A 1D-imaging XUV spectrometer

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Swedish Science Council

SQS scientific instrument session, Hamburg 24/1 2017
XES/RIXS

- Local electronic structure
- Selectivity and dipole selection rules
- Potential surfaces
- Fast dynamics: vibronic coupling, femtosecond symmetry breaking and dissociation
- Correlation and multiple excitations
- Photon-in-photon-out: no plasma potentials, no space charge --- non-linear X-ray physics
The In-Kind Contribution

- State-of-the-art spectroscopy in the vertical
- Imaging along the beam in the horizontal
Optical Layout
The mechanical setup of the 128-fold DLD

- MCP chevron stack (operation at about 2 kV)
- 128-fold DLD anode (8x 16 stripes)
- 8 x flexible boards for connection
- 256 lines RF feedthrough
- CF200 base flange
Imaging capability

$2 \text{ mm (7 ps)}$

$4 \mu m$

$1 \mu m$

$\Delta z \approx 10 \mu m \quad (\Delta t \approx 30 \text{ fs})$
Gas at high pressure

\[ n = 2.4 \cdot 10^8 \cdot \frac{p}{1\text{ atm}} \text{ [molecules/10\(\mu\text{m}^3\)]} \]

Photons absorbed assuming no saturation:

\[ n_{ph} = 4 \cdot 10^{12} \frac{p}{1\text{ atm}} \text{ [photons/pulse]} \]
• Assume $2 \times 10^8$ core ionized molecules.
• Neglecting linear effects, they emit $10^6$ photons.
• The angular distribution will be quasi-isotropic, and the spectrometer accepts $10^{-5}$ of the solid angle.
• Reflections and detector efficiency reduce the count rate to somewhat less than 1 count/pulse.

With a repetition rate of 27kHz we expect a count rate which allows a spectrum from each 10 micron segment in seconds-minutes acquisition times.

SASE pulses must be characterized!
Machine learning applied to single-shot x-ray diagnostics in an XFEL
A. Sanchez-Gonzalez, et al.
arXiv:1610.03378
Time resolution

\[
\Delta t_\theta = \frac{\Delta x}{c} \left(1 - \cos \theta\right)
\]
Intensity variation in a gas

- 10 mJ: $2 \times 10^{14}$ ph/pulse, 100 fs
- 0.2 mJ: $4 \times 10^{12}$ ph/pulse, 2 fs
Stimulated X-ray Scattering

Non-linear optical effects

Carbon monoxide

Victor Kimberg et al., Faraday Discuss., 194, 305 (2016)
Multiply ionized states

Resonance-Enhanced X-ray Multiple Ionization
Flat liquid beam at grazing incidence

Critical angle for “total reflection”
Around 2 degrees; evanescent wave

30 times loss in projection
A fraction in reflection

\[ \frac{\lambda}{3} \]

1 μm

10 μm

3 times gain in number of atoms
Status

- Optics procurement/ruling
- Mechanical design under way
- Detector Optimization
- Workshop: May 5
- Gas/Liquid Sample Delivery
- Pulse Characterization
THANK YOU!