Combining Interferometer Locking with Delay Control in Attosecond Streaking Experiments

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Synopsis: Attosecond streaking experiments suffer from the instability of the time delay between the attosecond pulse and streaking laser field due to fluctuating environmental conditions as well as mechanical vibration of the optical elements. The time delay is commonly introduced by splitting and recombining the XUV and NIR beams with interferometers. Here, we present a novel technique that is able to suppress the fast timing jitter while controlling the delay. Using this scheme, the streaked spectrogram of a single attosecond pulse was measured.

Single isolated few-cycle attosecond pulses have been characterized by the attosecond streaking technique using Mach-Zehnder [1, 2] and collinear [3] interferometer set-ups. Such systems rely on the ability to scan the delay between the extreme ultraviolet (XUV) attosecond pulse and the near infrared (NIR) streaking laser pulse in steps comparable to the duration of the attosecond pulse to be measured [4]. This is especially difficult in the Mach-Zehnder interferometer configuration, for which fluctuations in the environmental conditions as well as mechanical vibrations are likely to affect the optical path length difference between the two interferometer arms. In the past, we demonstrated that an interferometer can be locked with one piezoelectric delay stage (PZT) while the delay is changed by another PZT [2]. Here we show that the interferometer locking and delay change can be done using one PZT.

The experiment used a Mach-Zehnder interferometer attosecond streak camera [2]. A weak 532 nm CW laser beam was copropagated through both the attosecond generation arm and the streaking arm of the interferometer, and the two arms were recombined at a drilled mirror. The interference pattern of the green laser was detected by a CCD camera, and the relative phase and time delay were extracted by a computer. Figure 1(a) shows the time delay drift of the unlocked interferometer due to environmental conditions and mechanical vibrations.

The phase error signal was used for feedback control of a piezoelectric delay stage to suppress the fast jitter at a preset position for the targeted delay value. When the delay was set to a new value, the feedback loop stabilized the interferometer around that value. This technique also allows for fine control of the delay between the XUV and NIR pulses. As is shown in Figure 1(b), the time delay was scanned in steps of 280 as over a range of nearly 20 fs, less than 1/5 of the full range of the PZT stage, while the relative delay was locked to within 80 as RMS. This method was used for the measurement of a streaking trace from isolated attosecond pulses.

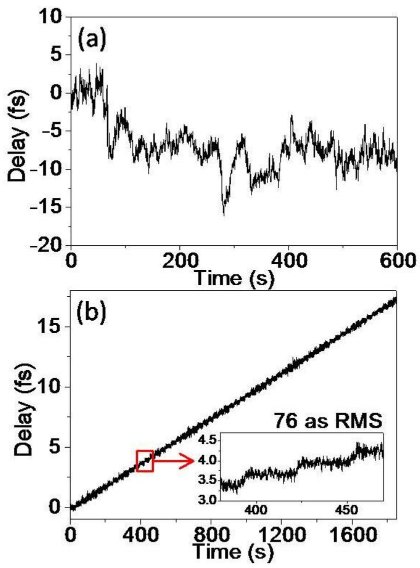

Fig. 1. (a) Time delay drift of free-running interferometer. (b) Time delay when locked and scanned.

In conclusion, by copropagating a CW laser beam through an attosecond streaking camera, the delay between the XUV and NIR pulses was controlled while maintaining interferometric stability of the system. Such a technique allows for complete control of the delay in attosecond pump-probe experiments.

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