

Double-arm three-dimensional ion imaging apparatus for the study of ion pair channels in resonance enhanced multiphoton ionization

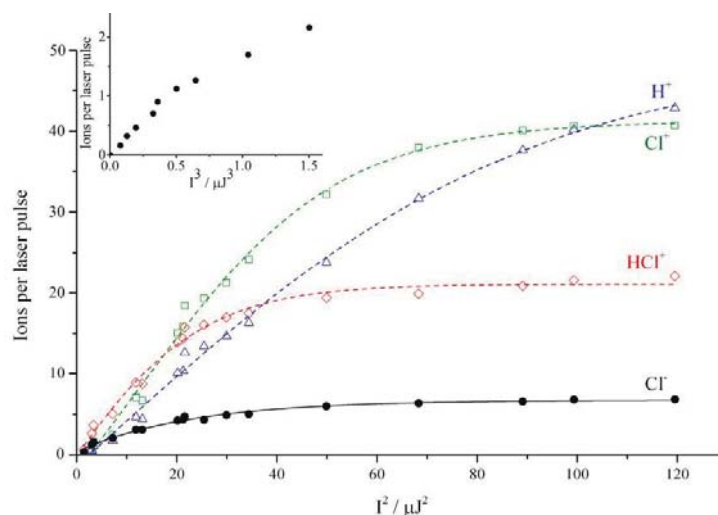
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We present a novel experimental configuration for the full characterization of the multichannel resonance enhanced multiphoton ionization (REMPI) of small molecules in cases when the ion-pair dissociation channel is important. For this purpose, a double-arm time-of-flight mass spectrometer with three-dimensional (3D) ion imaging detectors at both arms is constructed. The REMPI of HCl molecules is used to examine the constructed setup.

The apparatus allows us to perform simultaneous measurements of the 3D velocity vector distributions of positive (H^+ , HCl^+ , and Cl^+) and negative (Cl^-) photoions. The characterization consists of the determination of “two-photon absorption cross sections” for the process $HCl(X) + 2h\nu \rightarrow HCl^*$, one-photon absorption cross sections for subsequent processes $HCl^* + h\nu \rightarrow HCl^{**}$, and the probability of the subsequent non-adiabatic transition $HCl^{**} \rightarrow HCl(B) \rightarrow H^+ + Cl^-$, which leads to ionic pairs. All these data should be obtained from the analysis of the dependencies of the number of ions on the laser energy, see figure.



The full characterization of the laser beam and the knowledge of the ion detection probability are necessary parts of the analysis. Detailed knowledge of losses of produced ions in the mass spectrometer before detection requires understanding and characterization of such processes like electron emission from metallic grids under ion bombardment or charge transfer between positive ions and the metal surface of the grids, like $Cl^+ + (\text{grid}) \rightarrow Cl^-$. These important phenomena from surface science are rarely discussed in the imaging literature, and here, we try to compensate for this shortcoming.

[1] M. Poretskiy, A. I. Chichinin, C. Maul and K.-H. Gericke, "Double-arm three-dimensional ion imaging apparatus for the study of ion pair channels in resonance enhanced multiphoton ionization", *Rev. Sci. Instr.*, v.87 (2016) 023107-15.