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Focusing properties of high-order harmonics

The investigation of ultrafast electron dynamics using nonlinear extreme ultraviolet (XUV)-pump XUV-probe spectroscopy requires light sources with high flux and high intensity. High-order harmonic generation (HHG) can provide this, but tight spatial focusing is needed. Hereby, the longitudinal overlap of harmonic foci is critical. We present experimental and simulated results on the focusing properties of harmonics in the spectral range between 17-45 eV for different generation conditions.
A terawatt laser system delivers 40 fs pulses with 45 mJ pulse energy at 806 nm at a repetition rate of 10 Hz. The infrared (IR) beam is wavefront corrected by a deformable mirror (DM). The DM allows us to add a curvature to the beam, changing the IR focus position relative to the pulsed Ar gas cell used for HHG. After propagation and IR-filtering, the XUV is refocused to a few micrometers focal spot by two toroidal mirrors in a Wolter configuration, with a high demagnification factor. A knife-edge is inserted into the beam at different positions along the propagation axis close to the geometrical focus. From this measurement, we determine the focal spot size and longitudinal position for each harmonic and compare the results with simulations. We show that the focusing properties depend on the harmonic order and the position of the IR focus relative to the gas cell. We conclude that, even when the total HHG yield is rather constant, the spatial and temporal profiles and thereby the XUV intensity change strongly with the generation conditions.

Author: PLACH, Marius

Co-authors: Mrs HOFLUND, Maria (Lund University); Mr PESCHEL, Jasper (Lund University); Mr DACASA, Hugo (Lund University); Mr VEYRINAS, Kevin (Universite de Bordeaux); Mr CONSTANT, Eric (Universite de Lyon); WIKMARK, Hampus (Lund University); Mr MACLOT, Sylvain (Lund Unviversity); Mr ENG-JOHNSSON, Per (Lund University); Mr ARNOLD, Cord (Lund University); Mrs L'HUILLIER, Anne (Lund University); Mr GUO, Chen (Lund University)

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