Generation of attosecond electron beams and the potential applications to electron-atom collisions

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Electron beams have been employed for microscopic imaging and collision experiments. Recent advances allowed the coherent optical manipulation of beamed electrons with high temporal resolution[1]. Especially, it enabled the production and the detection of attosecond electron pulses[2-6]. In this presentation, we review our recent experiments on the compression of electron beams to attosecond durations[4,6] and our recent theoretical studies on the collision of attosecond electron pulses with isolated atoms[9,10].

Attosecond electron beams are produced by modulating velocity of electrons by a laser electric field. In our experiment[4], a 1-ps-long electron beam of 70-keV energy was modulated by a laser field of 1-μm wavelength at a free-standing membrane. The velocity modulation induced a temporal density modulation and attosecond peak structures appeared[4]. We analyzed the modulated temporal density by real-space streaking induced by optical cycles of the laser light.

Electron beams for atomic collision experiments are usually monochromatic and well approximated by plane waves. In contrast, attosecond electron beams have coherent and broadband energy distributions. In the scattering of a broadband electron beam, quantum interferences may occur[7,8]. We demonstrate theoretically that the probability and asymmetry of electron-atom scattering can be modulated by properly shaping electron beams[9,10].

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