

Laser-driven resonant soft-X-ray scattering using the MOENCH detector for probing picosecond dynamics of nanometre-scale order

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X-ray scattering has been an indispensable tool in advancing our understanding of matter, from the first evidence of the crystal lattice to recent discoveries of nuclei's fastest dynamics. In addition to the lattice, ultrafast resonant elastic scattering of soft X-rays provides a sensitive probe of charge, spin, and orbital order with unparalleled nanometre spatial and femto- to picosecond temporal resolution. However, the full potential of this technique remains largely unexploited due to its high demand on the X-ray source. Only a selected number of instruments at large-scale facilities can deliver the required short-pulsed and wavelength-tunable radiation, rendering laboratory-scale experiments elusive so far. Here, we demonstrate time-resolved X-ray scattering with spectroscopic contrast at a laboratory-based instrument using the soft-X-ray radiation emitted from a laser-driven plasma source. Specifically, we investigate the photo-induced response of magnetic domains emerging in a ferrimagnetic FeGd heterostructure with 9 ps temporal resolution. Leveraging the latest hybrid-pixel MOENCH detector with its low-noise, high repetition rate, and single-photon-counting capabilities in the soft X-ray range, we can track the reorganisation of the domain network on pico- to nanosecond time scales in great detail. This instrumental development and experimental demonstration break new ground for studying material dynamics in a wide range of laterally ordered systems in a flexible laboratory environment.

Author: SCHICK, Daniel (Max Born Institute)

Presenter: SCHICK, Daniel (Max Born Institute)

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