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Diffractive imaging of clusters and ultrafast dynamics

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Exciting clusters and nanodroplets with intense laser pulses provides a well-defined scenario to study the correlated dynamics of highly excited matter. We use diffractive imaging of single nanoparticles in free flight with XUV and X-ray free-electron lasers (FELs) to explore the light-induced dynamics with high spatial and temporal resolution. From the measured diffraction patterns the nanoparticles'structure can be determined, allowing to study such fragile and short-lived specimen as superfluid helium nanodroplets (Langbehn et al., accepted at PRL 2018) and the observation of structural changes, like e.g. ultrafast melting in metal clusters. But also the even faster electron dynamics change the scattering response of the irradiated cluster and can therefore in principle be traced by diffractive imaging.
With today's typical pulse duration of FEL pulses of 10-100 femtoseconds, it is not possible to resolve electron dynamics in time. Sub-femtosecond pulses are currently under development at FELs, e.g. at SwissFEL. Already today, isolated attosecond XUV pulses and attosecond pulse trains can be generated with high-harmonic-generation (HHG) sources based on intense femtosecond lasers, but they are typically orders of magnitude weaker than FELs. Thus, an important step towards attosecond diffractive imaging was taken by our demonstration of single-particle single-shot diffractive imaging of individual helium nanodroplets with a high-intensity HHG source (Rupp et al., Nature Communications 8, 493 (2017)).
In my talk I will introduce the method and its applications and discuss recent results from time-resolved diffraction imaging experiments using both FEL and HHG sources.

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