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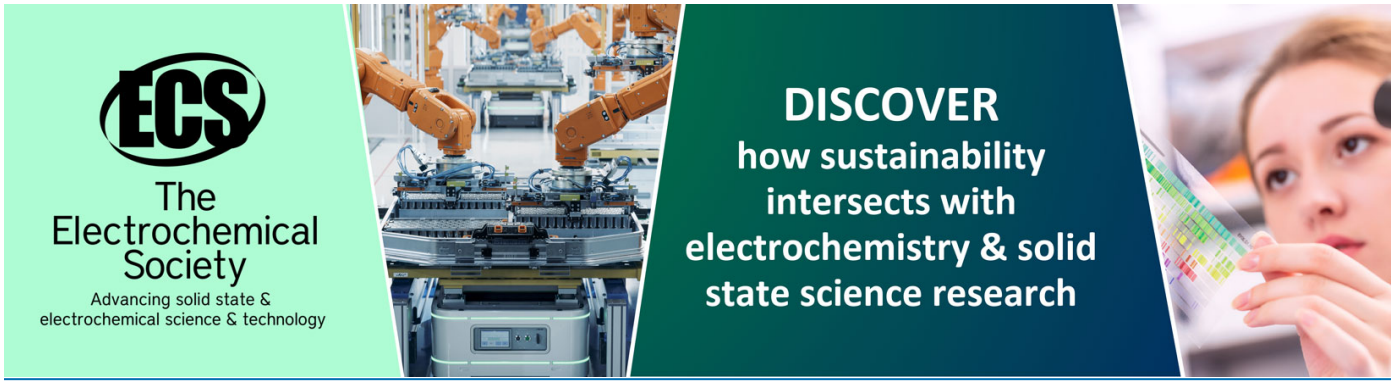


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# The Small Quantum System (SQS) Instrument at European XFEL: Results of commissioning and first experiments

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**Synopsis** The Small Quantum System (SQS) instrument on the soft X-ray undulator SASE3 of the European XFEL went into operation during 2018. We present first results from the instrument characterizing the focus properties and the time-of-flight as well as velocity map imaging spectrometers of the AQS chamber.

The SQS instrument is designed for experiments on atomic and molecular systems, as well as clusters, nano-particles and small bio-molecules. It is located at the SASE3 soft X-ray undulator of the European XFEL, which produces FEL radiation in the photon energy range between 250 eV and 3000 eV. The instrument enables studies of non-linear and multi-photon processes, as well as time-resolved experiments on fast dynamic processes.

The SASE3 undulator and the SQS instrument were taken into operation during 2018. The first commissioning activities were dedicated to characterize and optimize the focussing properties of the Kirkpatrick-Baez (KB) mirror system. A Hartmann-type wavefront sensor was utilized and the results compared to imprint measurements using $PbI_2$ coated CVD diamond substrates. The focus size was determined to be 1.3(3)x1.2(3) $\mu m^2$ at a photon energy of 1050 eV and consistently below 2x2 $\mu m^2$ for the energy range 500 - 1200 eV available at that time.

The first experiments were performed in the AQS (Atomic-like Quantum Systems) endstation of SQS, which is equipped with up to six high-resolution electron time-of-flight spectrometers as well as a Velocity Map Imaging (VMI) spectrometer. Sequential ionization of Neon and Xenon was investigated at photon energies between 900 eV and 1200 eV and pulse energies of up to 2 mJ. The measured charge states of up to $Xe^{41+}$ are compared to similar studies at other FELs [1,2] demonstrating directly the feasibility of studies in the non-linear regime at SQS.

Furthermore, angle-resolved, high-resolution electron spectroscopy was used to study the sequential ionization of the Neon 1s core-electron and the corresponding Auger decay of the single- or double core hole (cf. [3]). During this first campaign at SQS, advantage was taken from the possibility to easily tune the photon energy of the SASE3 undulator. This enabled for the first time to study beside the direct also the resonant double core-hole Auger decay in Neon around a photon energy of 1000 eV [4].

During 2019, the other two endstations of SQS are taken into operation: the reaction microscope (SQS-REMI) for coincidence studies on electrons and ions and the NQS (Nano-sized Quantum Systems) for imaging and scattering experiments on clusters or nano-particles.

## References

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