A.7. Offsite Experiments

A.7.1. Double Photo-Ionization of He and D_2 by Single Photons--*R. Dörner,* H. Bräuning,* V. Mergel,* O. Jagutzki,* L. Spielberger,* H. Khemliche,** M. H.Prior,** A.Staudte,** J. Ullrich,* C. L. Cocke, H. Schmidt-Böcking,* A. Bräuning-Demian,* K. Carnes, P.Richard, S. Dreuil,* M. Achler,* J. M. Feagin, T. Osipov, A.Cassimi,**** A.Landers,*** T.Weber,* A. Czasch**

This work is carried out in a collaborative project involving the University of Frankfurt*, Lawrence Berkeley Laboratory**, Kansas State University, Western Michigan University***, and CIRIL****. The primary emphasis has been to use COLTRIMS techniques to investigate in a kinematically complete experiment the photodouble ionization of He and D_2 by single photons from the Advanced Light Source (ALS) at LBL over an energy range from threshold to typically 30 eV above threshold. The scientific goal of the experiments is to determine what the correlation patterns of the two out going momenta of the electrons is and to seek identifiable mechanisms for this correlated motion (such as initial state correlation, final state correlation, collective motion in either state, etc.). For the case of the molecular target, an additional goal is to determine how the process depends on the alignment of the internuclear axis. The experiments are performed on "fixed in space" molecules, using *a posteriori* alignment. Control over this alignment has not been possible traditionally, with the first such experiments appearing only a few years ago. The experimental results show that the molecular alignment has a very large effect on the electron momenta. Because the selection rules which apply to photodouble ionization of He differ from those for triplet final states of Ne, we measured the patterns for double ionization of He. During our last running period, this work was extended to include the measurement of photoelectron angular distributions from CO molecules fixed in space, where the excitation took place near the K ionization thresholds of the C and/or O. Results on He have been published in Publications #40 and 41.

The specific experiments we have performed over the past two years include:

1. Photodouble ionization of D_2: the initial experiment on molecular deuterium was carried out without full kinematic control over the four Coulomb particles emanating from the experiment. The detection of two D^+ ions and only one electron was performed using multihit delayline detectors for the two D^+ fragments and single electron detection. This experiment allowed us to unambiguously determine the energy sharing between electronic and nuclear

degrees of freedom and to see the influence of the molecular axis on the photoelectron angular distribution, but did not permit the investigation of the influence of the molecular alignment on the correlation pattern of the two-electrons´ momenta. The major results were that the energy sharing can be understood using a simple reflection (Franck-Condon) model based on a vertical transition from the D_2 initial state directly to the four particle continuum, and that the angular distribution of single photoelectrons is strongly influenced by the molecular alignment, appearing to be focused by the presence of the dissociating D^+ ions. Some angular distributions are shown in Fig. 1. These results are reported in Publication #42.

Figure 1. Polar plots of electron distributions from double ionization D_2 by 58.8 eV photons. The polarization vector is horizontal. In the left and right hand panels the molecular axis is parallel to and perpendicular to the polarization vector, respectively (Publication #42).

2. In two further runs, complete four body data were obtained, allowing us to investigate the degree to which the correlation patterns seen earlier by us in photo double ionization of He remained present for the molecular case. These data are still under analysis, but some general features can be described. When averaged over all molecular alignments, the correlation patterns in He and D_2 are found to be quite similar. However, these patterns do vary with molecular alignment.

3. The analysis of the double photoionization of Ne is still underway. A technical problem in this case is that it is necessary to detect the two electrons directly with a multihit detector. The pulse pair resolution of the detector has a strong influence on the observed correlation pattern, and we are working to improve the data analysis to get by this problem.

4. Complete photoelectron angular distributions for the CO ionization were measured up to 30 eV above the O and C K edges as a function of molecular orientation, photon energy and final ionic channel. The data set is sufficiently large to permit a very comprehensive picture of the important processes to be formulated. Some physical effects, which are apparent are: The

f wave shape resonance of the photoelectron in the molecular potential is very apparent and has been mapped as a function of photoelectron energy. The interference between outgoing waves from the primary K ionized center and that scattered off the other center is strong and mapped as a function of electron energy and orientation. Strong non-dipole effects in the ionization are observed, especially for orientation of the molecule parallel to or antiparallel to the propagation vector of the photon. Theoretical analysis of this process is being carried out at LBL by Ricardo and collaborators. Analysis of this data is in process.

References

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