Iodine anion photodetachment in a 16-pole ion trap

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Synopsis We benchmark a room-temperature 16-pole radiofrequency ion trap by measuring the absolute photodetachment cross section of mass-selected iodine anions (I^-) from the photodetachment decay rate and the simulated ion column density, obtaining $(2.0 \pm 0.2) \times 10^{-17}$ cm^2 at 378 nm and $(1.7 \pm 0.2) \times 10^{-17}$ cm^2 at 403 nm. The 16-pole ion trap will be used for gas-phase photofragmentation or photodetachment of biomolecular ions and chirality-sensitive photofragmentation of enantiomers with circularly polarised light.

The absolute photodetachment cross section is a measure of the photostability of anions. A room-temperature 16-pole ion trap has been developed in our group [1], with which absolute cross sections of molecular and atomic ions can be measured within hours [2].

Anions from an electrospray source pass an ion transfer capillary, an RF ion funnel and a quadrupole ion guide, are mass-selected by a quadrupole mass filter (QMF) and stored in the 16-pole trap (figure 1). After a variable storage time they are extracted through an einzel lens and a second QMF, set to the parent or a fragment mass, onto a microchannel-plate (MCP) detector.

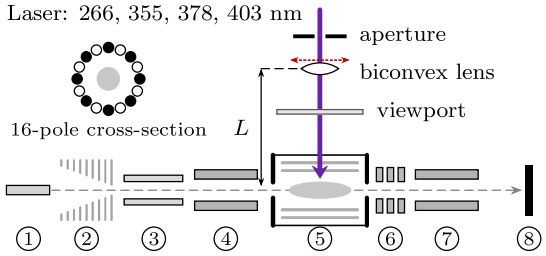


Figure 1. Setup: (1) capillary, (2) ion funnel, (3) quadrupole ion guide, (4, 7) QMFs, (5) 16-pole trap, (6) einzel lens, (8) MCP detector; L is the lens–trap distance.

Laser-on and laser-off decay curves of the ion number versus storage time give the photodetachment rate k_{pd} and the background rate k_{bg}. As $k_{\mathrm{pd}} = \sigma_{\mathrm{pd}}\,\rho(r)\,F_{\mathrm{L}}$, where F_{L} is the photon flux and $\rho(r)$ the single-particle column density at the laser position obtained from simulations of the trapped ion cloud, a single rate measurement yields σ_{pd} without full laser depletion tomography [2].

The iodine anion (I^-) is an ideal benchmark, since its only photo-induced loss is detachment. We obtain $\sigma_{\mathrm{pd}} = (2.0 \pm 0.2) \times 10^{-17}$ cm^2 at 378 nm and $(2.0 \pm 0.2) \times 10^{-17}$ cm^2 at 403 nm, in agreement with the reported values [3].

Our main goal is to probe chirality by photofragmentation. Irradiating a mass-selected enantiomer with left- or right-circularly polarised light (LCP/RCP) gives the photofragmentation cross sections σ_{L} and σ_{R} and hence the asymmetry factor $g = 2(\sigma_{\mathrm{L}} - \sigma_{\mathrm{R}})/(\sigma_{\mathrm{L}} + \sigma_{\mathrm{R}})$, a mass-resolved analogue of circular dichroism [4]. Enantiomer pairs such as D/L-tryptophan provide a built-in control: a genuine chiroptical signal reverses sign between D and L.

References

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