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Space-, time-, and energy-resolved observation of charge dynamics in a single nanostructure

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Observing the motion of charges in solid state nanostructures during their interaction with strong light fields is a fundamental goal and an open challenge of contemporary ultrafast science. It requires ultrahigh combined spatial and temporal resolution, and in order to reveal the interaction, the charges‘energy gain or loss are vital information. Here we present a first experimental demonstration of space-, time-, and energy-resolved measurements, where we observe the motion of charges photoemitted from a plasmonic nanoresonator.

Merging ultrafast nanoplasmonics and point-projection electron microscopy achieves 20 nm spatial resolution and 25 fs temporal resolution. Probing electrons are emitted from a sharp nanotaper and propagate through a light-driven plasmonic nanoresonator. In order to have direct access to the energy gain or loss they experience, the probing electrons are detected with a time-of-flight delay-line detector. We study the effect of the real-space motion of charge carriers photoemitted in the plasmonic nanoresonator on the energy and momentum of the probing electrons. We will discuss applications of this new microscope for probing strong, ultrafast fields in plasmonic nanostructures.

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