Benchmark experiment on H_3^+ in intense ultrashort laser pulses

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Synopsis Using coincidence 3D momentum imaging we have probed, for the first time, the fragmentation dynamics of H_3^+ and its isotopologues in intense ultrashort laser pulses. As the simplest polyatomic molecule, these measurements on H_3^+ can serve as a benchmark for future theoretical calculations.

The two-electron H_3^+ ion is the simplest stable polyatomic molecule. The H_3^+ nuclei are arranged in a unique triangular configuration, which provides a fundamentally new system for theoretical development of calculating strong laser-field phenomena. Currently, however, H_3^+ is a serious challenge to theorists since it is at the boundary of present capabilities. Thus, appropriate simplifying assumptions are needed and experiments can provide the necessary guidance to find them.

Unfortunately neither H_3^+, nor H_3, exist naturally in the laboratory, despite their central role in interstellar chemistry. Thus, to perform experiments on H_3^+ requires their production in an ion source. This necessitates the use of the more demanding ion beam targets. Nonetheless, many previous attempts have been made to study H_3^+ in an intense laser field without any success.

Seemingly the biggest factor in these failings has been the low rate of H_3^+ fragmentation, even at intensities up to 10^{16} W/cm^2. Consequently, in parallel with work on diatomic molecules [1, 2], we have developed a coincidence 3D momentum-imaging method [1] that allows for the efficient detection of all fragments, both from two-body and three-body breakup of H_3^+ — see illustration in Fig. 1.

At this conference we present extensive measurements from dissociation and ionization of a few keV D_3^+ beam target and contrast them with measurements on H_3^+ and D_2H^+, where interestingly we find isotopic effects in the latter. We use 790 nm, 7-40 fs, 1 kHz (linearly polarized) laser pulses that span $10^{14} - 10^{16}$ W/cm^2 in our measurements.

Some of the interesting questions we address involve the competition between two-body and three-body dissociation, and single ionization. Moreover, the three-body breakup channels particularly provide insight on the alignment and orientation preference of fragmentation of the H_3^+ triangle relative to the laser polarization.

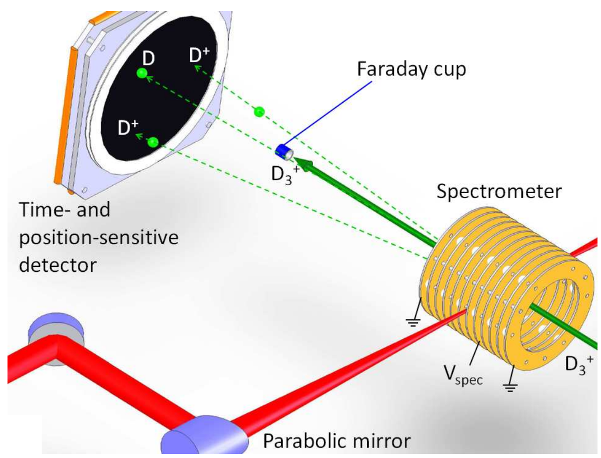

Fig. 1. Schematic of the experimental setup where all fragments from D_3^+ breakup are imaged in coincidence.

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References

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