Commissioning a new COLTRIMS-Reaction Microscope for the SQS instrument at European XFEL

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Synopsis In order to investigate the process of ultrafast dissociation we performed a commissioning measurement at SOLEIL-Synchrotron using a newly designed COLTRIMS-Setup.

We designed a highly modular COLTRIMS-Reaction Microscope to investigate correlated dynamics of electrons and ions in atomic, molecular and cluster systems [1], [2]. In a COLTRIMS-(COLd Target Recoil Ion Momentum Spectroscopy) setup, containing three different UHV-recipients (expansion-, target- and jetdump-section (Figure 1)), the target is prepared in a supersonic gas-jet. Varying parameters as the driving pressure and the temperature of the nozzle (12 K – 500 K, using a He-flow cryostat or heating) makes it possible to generate an extremely well defined and localized atomic or molecular gas-jet which can selectively consist of e.g. He-clusters, molecular clusters or organic molecules. The newly designed setup allows shaping the jet with up to four differentially pumped vacuum stages including nanometer precise piezo-actuator driven apertures. The intense X-ray beam from XFEL interacts with the molecular gas-jet and allows the investigation of photon induced processes (such as Augerdecays, molecular rearrangement etc.) in a time-resolved scheme. We aim to measure up to 10 ions and electrons per X-ray pulse in coincidence. In order to measure all charged fragments from an ionization event in coincidence, it is necessary to have less than one reaction per pulse. Therefore both, the residual vacuum needs to be lower than $2 \cdot 10^{-11}$ mbar and the gas jet should also provide less than 1 molecule within the focal volume.

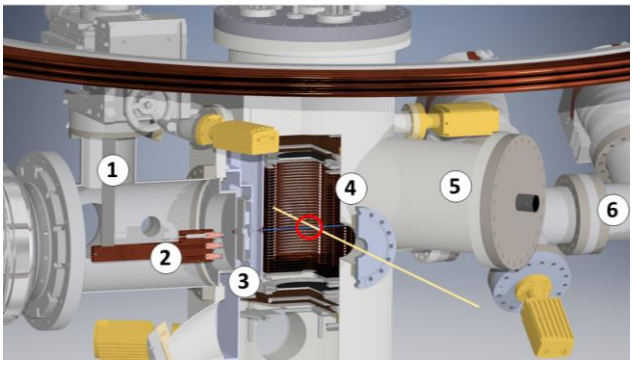

Figure 1. 3D-Model of the XFEL-COLTRIMS-Setup. Blue line: supersonic gas-jet, yellow line: XFEL-Beam, red circle: interaction-region. (1) Expansion-Chamber with He-Flow-Cryostate, (2) nozzle system with 3 different nozzles, (3) high-density 3-stage jet-system with piezo-apertures , (4) reaction-chamber with spectrometer and detectors, (5) NEG-Pump, (6) differential jet-dump.

To investigate time-resolved processes in molecules with pump-probe experiments, SQS additionally provides a tunable femtosecond laser. This laser can be injected collinear to the X-ray beam. With this setup, different pump-probe scenarios are possible: X-ray pump-laser probe, laser pump-X-ray probe, laser pump-laser probe and X-ray pump-X-ray probe. To commission the new experimental setup we used X-ray light from SOLEIL Synchrotron, France, to investigate the process of Ultrafast Dissociation in CH_3Cl molecules [3].

References

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