Imaging the structure and dynamics of helium nano- and microdroplets

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For the past decade, we have been able to take snapshots of individual nanoparticles in a vacuum using elastic light scattering of intense X-ray pulses. As a result, the structure of helium droplets is now better understood, we have gained control over e.g. the number of quantum vortices, and their importance as perfect model systems for light-matter interaction studies has grown once again.
Helium clusters, nano- and microdroplets are particularly suitable for the investigation of ultrafast electron dynamics on the shortest time scales. They are a relatively simple two-electron atoms and their weak interatomic interaction results in a gradual and tracable transition of properties from atomic to macroscopic matter.
In our experiments, we are investigating whether it is possible to reproducibly switch electronic properties of nanoscopic matter with an optical laser pulse, an important question for the development of all-optical data processing. Attosecond transient absorption measurements (ATAS) on helium gas had revealed that through AC Stark shift and light-induced states (LIS), an optical laser pulse can completely change the absorption of the material at a certain frequency. We have now shown in CDI experiments using intense higher harmonic (HHG) pulses that the scattering response of a helium droplet can also be transiently switched faster than one laser cycle.
In the context of newly emerging attopulses at X-ray free-electron lasers, this first-of-its-kind experiment opens up a whole new range of possibilities to resolve ultrafast dynamics such as coherent excitation in nanoscale matter in space and time.

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