Femtosecond laser-induced associative desorption of molecular hydrogen from graphite

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The formation of molecular hydrogen via radiation-induced associative desorption from dust particles may play an important role in photon dominated regions of the interstellar medium and the interstellar cycle of matter. In the present study we investigate the desorption of molecular hydrogen and deuterium from HOPG (highly oriented pyrolitic graphite) following surface excitation with fs-laser pulses at $\lambda = 400\,nm$. Desorbed neutral species are analyzed by internal state selective two-photon ionization (1+1) REMPI in the XUV region.

The desorbing hydrogen molecules show a strong non-equilibrium behavior. The vibrational ground state is less populated than the first excited one, while measurements for higher excitations are on-going. State specific kinetic energy measurements show a significantly lower energy for $v'' = 1$: $E_{kin} = 170\,meV$ for $v'' = 0$ and $E_{kin} = 100\,meV$ for $v'' = 1$. Regarding the rotational populations, they present a non-thermal distribution that can be fitted by two rotational temperatures for low and high J''. The average rotational energy is determined to $E_{rot} = 390\,cm^{-1}$ and $480\,cm^{-1}$ for $v'' = 0$ and $v'' = 1$, respectively. The rotational behaviour for higher vibrational states is still to be determined. A nonlinear fluence dependence of the desorption yield allows two-pulse correlation measurements, which give an insight into the relevant desorption mechanisms. The FWHM is about $450\,fs$ which suggests an electron induced desorption mechanism. Measurements for molecular deuterium reveal similar results.