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Single-shot holographic measurement of attosecond pulses and the time-dependent field of an ultrashort pulses

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We demonstrated simultaneous all-optical, single-shot holographic measurement of attosecond high harmonic pulses and a femtosecond laser pulse. To achieve this, we introduce a weak laser beam into the harmonic generation medium together with the strong driving laser field. The weak laser field perturbs the trajectories of ionized electrons that are responsible for high harmonic generation and therefore diffracts the harmonic radiations. Since the periodic structure in the near-field harmonic radiations implies cross-correlation between the attosecond pulse and the perturbing laser pulse, we can achieve temporal characterization by measuring the diffracted high harmonic radiations.

However, since the far-field intensity distribution is insensitive to the near-field harmonic radiations, we superposed a reference X-ray beam generated from a secondary harmonic source. The measured harmonic spectrograph shows dense fringes that originate from two-source interference. The rapid oscillation enables us to reconstruct the near-field harmonic radiations by applying Fourier transform. As a result, we determined the attosecond pulses, showing a pulse duration of 390 as, and the time-dependent electric field of the perturbing pulse from the retrieved near-field image. The duration of the perturbing pulse that we obtain is consistent with the result achieved by a conventional FROG measurement.

The single-shot measurement method is a fast, robust and effective way to monitor high harmonic or attosecond pulses. Consequently, it will be a new technique to probe ultrafast strong-field interactions in many materials.

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