

Hydrogen formation in PDRs: Laboratory studies on recombinative hydrogen desorption from graphite

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Abstract.

Recent laboratory studies have shown that hydrogen atoms with temperatures exceeding 2000K, corresponding to velocities higher than 0.6 Km/s, adsorb into the chemisorption state on graphite surfaces [Zecho (2002)], at conditions similar to those occurring near dissociation fronts in photo dissociation regions (PDRs) [Hollenbach, & Tielens (1999)]. In the same study it was found by thermal desorption spectroscopy that hydrogen desorbs recombinatively with first order kinetics at temperatures around 450 K on a laboratory time scale [Zecho (2002)]. The corresponding desorption energy is compatible with 1.3eV, a value derived from an elaborate density functional analysis [Sha, & Jackson (2002)].

We present and discuss results of laboratory investigations on the dynamics of the molecular hydrogen formation reaction. In our ultra high vacuum surface science apparatus, we first cover a highly oriented pyrolytically grown graphite (0001) surface (HOPG) at room temperature with hydrogen atoms from a thermal cracker type atom source (T(H)= 2000K). We then apply pulsed laser assisted associative desorption (LAAD)[Diekhoner (2001)] to measure time-of-flight distributions of hydrogen and deuterium molecules released from the surface. We find that the molecules are ejected with high translational energies into the gas phase. The translational energy distribution peaks at around 1.3eV and is about 1.0eV wide, indicating that in the extreme up to 1/2 of the recombination energy is going into the translational co-ordinate. Molecules desorbing from step edges desorb at higher temperatures but exhibit a lower translational energy component, compatible with a surface temperature Maxwell Boltzmann distribution. Angular resolved measurements show that the desorption is sharply peaked into the direction of the surface normal, the width of the distribution depending on the surface temperature and the nature of the 'launch site' (basal plane sites/ edge site). An isotope effect could not be detected within the accuracy of the experiment.

Our experimental findings will be compared to theoretical analyses by density functional analysis of several groups [Sha, & Jackson (2002), Sidis (2000), Ferro *et al.* (2002), Miura (2003)], and will be discussed in terms of their astrochemical relevance. State resolved experiments on the energy partitioning into the remaining molecular degrees of freedom and into the energy left in the surface are in preparation.

Keywords. astrochemistry, ISM: molecules, ISM: atoms, methods: laboratory, (ISM:) dust, extinction

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