Effects of acceptance angle on characterizing contrast of isolated 25 as pulses

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Abstract: The spectral resolution of a magnetic bottle spectrometer can be significantly improved by restricting the acceptance angle with a pinhole located near the birth place of the photoelectrons. With the improved resolution, the intensity of the pre- and post-pulses which are 1% of a main 25 as pulse can potentially be measured with less than 10% error.

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1. Introduction

When an isolated attosecond pulse is generated, the main pulse is always accompanied by pre- and post-pulses separated by half or one optical cycle. The contrast of the attosecond extreme ultraviolet (XUV) pulses can be retrieved from attosecond streaking traces. The effects of many experimental defects to the retrieval have been discussed for pulses longer than 80 as [1]. In this report, we numerically simulated the resolution of a Magnetic Bottle Electron Spectrometer (MBES), with which 67 as pulse was recently measured [2] and its effect to the satellite pulse retrieval of a 25 as pulse.

2. Simulation result and discussion

We simulated a 25 as transform-limited Gaussian pulse, with central photon energy at 151 eV, and 1% pre-and post-pulses contrast. The streaking trace was generated with the XUV and a near infrared (NIR) laser with pulse duration of 5 fs and central wavelength of 750 nm. To analyze the effect of MBES resolution, spectrum in each delay of the streaking trace is convoluted with the response function of the MBES and forms a new streaking trace. The FROG-CRAB technique is used for retrieving the satellite pulse contrast. Only 0.16% of the satellite pulse intensity contrast is retrieved, comparing to the 1% real value. Therefore, better resolution is needed for improving the retrieval accuracy. This can be achieved by limiting the acceptance angle of the MBES with a pinhole near the photoelectron birth place. The dependence of the acceptance angle to the pinhole size is plotted in Fig.1 (a), and the retrieved satellite pulse contrast is plotted in Fig.1 (b) with different pinhole diameters. This figure shows that as pinhole size decreases, the satellite pulse characterization becomes more accurate. Particularly, a 0.25 mm pinhole for an 8 m TOF or a 0.15 mm pinhole for a 3 m TOF can be used to reduce the retrieval error to less than 10%.

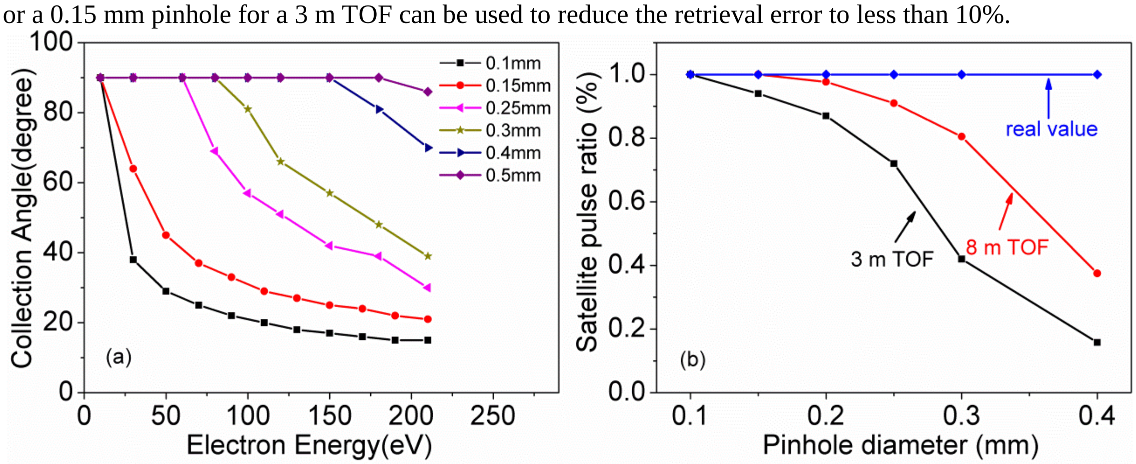

Fig. 1 (a) Collection angle as a function of the electron energy for different pinhole diameters. (b) Satellite pulse contrast limited by MBES resolution comparing with real values.

3. Conclusion

We demonstrate that the spectral resolution of MBES can be significantly improved by restricting the acceptance angle with a pinhole located near the birth place of the photoelectrons, and the satellite pulse of a 25 as pulse can be potentially retrieved with less than 10% error. This material is based upon work supported by the Army Research Office and the National Science Foundation under Grant Number 1068604.

4. References

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[2] K. Zhao et al., Opt. Letter **37**, 3891 (2012).