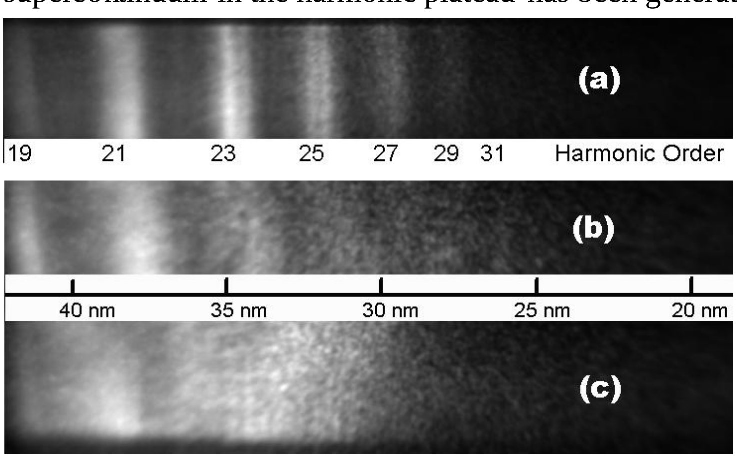
Generation of soft x-ray supercontinuum and single attosecond pulse by polarization gating

Bing Shan, Shambhu Ghimire, Chun Wang, and **Zenghu Chang**
J. R. Macdonald Laboratory, Physics Department,
Kansas State University, Manhattan, KS 66506
Phone: (785)532-2746 FAX: (785)532-6806 Email: chang@phys.ksu.edu

It has been proposed ten year ago that a single attosecond pulse from high harmonic generation could be produced by an ellipticity dependent laser pulse, in which the ellipticity varies rapidly from circular to linear, and then back to circular. We report here a unique method for forming such a pulse with birefringence optics.

First we used a hollow-core fiber pulse compressor to generate a seed pulse. The chirp of the output pulse from the fiber was over-compensated by passing through two pairs of chirp mirrors with a total of 4 bounces. It is negatively chirped so that fused silica compensating plates can be added to control the pulse duration. The pulse was sent to a 0.5 mm quartz plate with its optic axis at 45 degrees with respect to the polarization direction of the pulse. By doing so the input pulse is evenly divided into an o-ray pulse and an e-ray pulse, a time delay of ~15 fs between the two pulses was introduced when they left the plate. The two orthogonal linear pulses were converted into a left circular pulse and a delayed right circular polarized one when they propagated through an achromatic quarter waveplate. The superposition of these two pulses produced an ellipticity varying pulse. The method is simple and robust. It avoids the difficulties of spatial and temporal overlap of a Mach-Zehnder interferometer type delay line.

High order harmonic were generated by focusing the ellipticity dependent pulse onto an argon target by a parabolic mirror with a focal length of 250 mm. The measured harmonic spectra are illustrated in Fig. 1. In Fig. 1(a) the seed pulse duration is ~12 fs from a FROG measurement. In this case, the linear polarized portion is relatively long (~3 fs), so the HHG spectrum lines are well resolved. In Fig. 1(b) the pulse duration is ~9.2 fs and the linear portion is ~1.7 fs. The smeared HHG spectra imply generation of single attosecond at high orders. In Fig. 1(c) the thickness of the fused silica has been chosen to fully compensate for the chirp of the pulse, resulting in ~8 fs pulses. Thus the linear part is only ~1.3 fs, roughly half cycle of the driving field (2.8 fs). The HHG spectrum shows a supercontinuum, which indicates a single attosecond pulse was generated in the plateau region. To the best of our knowledge, this is the first time that supercontinuum in the harmonic plateau has been generated by polarization gating.



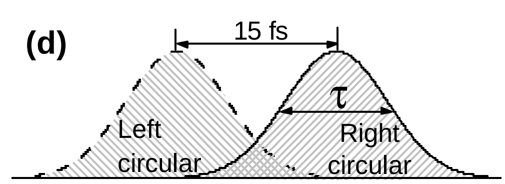


Fig. 1. Measured high harmonic spectra with different driving pulse durations.
(a) τ=12 fs, linear portion: ~ 3 fs;
(b) τ=9.2 fs, linear portion: ~1.7 fs;
(c) τ=8 fs, linear portion: ~1.3 fs;
(d) The two circular pulses.