Selective Enhancement of a Single Harmonic Emission

A group of scientists from the State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics (SIOM) has achieved the selective enhancement of tunable monochromatic coherent EUV radiation for the first time, as reported by *Physical Review Letters* on June 7, 2013.

Under the leadership of Prof. XU Zhizhan and Prof. LI Ruxin, researchers used multicolor laser pulses to control the field waveform on sub-cycle timescale and to selectively enhance the harmonic radiation of specific orders, achieving a high contrast ratio (15.9:1).

The high harmonic generation by strong laser field interacting with gas is a key research area in high-field laser physics. High order harmonics are usually generated like combs with similar strength for different frequencies in the plateau region, which can be attributed to the nonperturbative process of high-order harmonic generation. In order to concentrate the energy to a specific order of high-order harmonics, the researchers proposed a unique design with sub-cycle waveform control and two-dimensional polarization controllable multicolor laser field to realize both the macro-phase matching and the intra-atomic phase matching, thus implementing successfully the great enhancement of a specific harmonic and the suppression of the adjacent harmonics. This specific harmonic order can be tuned by the phase-matching techniques to obtain tunable monochromatic coherent EUV radiation output.

In 2000, a group of scientists from the University of Colorado and the National Institute of Standards and Technology reported the enhancement of the target harmonic (eight times) by using a deformable mirror to optimize the chirp characteristics of driving laser pulses. However, they did not suppress the adjacent harmonics. In the following years, no substantial progress had been reported. The present study was the first breakthrough to achieve selective enhancement of a single high-order harmonic, with the output intensity enhanced by 10^2-10^3 times (comparing with the case of the monochromatic laser field) and the contrast ratio increased to 15.9:1.

The study had important theoretical significances and application prospects. As the three reviewers pointed out, "this technique is useful in producing a monochromatic coherent XUV source", "the work is interesting for applications such as seeding XUV FELs. The mechanism is also interesting because it is related to sub-cycle waveform control, which is currently a hot-topic in high harmonic generation research", and "these results are very interesting and useful for application of high harmonics, because much larger enhancement is obtained, compared with the previously reported methods".

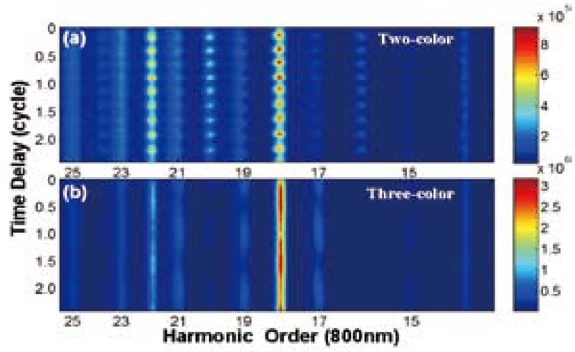

Figure 1. (a) Harmonic spectra driven by the two-color laser field with orthogonally polarized 800 nm and 400 nm laser pulses as a function of the time delay between them. (b) Harmonic spectra driven by the three-color scheme as a function of the time delay between the 800 nm and 400 nm laser pulses.

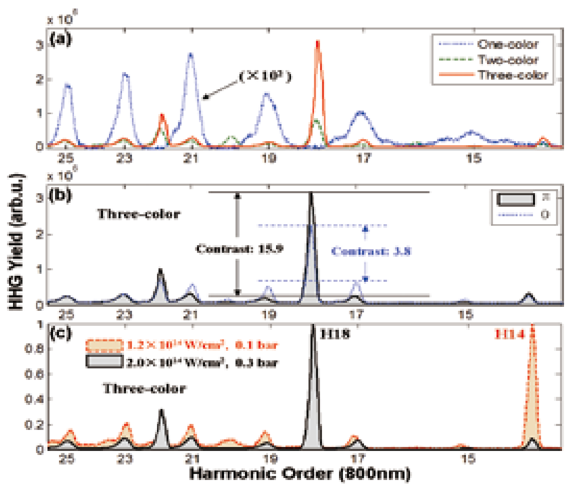

Figure 2. (a) Comparison of the maximum harmonic yields driven by the one-color, two-color, and three-color laser fields, respectively. (b) Comparison of the harmonic yields driven by the three-color laser field with two different relative phases, respectively. (c) Comparison of the harmonic yields driven by the three-color laser field with different conditions. The harmonic emission of the selective enhancement can be tuned by controlling the laser intensity and the phase matching parameters.

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