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Photoelectric Emission from Metal-Doped Water Ice

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Water ice is known to be abundant throughout the universe. The photoelectric work function of pure water ice was established by VUV and X ray photoemission to lie between 8 - 9 eV.[1, 2] The work we describe here was stimulated by the observation of positively charged ice aerosols in the earth's polar summer mesopause region.[3,4] These ice particles occur close to the layers of metal atoms produced by meteoric ablation; if the inclusion of metal atoms in the ice lowered the ionization threshold, then this could potentially explain the observations. We will report a laboratory study of the photoelectric properties of the amorphous solid water (ASW) and cubic (I_c) ice phases, doped with sodium atoms. The ice layers were prepared by deposition from the gas phase using a directional doser under ultra high vacuum conditions (background pressure $<$ 8 x 10^{-11} Torr). The kinetic energy of emitted electrons, following pulsed laser irradiation, was measured by a time-of-flight detector as a function of the incident photon energy (2.2 – 4.6 eV). The deposition of .02 ML of sodium on the cubic ice reduces the work function of the surface to only 2.65 $\pm$ 0.1 eV. The photoemission cross-section is (1.7 $\pm$ 0.8) x 10^{-18} cm^2 for photon energies $>$ 2.8 eV, consistent with optical absorption measurements. The photoemission signal exhibits both a linear dependence on the laser power and on the amount of the deposited Na (0.01 - 0.1 ML). The Arrhenius activation energy for the decay of the initially formed Na species in the ice was determined as (10 $\pm$ 2) kJ mol^{-1}, corresponding to a lifetime of 10^3 s at 90 K. This is considerably slower than the time for photoelectric emission, about 10 s at 1 AU.

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