Attosecond dynamics in solids after photoexcitation as a benchmark for our understanding of complex quantum systems

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In recent years, time-resolved spectroscopy advanced to the attosecond regime, i.e. on the time scale on which electron motion occurs on an atomic scale. In such experiments an extreme ultraviolet (EUV) pulse with durations of typically a few 100 as is used to excite the system and the response is probed by correlating this excitation with a field in the near infrared (NIR). One example of such a technique is attosecond time-resolved streaking spectroscopy of solid state photoemission [1]. In these experiments a photoelectron is excited in the solid and starts interacting with the NIR field when it crosses the solid-vacuum interface. Slight differences of this photoemission time result in different correlations with the NIR field and hence relative photoemission times for different emission channels can be timed with few-attosecond resolution.

Using this technique we were recently able to demonstrate that the present theoretical model of solid state photoemission misses an essential effect that significantly affects such photoemission delays [2]. Intra-atomic delays determined by the involved angular momentum of the photoelectron affect the photoemission times and are not accounted for in present theoretical models of solid state photoemission. In our present approach to describe the observations we dissect the photoemission process artificially in an intra-atomic and a propagation part that are modeled based on theoretical concepts from atomic physics and solid state physics, respectively. To overcome this artificial dissection new theoretical models of the photoemission process are needed and, hence, attosecond time-resolved spectroscopy provides new benchmarks for a further development of a complex quantum system, i.e. the dynamics of the many-body problem of a photoelectron interacting with the remaining photohole and the other electrons.

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