LABORATOIRE INTERACTIONS, DYNAMIQUES ET LASERS

LIDYL-UMR 9222
CEA, CNRS, Université Paris-Saclay

THESE LIDYL

Shatha KAASSAMANI

Groupe ATTOPHYSIQUE

Le Jeudi 10 Décembre 2020 à 14h00

En visio (https://eu.bbcollab.com/guest/f56ff263bf934d629ab1f22321e48ea1)

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"Polarization Spectroscopy of High Order Harmonic Generation in Semiconductors"

In the first part of this thesis, we investigate high harmonic generation (HHG) from the visible to the XUV in 2D materials, specifically graphene, and 3D crystals mainly zinc oxide (ZnO), silicon (Si), gallium arsenide (GaAs) and magnesium oxide (MgO). We report on HHG in graphene with a particular emphasis on the sustainability of the process. HHG is measured from few layers of graphene deposited on a substrate, and for the first time from freestanding graphene. In addition, we investigate fundamental aspects of solid-state HHG by studying the dependence of the process on the laser properties, such as the intensity, polarization and ellipticity. We find that during the HHG process the driving laser and the crystal properties are correlated. For instance, HHG in semiconductors with cubic or zinc-blende crystal structures such as MgO and GaAs shows a strong anisotropic dependence (fourfold symmetry) on the laser polarization state. We propose to use the strong polarization dependence of XUV harmonics from MgO to generate isolated attosecond pulses by the anisotropy gating technique. Special emphasis is made on the role of linear and nonlinear propagation effects mainly the Kerr effect, upon laser interaction with the crystal, which can significantly influence the HHG efficiency. Although this presents major limitations, in some cases it turns out to be an advantage. For example, the self-focusing in a thick silicon crystal increases the effective laser intensity and, consequently, the HHG yield as compared to a thinner crystal. Besides, the self-phase modulation effect in a MgO crystal leads to "self-compression" of the laser pulses.
In the second part, we exploit the 3D solid nature of the generating medium to manipulate the harmonic emission. First, we pattern nanostructured ZnO cones to enhance the intensity of few nanojoules MHz laser pulses in a sub-wavelength spot, and to consequently generate non-perturbative harmonics with an increased efficiency. Second, we generate harmonic beams carrying orbital angular momentum (OAM) by patterning diffractive phase objects (spiral zone plates) at the exit surface of the ZnO crystal. In addition, we verify the transfer and conservation of the OAM from the generating laser to the harmonics. Lastly, we illustrate the spatial coherence of solid-state harmonics by performing a lensless imaging application based on the coherent diffractive imaging (CDI) technique.

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