Extending the upper limit of laser pulse duration for generating single attosecond pulses

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Synopsis: We propose and demonstrate a technique called generalized double optical gating for generating isolated attosecond pulses with 20 fs lasers. These pulses are measured to be 260 attoseconds by reconstructing the streaked photoelectron spectrogram.

Since isolated attosecond pulses were first generated in 2001 [1], only a few laboratories can produce and use such pulses. The stringent requirement of few-cycle driving lasers is one of the main obstacles. We report a technique call generalized double optical gating (GDOG), with which multi-cycle laser pulses as long as 20 fs can be used to generated single attosecond pulses. The technique is significant in spreading attosecond optical technologies.

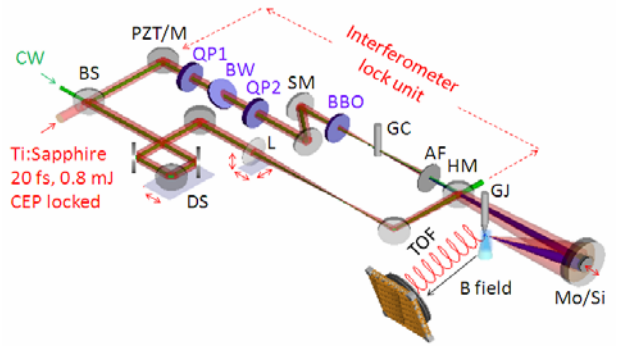

Fig. 1. Experimental setup of double optical gating and for measuring the single attosecond pulses.

GDOG is a generalized version of double optical gating (DOG) that we reported previously [2, 3]. The main idea in GDOG is to create a polarization gating field with two counter-rotating elliptically polarized pulses. The ground state population of the atoms is less reduced in such a field as compared with other gating methods allowing high intensity to be used with long laser pulses.

Figure 1 shows the experimental setup for generating and measuring single attosecond pulses. The GDOG optical components include two quartz plates (QP1 and QP2), a Brewster window (BW), and a BBO crystal. A Mach-Zehnder interferometer configuration was used to control the temporal and the spatial overlap of the attosecond XUV beam and the NIR streaking field. The photoelectron spectrum was collected with a time-of-flight spectrometer.

The isolated XUV pulses from argon gas were measured using the FROG-CRAB method based on attosecond streaking [4, 5]. Figure 2(A) and (B) show the experimental and retrieved CRAB traces. Fig. 2(C) shows the temporal shape and phase of the 260 as XUV pulse. The frequency marginal check shown in Fig. 2(D) indicates good agreement.

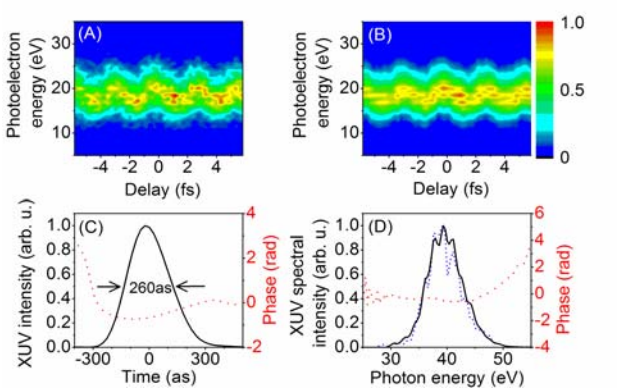

Fig. 2. Attosecond XUV pulse generated using 20 fs laser pulses and the retrieved results.

In conclusion, we have generated 260 as single attosecond pulses from 20 fs multi-cycle laser pulses and measured the pulses with the CRAB method. With the generalized double optical gating demonstrated here, it is conceivable that high energy single isolated attosecond pulses will be generated using high energy chirped pulse lasers directly in the future. This material is supported by the U. S. Army Research Office under Grant No. W911NF-07-1-0475, and by the Chemical Sciences, Geosciences, and Biosciences Division, U.S. Department of Energy.

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