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Efficient High-order Harmonic Generation via Surface Plasma Compression with Lasers

Boyuan Li[1], Feng Liu[1], Min Chen[1], Fuyuan Wu[1], Zhengming Sheng[1,2] and Jie Zhang[1,2]
[1] Key Laboratory for Laser Plasmas, Shanghai Jiao Tong University
[2] Tsung-Dao Lee Institute, Shanghai Jiao Tong University
e-mail (speaker): liby1990@sjtu.edu.cn

High-order harmonic generation (HHG) using ultrashort laser interacting with solid targets is a promising method for developing advanced extreme ultraviolet (EUV) or x-ray sources without laser intensity limitations. Such light source can be used for attosecond pulse generation and achieving extremely strong fields [1,2], etc.

The efficiency of laser-solid HHG depends greatly on surface plasma distribution. Large-scale surface plasmas created by low-contrast (LC) lasers will defeat the efficient HHG. The usual method of enhancing efficiency involves tuning the plasma scale length carefully by improving the laser contrast [3,4], which is a significant challenge for high-power laser systems.

Here, we experimentally demonstrate that efficient harmonics can be achieved directly by compressing large-scale surface plasma via the radiation pressure of a circularly polarized normally incident prepulse (NIP). The HHG efficiency obtained by this method is comparable to that obtained with optimized plasma scale length by high-contrast (HC) lasers.

Figure 1 shows the experimental setup and results. It is clear that no harmonics could be observed for the LC laser, whereas intense harmonics were produced by the HC laser. The hydrodynamic simulation results indicate that a very steep surface plasma was created by the HC laser for efficient HHG, however for the LC laser, a large-scale low-density preplasma existed before the surface. If we introduced a NIP to compress the preplasma, efficient HHG could also be observed, which indicates that the large-scale preplasma was removed by the NIP compression.

Such NIP-assisted scheme avoids the use of plasma mirrors typically required for laser-solid HHG, which may pave a way for high repetition rate EUV sources with high brightness for various applications. This work has been published on Physical Review Letters [5].

References

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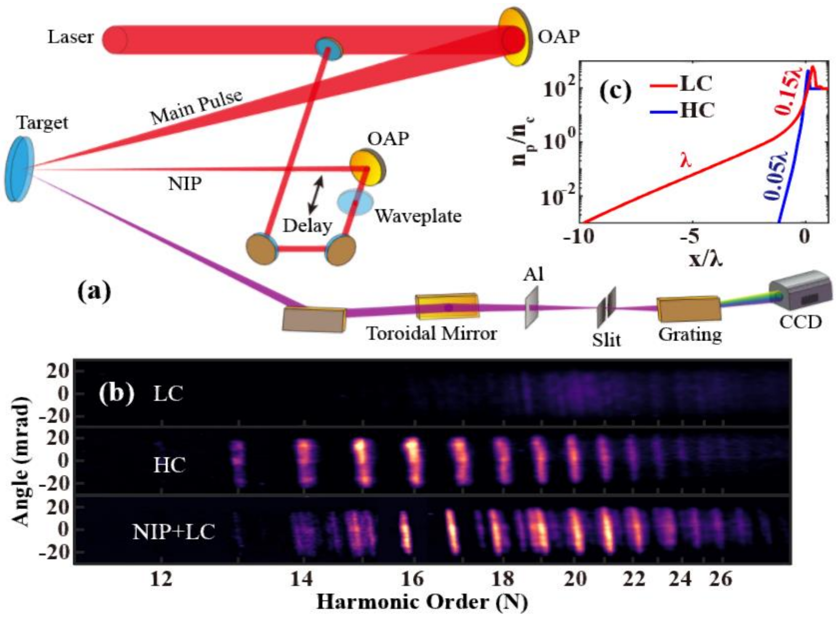

Figure 1. (a) Experimental setup for HHG and measurements. (b) Experimental harmonic images obtained using LC, HC and NIP+LC lasers. (c) Preplasma profiles by hydrodynamic simulations for LC and HC lasers.