Invited speaker

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Attosecond control of electrons inside of graphene and in free-space beams

Abstract

Attosecond and strong-field physics represent an entirely new field that has not only allowed the generation of attosecond extreme ultraviolet light pulses but also controlling electrons on these extremely fast atomic times scales. Spectacular insights have so been gained in various kinds of atomic and molecular processes over the last 25 years. More recently, strong-field and attosecond physics phenomena have been observed at the surface of and inside of solids [1, 2], where the various material classes allow for a rich variety of phenomena to be observed. Because electrons driven at the apex of sharp needle tips are sensitive to the optical carrier field, we could recently measure the phase of a focused broadband pulsed laser beam in full 3-d [3]. Inside of graphene, an atomically thin sheet of carbon atoms, we could show the transition from the weak-field to the strong-field regime. In the latter, interband propagation and intraband transitions are coupled, and electrons undergo Landau-Zener-Stückelberg interferometry, where the quantum phase determines whether or not an electron is excited to the conduction band. This takes place on the 1-femtosecond time scale, representing the fastest current switching in a conductor [2]. With free-space electron beams, we have recently demonstrated a novel acceleration scheme called dielectric laser acceleration [4]. Here, a photonic nanostructure is used to shape the optical field such that efficient electron acceleration can take place [5]. Interestingly, the electrons in the beam become bunched on sub-cycle time scales. We could recently show an electron pulse train with pulse duration of less than 300 attoseconds [6], generated with the help of a traveling optical grating [7].

References

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About the Author

Peter Hommelhoff is Professor of Physics at Friedrich-Alexander University Erlangen-Nuremberg and associate member of Max Planck Institute for the Science of Light in Erlangen, Germany. After receiving his Ph.D. from Ludwig-Maximilian University Munich in 2002 in T. W. Hänsch's group, he was a postdoctoral scholar at Stanford University in the group of M. A. Kasevich from 2003-2007. In 2007 he was appointed head of a Max Planck Research Group (free floater), which he run at Max Planck Institute for Quantum Optics in Garching/Munich from 2007-2012. In 2012 he finished his habilitation and received offers for full professor positions (W3) in Erlangen and Oldenburg. His current research interests focus on exploring optical-field-driven phenomena at and in solids on femtosecond and attosecond time scales, laser acceleration of electrons with the help of nano-photonic structures, and quantum-enhanced electron microscopy. He has received a Feodor Lynen Postdoctoral Fellowship of the Humboldt Foundation (2003), a Trimble Postdoctoral Fellowship of the Stanford Center for Position, Navigation and Time (2006), an ERC Consolidator Grant (2014), and three grants from the Gordon and Betty Moore Foundation (Quantum Electron Microscope I an II in 2012 and 2017; Accelerator on a Chip International Program in 2015). In 2018, he will be local organizer of the DPG Annual Meeting and SAMOP Spring Meeting in Erlangen.