Photodetachment of O^-: the complete picture

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Synopsis We have measured together the absolute total, partial and differential cross sections for the photodetachment of the oxygen anion over an unprecedented range of photon energies. The total cross section is measured using the animated-crossed-beam technique while the asymmetry parameters and branching ratios are measured using a velocity map imaging spectrometer. The broadband OPO light source used allows to finely scan the photon energy from threshold to 5.5 eV.

Although photodetachment of atomic negative ions has been widely studied, experimental work is very often limited to a few photon energies, and targets a specific quantity, either the asymmetry parameter β or the total photodetachment cross section σ. With the advent of widely tunable laser sources, measurements over much broader photon energy ranges are now feasible. In parallel, the development of the animated-crossed-beam technique for photodetachment [1] has opened the way to systematic, accurate and absolute cross section measurements, while the well-established velocity map imaging (VMI) technique is particularly powerful for the determination of asymmetry parameters and branching ratios. We have combined these techniques to study the photodetachment of O^- in full detail.

In a first experiment, we used the animated-crossed-beam technique, together with a pulsed laser, to measure the total absolute photodetachment cross section for photon energies ranging from threshold (1.46 eV) to 5.5 eV. The animated crossed beam technique eliminates the need for estimating the interaction volume, which often introduces inaccuracies in experimental results, leaving only integrated fluxes to be measured and thus providing us with a robust and reliable method for absolute measurements. The results, displayed in Fig. 1, confirm the trends observed in our previous measurement [1]: pronounced disagreements exist with the calculation of Zatsarinny and Bartschat [4], and with other absolute experiments [5].

In a second step, we have constructed a VMI spectrometer in order to measure asymmetry parameters and final-state branching ratios. The instrument is devised to detect photoelectrons detached from a fast (several keVs) anion beam entering the VMI perpendicularly to the detection axis. The issues brought by the use of a fast beam and the perpendicular geometry have been tackled by modifying the original VMI design of León *et al.* [2] in order to accommodate a deflector and re-referencing unit. Our setup provides an energy resolution of about 2% and an accuracy of about 5% for β. We have taken VMI images for photon energies ranging, again, from threshold to 5.5 eV, and the analysis of the data is currently under way. Preliminary results for the asymmetry parameter β already show good overall agreement with previous works [3].

The present results offer a complete picture of the photodetachment of O^- in terms of *absolute* total, partial and differential cross sections, and over an unprecedented range of photon energies. Discrepancies with some theoretical calculations and some other experiments certainly call for further studies. The present work also stands as a methodological development paving the way to complete studies of the photodetachment of other atomic and molecular anions, and of other photoinduced processes.

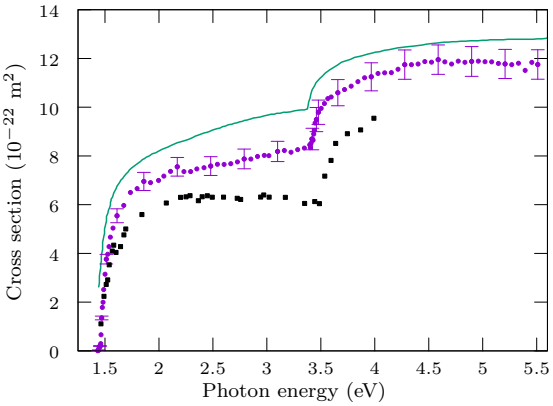

Figure 1. Absolute photodetachment cross section of O^-. Circles: present results, squares: Branscomb *et al.* and Smith (see [5] and references therein), full line: of Zatsarinny and Bartschat [4]

References

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