Dissociation and Coulomb Explosion of Model Molecular Hydrogen Ions by Intense Short Laser Pulses

Uwe Thumm[*thumm@phys.ksu.edu*] and Bernold Feuerstein
Dept. of Physics
Kansas State University
Manhattan, KS 66506

In this talk I will discuss the interaction of 25 fs, 0.2 PW/cm^2, 780 nm pulses with H_2^+ molecular ions within a reduced-dimensionality model that represents both the nuclear and electronic motion by one degree of freedom. We carefully adjusted the adiabatic molecular electronic potential by introducing a “soft-core function” a(R) in the electron-nucleus interaction potentials $1/(x \pm R/2 + a(R))$ that depends on the internuclear distance R instead of the commonly used fixed soft-core constant a. We obtained molecular model potentials that reproduce accurate three-dimensional results for the known number of 19 vibrational states in the electronic ground state and for the dipole oscillator strength.

We solved the time-dependent Schrödinger equation on a two-dimensional numerical grid and designed a simple, but as far as we know, new method to calculate the flux of emitted electrons and protons by means of “virtual detectors” for electrons and protons. These detectors are placed outside the excursion range of the electron and at a distance R where the amplitudes of bound vibrational states have become irrelevant, respectively.

Our results reproduce the main features of measured kinetic-energy release spectra, support the “charge-resonance enhanced” ionization mechanism, and allow us to clearly distinguish between molecular dissociation (MD) into field-dressed final channels and fast, ionization-induced Coulomb explosion (CE). Both MD and CE appear as distinct peaks in the kinetic energy release spectra. We find that MD dominates for molecular ions that are prepared in the two lowest vibrational states only, while CE becomes increasingly dominating for higher vibrational states.

For two short laser pulses of variable delay, we started to resolve in time the interplay between MD and CE. We intend to further investigate the pump-probe dynamics for two short pulses of which I will discuss some first results. Motivated by new experiments in the Macdonald Laboratory, we have started to investigate the ionization of model atoms under the combined influence of a few-cycle intense laser pulse (10^{14} to 10^{15} W/cm^2) and a significantly longer and less intense pulse (about 10^{12} W/cm^2). I anticipate to discuss first results, including the effect of phase coherence between the two pulses.