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Tracing Collective Electron Motion

Matthias Kling receives ERC Starting Grant of the European Union

How do electrons in nanoparticles collectively behave under the influence of strong laser fields? The opportunity to follow up on this question is now given to the team of researchers lead by Dr. Matthias Kling from the Max Planck Institute of Quantum Optics. With the ERC Starting Grant their research is supported by the European Union (EU) for 5 years. Starting Grants are given to young researchers for outstanding and groundbreaking research projects. The research project "ATTOCO," under which the control and tracing of collective electron dynamics on attosecond timescales is going to be investigated, will be supported by about 1,5 million Euros.

Matthias Kling and his team study the extreme. The dimensions in the microcosm are tiny, the timescales of particle motions ultrashort. Kling and his colleagues are interested in particular in the collective motions of electrons in nanoparticles. Nanoparticles typically consist of millions of atoms. If strong laser light hits such nanoparticles, their electronic and optical properties can be dramatically altered and electrons can be released and accelerated strongly. The interaction between light and electrons takes place within attoseconds (an attosecond is a billionth of a billionth of a second). Attosecond nanophysics is an emerging research field and offers much room for novel phenomena that might find their way into applications such as light-controlled nanoelectronics.

With the project ATTOCO the Max Planck scientists aim to deepen the understanding of the interaction of nanomaterials with strong laser fields. Building on the unique infrastructure at the Max Planck Institute of Quantum Optics, they plan to utilize the so-called attosecond nanoplasmonic streaking technique. It should permit following the electronic and optical properties of nanoparticles in time. The technique was recently theoretically tested by the scientists and is awaiting its experimental implementation.

The attosecond nanoplasmonic streaking technique is based on the monitoring of the electron collective via so-called plasmonic near-fields. Plasmonic near-fields are very high electromagnetic fields in the vicinity of the nanoparticles, which arise from the collective motions after their excitation by laser light. The field strength near the surface of the nanoparticles can thereby greatly exceed the field strength of the incident light. When an attosecond light flash releases electrons from the nanoparticles they will be accelerated by the near-fields. The attosecond light flashes are synchronized to the previous excitation of the nanoparticles by a strong infrared light pulse. The scientists therefore know precisely how the freed electrons were accelerated by the near-fields. The velocity of the electrons serves as a measure for the directionality and temporal behavior of the electron collective in the nanoparticles. The technique reaches an extremely high time resolution in the attosecond domain.

Matthias Kling's team also collaborates closely with the ultrafast x-ray physics group of Prof. Ulf Kleineberg at the Ludwig Maximilian University Munich (LMU). Ulf Kleineberg operates a time-of-flight photoelectron emission microscope. With this instrument the emission of electrons from nanostructured surfaces that were excited by ultrashort light pulses is recorded as a function of time, space and electron energy. The experiments offer resolutions in the few nanometer and sub-femtosecond domains.

The researchers will have the opportunity to follow ultrafast light-induced changes in nanomaterials in real-time and gain novel insight into the collective motion of electrons in strong laser fields. "We like to learn how electrons in nanostructures can be controlled via light waves and how the material properties are changing in strong fields. Our research aims at building the basis for the development of ultrafast, light-controlled nanoelectronics, which may outperform conventional electronics by many orders of magnitude", explains Matthias Kling.

Further information is available from:

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