Laboratory measurements of atomic hydrogen diffusion and the ortho-para conversion of nascent H_2 molecules on amorphous solid water

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We experimentally approach the two astronomically significant issues: diffusion of hydrogen atom on amorphous solid water (ASW) at a low temperature and the ortho/para ratio of nascent H_2 molecule formed by recombination on ASW. Atomic hydrogen on ASW was directly detected by the combination of a photostimulated desorption and a resonance enhanced multiphoton ionization techniques [1]. Using this method, attenuation in the number of hydrogen atoms on ASW due to recombination and/or desorption was first measured in temperature range 8—20 K at very low H atom coverage, relevant to H_2 formation on cosmic ice dust. The obtained attenuation curve at 8 K clearly consists of fast and very slow components. The fast component is mainly attributable to the loss by H-H recombination after H-atom diffusion on shallow potential sites, while the very slow component would reflect the hydrogen atoms trapped in deep potential sites of ASW. Activation energies of the H-atom diffusion on shallow and deep potential sites are determined to be ~20 and >50 meV, respectively. Our results cover the previously reported activation energies of both 22 [2] and 41-55 meV [3]. The ortho-para nuclear spin ratio of nascent H_2 formed by recombination on ASW has been obtained for the first time and is higher than approximately 200 K. After formation, H_2 molecules are trapped and their spin temperature decreases due to the conversion of spin states on ASW. The scenario for H_2 formation on cosmic ice dust is that the hydrogen atom encounters another atom strongly trapped in the deep site after traveling on the shallower potential sites and after formation, H_2 molecules are trapped and their spin temperature decreases due to the conversion of spin states on ASW.

References

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