Preface

Attosecond nanophysics is a new research field merging ultrafast science with time scales reaching into the attosecond domain with studies on nanoscale materials. An attosecond is incredibly short. To put it in perspective, one attosecond (one attosecond = 10^{-18} seconds) compares to one second roughly as one second compares to the age of the universe. Within one attosecond even light only travels a distance of 0.3 nanometer (1 nanometer = 10^{9} meter). Attosecond time and nanometer length scales are thus inherently connected. The attosecond timescale is particularly important for electrons, which are light enough to move so fast that they must be clocked with attosecond precision to track their motion. These fast electron dynamics govern the interaction of light with matter and form the basis for optoelectronics. The possibility to steer electronic processes in nanomaterials with tailored lightwaves can be exploited in ultrafast nanoelectronic circuitry with switching frequencies approaching the petahertz domain (many orders of magnitudes above conventional electronics). This potential has motivated the rapid growth of attosecond nanophysics.

The master thesis of Johannes Schötz discusses an important experimental advance in this young field, namely the ability to measure the evolution of fields on the nanoscale in real-time, i.e. attosecond timescales. He describes both experimental and theoretical advances towards the realization of the attosecond streak-camera technique on the nanoscale. While the attosecond streak-camera has become a standard tool in attosecond physics, and related measurements on electron dynamics in atoms, molecules, and extended surfaces, its realization for measurements of nanostructures is not straightforward.

The reasons are discussed in detail in the thesis, with a special emphasis on metallic nanotips, which Johannes Schötz has investigated in his work.

In attosecond streaking, electrons are photoemitted through an attosecond light pulse in the extreme ultraviolet and are accelerated by an external field provided by e.g. a synchronized optical light pulse (with a duration of a few cycles). While in conventional attosecond streaking the external fields are spatially homogenous, the near-fields of nanostructures are inhomogenous. The ramifications of the nanometer spatial inhomogeneity are non-trivial and therefore typically detailed simulations of the streaking process and its application in real-time measurements of nanoscale near-fields are required. Johannes Schötz performed such simulations and shows them in his thesis.

The thesis not only describes the first steps into the new territory of attosecond resolved measurements on nanostructures, but it is also written such that it provides guidance to a newcomer. The thesis of Johannes Schötz is of high relevance to future research in attosecond nanophysics and I wish that his ground breaking work will find the wide and interested readership that it certainly deserves.

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