Modulating far-field properties of attosecond pulses based on relativistic plasma mirrors

Y. Zhang,[1,3] S. P. Zhu,[2] X. T. He,[1, 2] P. Zeitoun,[3*] and B. Qiao[1*]

[1] *Center for Applied Physics and Technology, HEDPS, and SKLNPT, School of Physics, Peking University, Beijing 100871, China*

[2] *Institute of Applied Physics and Computational Mathematics, Beijing, 100094, China*

[3] *Laboratoire d'Optique Appliquée, ENSTA Paris—École Polytechnique IP Paris- CNRS UMR 7639, Palaiseau, France*

High-order harmonic generation driven by relativistic laser-plasma interaction is one of the most promising ways to realize table-top high-brightness attosecond sources, attracting a wide range of research interests for their broad applications. In the contribution, we report that the far-field properties of such attosecond pulses are greatly impacted by optically-formed parabolic-like relativistic plasma mirrors (PMs) [1]. Utilizing particle-in-cell codes and self-developed computation modules for the far field, we show that through adjusting the distance between foci of incident lasers and plasma targets, the divergences, waveforms and wavefront of far-field attosecond pulses can be efficiently adjusted.

An experimentally feasible proposal to obtain intense attosecond pulses in the far field without filters has been proposed recently [2], which can greatly improve intensities and useable spectrum width of attosecond pulses. With a proper defocusing distance, attosecond pulse trains with 65 times enhanced intensity and 50% decreased duration are obtained naturally in the far field due to suppressed divergences and locked peaks of harmonics. Besides, we also present a new method, named "divergence gating", to generate isolated attosecond pulses [3], where varying curvatures of defocused chirped lasers are used to modulate the focusing characteristics of the relativistic PM. Through making sure the most intense attosecond pulse generated at the peak cycle of lasers has the smallest divergence angle, isolated attosecond pulses can be obtained in the far field, confirmed by theoretical analysis and numerical simulations. Finally, what's more, the influence of PMs on the wavefront aberration of attosecond pulses will be discussed.

*Corresponding author: philippe.zeitoun@ensta-paris.fr, bqiao@pku.edu.cn

References:

[1] H. Vincenti, et al. Nat. Commun. 5, 3403 (2014).

[2] Y. Zhang, et al. Phys. Rev. Applied. 16 024042 (2021).

[3] Y. Zhang, et al. New J. Phys. NJP-113908.R3 (2022).