# Polarization Resolved High-order Harmonic Generation in Germanium

A. Annunziata[1], D. Faccialà[2], N. Tancogne-Dejean [3], E. Cinquanta [2], M. Devetta[2], G.Isella[1], M. Bollani[2], U. De Giovannini[3], H. Huebener [3], A. Rubio[3]. S. Stagira[1], C. Vozzi[2]

[1]Department of Physics, Politecnico di Milano, Piazza Leonardo da Vinci 32 (20139, Milano, Italy),

[2]Institute for Photonics and Nanotechnologies (IFN), National Research Council (CNR), Piazza Leonardo da Vinci 32 (20133, Milano, Italy)

[3]Max Planck Institute for the Structure and Dynamics of Matter, Center for Free Electron Laser Science (22761, Hamburg, state, Germany)

Corresponding Author: andrea.annunziata@polimi.it

When a solid is exposed to a strong mid-infrared field, harmonics of the central frequency of the driving field are emitted, a phenomenon referred to as high-ordec harmonic generation (HHG). Aiming to exploit HHG as a spectroscopic tool, we characterized the polarization state of the harmonics emitted from bulk germanium in reflection configuration as a function of the relative orientation between the linearly polarized driving field and the crystal orientation.

To characterize the polarization state of the emitted harmonics, we used a broad-band polarimeter consisting of an achromatic quarter waveplate and broad-band polarizer (denoted as analyser). Specifically targeting the harmonics in the visible range, namely the third, fifth, and seventh harmonics, our findings reveal a complex polarization state of the emitted harmonics, indicating a significant dependence on the band structure of the crystal under investigation, particularly noticeable for harmonics emitted near a resonance. Fixing the crystal orientation and acquiring the harmonics as a function of the analyzer angle, we could reveal spectral interference effects originating from different contributions in the harmonic emission. Employing a fitting procedure, we were able to disentangle these contributions and characterize the polarization direction as well as their relative phase. Our observation indicates that polarization-resolved HHG spectroscopy can be used as a powerful tool to investigate condensed matter in strong out-of-equilibrium conditions.