and rotational temperatures are 1800 K and 300 K, respectively. These energies are in good accord with those predicted by classical molecular dynamics calculations for H_2O photodesorption by a kick-out mechanism following absorption of a single UV photon, that is, an H_2O molecule is ejected from the ice by momentum transfer, mainly to the oxygen atom in H_2O, from an hot H atom released by photodissociation of a neighboring H_2O, i.e., reactions (1) and (2);

Photodissociation: H_2O(ice) + VUV -> hot H + OH, dH = 541.6 kJ mol^{-1}(1)
Water desorption: hot H + H_2O(ice) -> H + H_2O(gas). dH = 44.5 kJ mol^{-1}(2)

Keywords: amorhous aoild water, photodesorption, water molecule, comet, Kuiper Belt objects