Spectral Characteristics of High-Order Harmonics Generated in a Two-Color Femtosecond Laser Field

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Highly efficient high-harmonic generation (HHG) was achieved in helium using a two-color laser field that consisted of the fundamental and second harmonic (SH) of a femtosecond Ti:sapphire laser [1]. The harmonics generated in an orthogonally polarized two-color field were stronger than those obtained using the fundamental laser field alone by more than 2 orders of magnitude, and were also stronger than in the case where the two laser field polarizations are parallel. The two-color laser field with a suitable relative phase difference can select harmonics from the short quantum path with a dense electron wave packet, producing highly efficient high-order harmonics [1, 2].

We investigated the effect of wave mixing from the spectral structure of high-harmonics obtained by controlling the relative phase and time delay between the two laser fields. As the fundamental field was advanced with respect to the SH, strong harmonics were observed at 2(2n+1)th orders, but with closer temporal overlap between two laser fields, purely mixed orders such as 2(2n)th also became prominent, i.e. all even-order harmonics became strong. Beyond the temporal overlap, SH field was advanced, and the strong 2(2n+1)th harmonic orders were shifted towards higher orders while 2(2n)th orders got reduced. The intensity variation of high harmonics was π-periodic with respect to the change of the relative phase. In the case of parallelly polarized two-color field, a supercontinuous spectral structure was obtained at the cutoff region. This feature can be useful for generating an isolated attosecond pulse [3]. Using a long gas medium, we observed even stronger high harmonics, further increasing harmonic conversion efficiency. This high harmonic soft x-ray source emits approximately 3×10^{10} photons per single shot at the 38^{th} order (21.6 nm), corresponding to a conversion efficiency of 1×10^{-4}. The relative simplicity and effectiveness of the two-color method for strong HHG should be of great use in applications such as ultrafast soft x-ray spectroscopy for atoms and molecules.

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References

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