High resolution studies of dissociative electron attachment to molecules

H. Hotop[1], M. Braun[1], S. Marienfeld[1], M.-W. Ruf [1], and I. I. Fabrikant[1,2]

[1]*Fachbereich Physik, Universität Kaiserslautern, D - 67653 Kaiserslautern, Germany*
[2]*Department of Physics and Astronomy, Univ. of Nebraska, Lincoln, NE 68588, USA*

Experimental advances involving laser photoelectron sources have recently allowed detailed studies of low energy electron attachment to several small molecules at (sub)meV resolution [1]. For the first time, the limiting ($E \rightarrow 0$) threshold behaviour for s-wave (e.g. SF_6, CCl_4) and p-wave (e.g. Cl_2) electron attachment could be conclusively demonstrated [1]. At onsets for vibrational excitation, Wigner cusps due to channel interactions were clearly detected, and vibrational Feshbach resonances were observed for the first time in the dissociative electron attachment (DEA) channel [1]. Absolute DEA cross sections over the range E = 0.5 to 200 meV were established by normalizing the measured energy-dependent yields for anion formation to reliable rate coefficients, For comparison with the experimental results, semiempirical resonance R-matrix calculations have been carried out for several molecules; good agreement between the measured and calculated cross sections was achieved for the important cases Cl_2, SF_6, and CH_3I. The input for the theory includes the often known energetic and structural parameters of the neutral molecules and their anions while the parameters of the resonant anion curves are fixed with reference to the known thermal rate coefficients for the DEA process.

With the aim to provide benchmark DEA cross sections for some important molecules and to further test the theoretical calculations, we have extended the Laser Photoelectron Attachment (LPA) method towards higher energies by using a modified approach (EXLPA): it involves magnetically-guided combined acceleration/deceleration of zero-energy photoelectrons from a spatially separated photoionization region to the reaction volume, using as a molecular target either a static gas at 300 K or molecules in a seeded supersonic beam from a heatable nozzle (300 – 600 K). Typical resolutions of the EXLPA data are 20 –30 meV (FWHM). Joining the LPA with the EXLPA data in the energy range 50 – 200 meVyields highly-resolved absolute DEA cross sections from 1 meV up to several eV. At the conference results will be presented for the molecules SF_6 [3], CCl_4, $CHCl_3$, CCl_2F_2, CF_3I [4], and CF_3Br and compared with previous experimental and available theoretical work.

This work has been supported by the Deutsche Forschungsgemeinschaft and by the Forschungszentrum OTLAP. IIF acknowledges support from the US National Science Foundation.

[1] H. Hotop, M.-W. Ruf, M. Allan, I. I. Fabrikant, Adv. At. Mol. Opt. Phys. **49** (2003) 85-216

[2] L. G. Christophorou, Z. Phys. Chem. **195** (1996) 195

[3] M. Braun, S: Barsotti, S. Marienfeld, E. Leber, J. M. Weber, M.-W. Ruf, H. Hotop, Eur. Phys. J. D (submitted)

[4] S. Marienfeld, I. I. Fabrikant, M. Braun, M.-W. Ruf, H. Hotop, J. Phys. B (to be submitted)