Attosecond Field Emission

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Optical field-emission of electrons from metals by intense laser fields underlies major advances in science and technology, ranging from imaging the atomic-scale structure of matter [1] to signal processing at ever-higher frequencies [2]. The advancement of these applications to their ultimate limits of spatial and temporal resolution calls for techniques that can confine and probe the field emission on the sub-femtosecond time scale. Yet, the real-time tracking of the photoemission processes with the measurement of attosecond field emission has remained beyond the reach of modern optical or electronic methodologies.

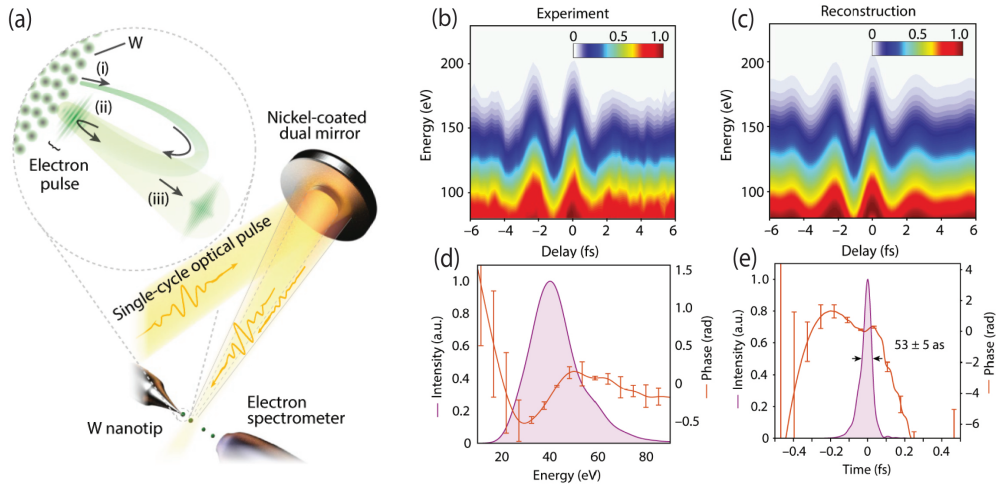

Figure 1: (a) Illustration of field emission from a metal nanotip, (b) Experimentally measured and (c) reconstructed HAS spectrogram. (d and e) Retrieved temporal structure of electron pulse.

In this work, an intense optical pulse is used to induce field emission of electron pulses from tungsten nanotip, while the weak replica of the same optical pulse directly probes the temporal structure of the electron pulses in real time (Fig.1a) [3]. This new optical streaking technique is called Homochromatic attosecond streaking (HAS). The HAS spectrogram (Fig.1b) is composed by recording electron spectra versus the delay between two optical pulses. The reconstruction (Fig.1c) of HAS spectrogram permits the direct investigation of emission dynamics including the energy and temporal profile of the emerging electron pulses, together with the duration τ = (53 as $\pm$ 5 as) and chirp (Fig.1d-e) [3].

Clocking the optical-field emission opens new routes for advancing light-field-based electronics, and lays the groundwork for attosecond, electron diffraction microscopy.

References

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