XUV photodetachment of anions at FLASH: first results on single and double detachment of O^-

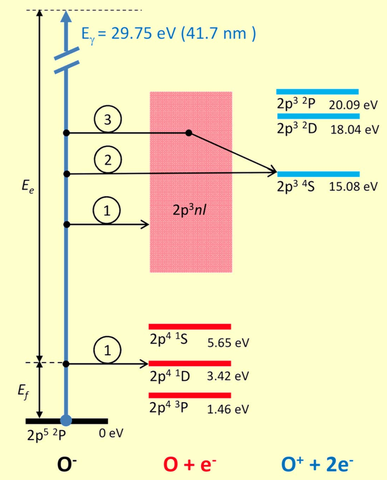
L. S. Harbo[1], A. Becker[2], S. Dziarzhytski[3], C. Domesle[2], N. Guerassimova[3], A. Wolf[2] and H. B. Pedersen[1]

[1]*Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark*
[2]*Max-Planck-Institut für Kernphysik, D-69117 Heidelberg, Germany*
[3]*HASYLAB at DESY, Hamburg, Germany*

XUV photodetachment

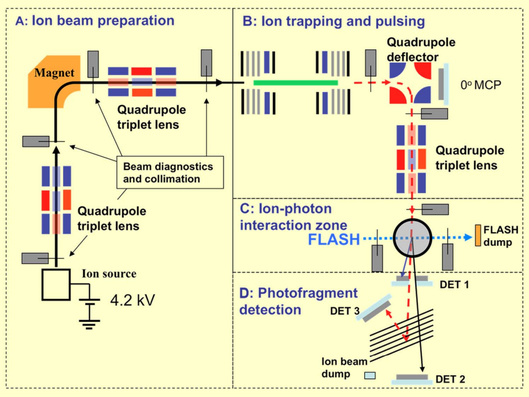
With an exploratory study of XUV photodetachment of the oxygen anion at FLASH we have investigated the potential for complete characterizations of photodetachment reactions using FELs in combination with accelerated ion beams.

O^- photodetachment

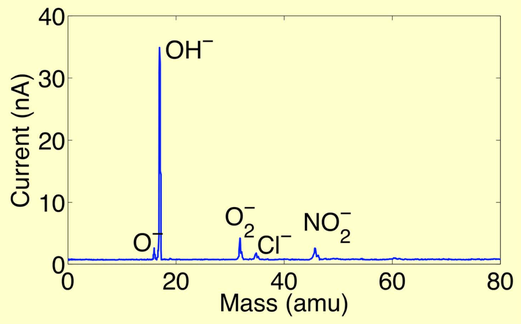


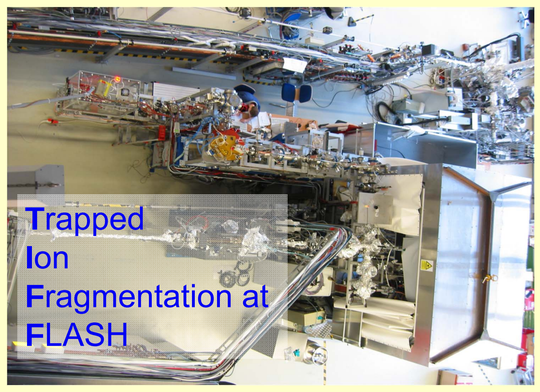
1 - Single detachment
2 - Direct double detachment
3 - Sequential double detachment

TIFF ion beam station[1] at FLASH[2,3]

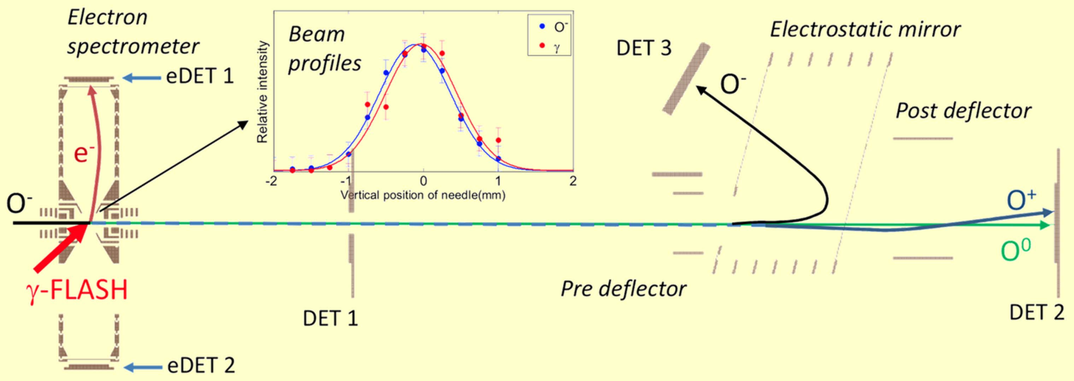


Hollow cathode ion source
(discharge in water vapor)





Photodetachment analyzing system (implemented 2011)

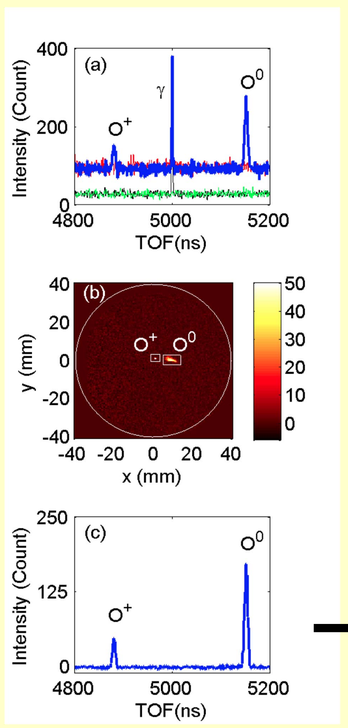


Photon beam
- Wavelength 41.7nm
- 50 bunches at 200kHz
- 30 μJ/pulse
- PG2 transmission T_{PG2} = 0.5±0.1

Ions beam
- Ion current 1 nA
- Ion energy 3 keV

Residual gas
- Mainly H_2
- UHV - 1-3□10^{-10} mbar

Single vs. double detachment



Detachment products on DET 2

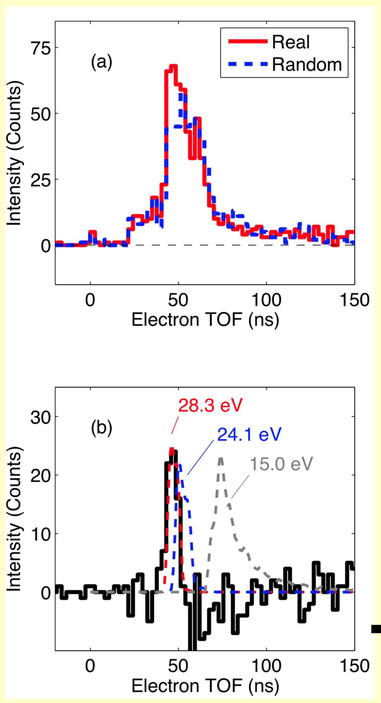
a) Direct TOF-signal

b) Positions after time cut

c) TOF with position cut

$$\frac{\sigma_{O^0}}{\sigma_{O^+}} = 4.12 \pm 0.17$$

Photoelectron-photoneutral (O^0) coincidence



Challenges for electron spectroscopy at FELs:

- Photodetachment events per ion-photon crossing

$$R_X = \sigma_X T_{PG2} N_\gamma l_{O^-} F \qquad \rightarrow R_{O^0} \approx 2 \cdot 10^{-3}$$

- Fragment background from ion-collisions with residual gas collision

$$R_X^g = \sigma_X^g n_g \left(I_{O^-}/e\right) L_X^g \Delta t_X \qquad \rightarrow R_{O^0}^g \approx 1 \cdot 10^{-4}$$

- Electron background from photoionizion of the residual gas

$$R_e^g = \sigma_e^g T_{PG2} N_\gamma n_g L_X^g \qquad \rightarrow R_e^g \approx 6$$

Coincidence detection enables identification the electron signal despite the large background.

Single detachment proceeds to

$O^0(^3P)$ and $O^0(^1D)$

Conclusion

The present exploratory study of XUV photodetachment of the oxygen anion demonstrates how photodetachment reactions can be completely dynamically characterized by combining FELs with *crossed* ion-photon beam methods.

The results are complementary to results obtainable at *merged* ion-photon beam experiments [4,5] at synchrotron radiation facilities were high resolution absolute cross sections are determined as function photon energy

References

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