Complete characterization of short-wavelength infrared few-cycle pulses via third harmonic generation dispersion scan

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Abstract

We present preliminary experimental results of third harmonic generation dispersion scans for the complete temporal characterization of few-cycle (~10fs) short-wavelength infrared (1-2.5µm) intense (400µJ) laser pulses. Some of the subtleties of using third harmonic generation in bulk, such as phase matching and self-phase modulation, are discussed.

Introduction

Intense few-cycle short-wavelength infrared (SWIR) carrier-envelope-phase (CEP) stabilized pulses offer an attractive method for the generation of isolated attosecond pulses in the water window via high harmonic generation. Complete temporal characterization of these pulses is highly desirable to optimize the pulse generation and compression.

Sub-10fs SWIR pulses can be generated via self-phase modulation (SPM) in a gas filled hollow-core fibre [1] seeded by the idler of an optical parametric amplifier (OPA) pumped by a Ti:Sapph laser. We recently proposed a method to amplify these few-cycle SWIR pulses to ~10mJ and compress down to ~6.5fs (1.15 cycles) full width at half maximum (FWHM) via a Ti:Sapph pumped OPA, and are undertaking proof-of-principle experiments [2].

Accurate temporal characterization is required to ensure an optimal balance between the level of spectral broadening and nonlinear dispersion resulting from SPM / material dispersion, as well as optimizing the dynamical interplay between amplification and temporal reshaping in the proposed OPA. Whilst FROG and SPIDER have previously been implemented in this wavelength regime [3, 4], third harmonic generation (THG) dispersion scan (DS) [5] offers a much simpler configuration (see fig. 1). Preliminary results for THG-DS in graphene at 3µm have previously been presented [6]. THG in bulk is more practical, but presents some subtle complications such as phase matching (PM) and SPM. In this contribution we demonstrate THG-DS of few-cycle SWIR pulses in bulk glass and discuss the effects of PM and SPM.

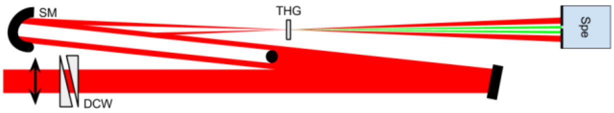

Fig. 1. Schematic of THG-DS setup - *DCW*: dispersion compensation wedges, *SM*: spherical mirror, *THG*: third harmonic generation, *Spe*: spectrometer.

Results

Fig. 2 shows measured and retrieved THG-DS traces of a few-cycle SWIR pulse, and the corresponding reconstructed spectral phase and temporal intensity. We used a 180µm thick BK7 slide for THG. Phase mismatch resulted in a strongly modulated THG spectrum, which can be accounted for in the phase retrieval algorithm provided the PM can be modelled by a pure spectral intensity modulation [5]: i.e. the pulse's temporal intensity must remain constant during THG; calculations indicate that <0.4mm of BK7 is necessary. SPM occurs simultaneously to THG and must be minimized to enable quick and simple modelling of the DS trace: we used the 'crossed-beam' geometry shown in fig 1. and reduced the input pulse energy with an iris to a level such that the THG spectrum did not depend on the energy.

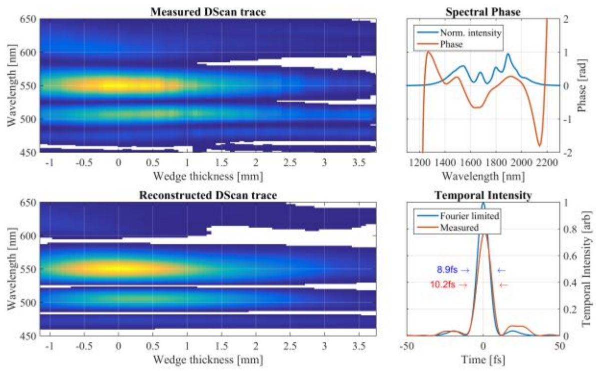

Fig. 2. Measured (top left) and reconstructed (bottom left) THG-DS traces and reconstructed spectral phase (top right) and temporal intensity (bottom right). Wedge thickness is relative to optimally compressed thickness.

Conclusions

We have demonstrated that it is possible to use THG-DS to measure the full spectral phase of few-cycle SWIR pulses simply and easily. We plan to use these measurements to optimize the hollow fibre pulse compression and our proposed few-cycle SWIR OPA.

References

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