Ionization with tailored laser fields from multi-harmonic field synthesizer

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Tailored laser fields in the femtosecond timescale are a prerequisite to control the strong field effects in atoms, molecules, solids [1], and nanoscale objects [2]. Using laser pulses with a tunable electric field synthesized from hollow-core fiber compressors, allows accessing new research fields [3], e.g. in the control of ultrafast chemical reactions [4]. However, most femtosecond laser systems deliver pulses that span less than an octave in spectral bandwidth. This limits the control over chemical reactions. Here, we present how to overcome that limitation by the generation of the second and third harmonic from an amplified Ti:sapphire laser system. Subsequently, we split the three harmonics, shape each pulse individually and recombine them by an interferometer (cf. Fig. 1a). With such tailored waveforms, we can control strong field interactions from atoms and molecules.

Here, we investigated the strong field ionization of argon, neon and acetylene with ω-2ω and ω-3ω fields. The 3D momentum distributions of ions were measured with a reaction microscope. Changing the phase between the different frequency components of the laser pulses tailors the waveform of the electric field enabling us to control the final momenta of the ions.

In the case of ω-3ω fields, we successfully achieved control over ionization yield with the relative phase (see Fig. 1b). We observed two broad contributions in the kinetic energy release (KER) of ions (marked as red and black dashed lines) which are out of phase. Quantum simulations were performed to interpret the results for ideal, Fourier-limited pulses and those obtained from the multi-harmonic field synthesizer with realistic parameters.

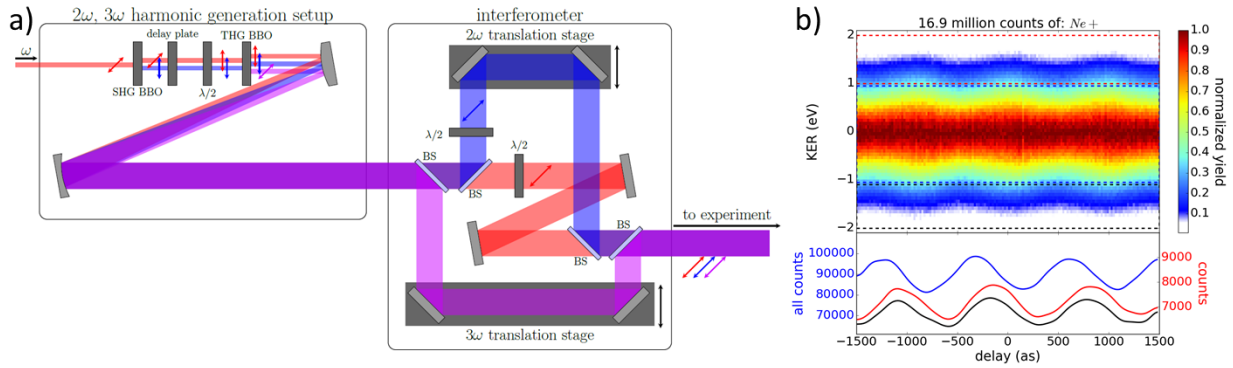

Figure 1 Schematic drawing of (a) the multi-harmonic generator and interferometric beam combiner for three-color waveform synthesis and (b) the result of the ω-3ω phase dependent single ionization of neon.

References:

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