Energy calibration of soft x-ray beamlines using highly charged ions

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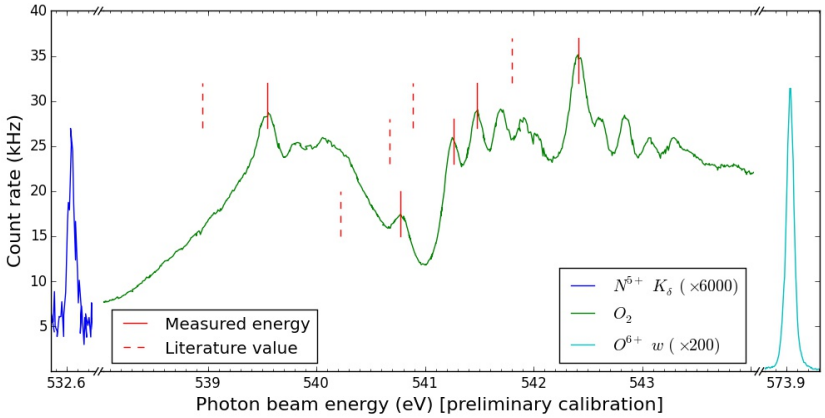
Precise knowledge of the photon beam energy is needed for many experiments at synchrotron light sources. Therefore mainly absorption spectra of solids and gases are used as a wavelength reference, but their dependency on temperature and chemical effects limits the achievable accuracy.

In contrast wavelength standards based on electronic transitions in atoms or ions have proven to be highly accurate and reproducible in the optical regime. By using transitions in highly charged ions (HCI) this method can be transferred to x-ray energies.

For this purpose a newly designed electron beam ion trap with a geometry that allows passing the photon beam through the trap was built [1]. As the ion cloud is basically transparent, this enables online calibration with HCI while performing measurements. Furthermore, the compact size (1m) of the trap facilitates the installation of the device at the beamline.

Here we present the first measurements using HCI as an energy calibration at a synchrotron. Absorptions spectra of neutral O_2 were measured simultaneously with the spectra of He-like nitrogen and oxygen at BESSY II. Using the latter as calibration, we were able to reduce the energy calibration error below 50 meV. Our preliminary analysis yields a 600 meV shift in the energy of the Rydberg lines of O_2 compared to previous experiments [2], emphasizing the need for accurate calibration standards.

The trap will become part of the PETRA III P01 beamline extending this calibration method to the 5-30 keV photon energy regime.



Spectrum of the O_2 Rydberg series and the HCI reference lines used to calibrate the photon beam energy. Red lines indicate the O_2transition energies measured in this experiment (solid) compared to previous values [2] (dashed).

References

[1] Micke et. al, submitted to Rev. Sci. Instrum., 2018

[2] T. Tanaka et. al, Phys. Rev. A 78, 022516, 2008