Intra-cavity photodetachment microscopy and the electron affinity of germanium

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Photodetachment microscopy is performed inside an optical cavity, on an ion beam and with an optical mode narrow enough not to blur out the output electron interferogram. This setting is used for an updated measurement of the electron affinity of germanium. Amplification of the photodetachment probability obtained in an optical cavity also opens the way to photodetachment microscopy with a p electron wave, even though photodetachment cross-sections are reduced considerably in this case, when compared to s-wave detachment, by the centrifugal barrier.

A linear optical cavity is set across a beam of Ge^- ions, itself produced by a cesium sputtering ion source. The optical cavity is injected with a single mode ring Ti:Sa laser, the wavenumber of which can be set either above the highest $^3P_2$ fine-structure excitation threshold, or just above the $^3P_1$, intermediate fine-structure threshold of the ^3P ground-term of Ge I. The freed photoelectron is accelerated towards an imaging detector by a uniform electric field of about 350 Vm^{-1}. When the initial kinetic energy is of the order of 50 m^{-1}, an electron interferogram can be observed, which semi-classically corresponds to the existence of a pair of trajectories bound to every detection point.

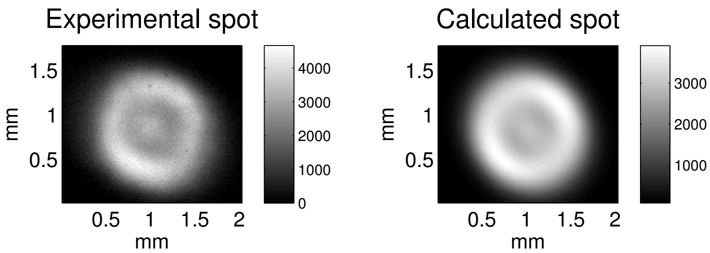

Figure 1: *Intracavity-produced electron interferogram. In this example, photodetachment of Ge^- at wavenumber $\lambda^{-1} = 1135\,258.9(1)\,\mathrm{m}^{-1}$, within an electric field of 357.6 Vm^{-1}, produces an electron interferogram of apparent energy $\epsilon = 44.2(15)\,\mathrm{m}^{-1}$. Persistence of a ring pattern, with fringes not much more than $100\,\mu m$ wide, shows that the ion beam diameter has been reduced to smaller values.*

Fitting these interferograms with the expected form of the uniform acceleration Green function, one gets a measure of the electron's initial kinetic energy. The precision of the method can be three orders of magnitude larger than the precision of classical electron spectrometry. Provided that the two photoelectron energies produced by the two opposite wave vectors contained in the optical cavity are not too different, i.e. provided that the illumination angle remains close to 90 °, subtraction of the mean photoelectron energy from the photon energy directly provides a high accuracy measurement of the electron affinity.

A Doppler-free measurement of the photodetachment threshold can thus be produced, in an optical cavity, even more directly than with the usual double spot photodetachment microscopy method [1], at the only expense of a slight reduction of the contrast in the interferograms. The obtained value of the electron affinity of germanium is 994 220.6 (10) m^{-1} or 1.232 6764 (12) eV, one order of magnitude more precise and a little smaller than the last measured value 994 249 (12) m^{-1} or 1.232 712 (15) eV [2].

References

[1] C. Blondel *et al.* Eur. Phys. J. D **33**, 335 (2005)
[2] M. Scheer *et al.* Phys. Rev. A **58** 2844 (1998)