Few-Cycle Optical Vortices from OPCPAs

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Optical vortices carrying orbital angular momentum (OAM) have enabled numerous and diverse applications including novel laser material processing, super-resolution microscopy, and high dimensional quantum cryptography among several others [1]. Recently, high intensity optical vortices in the visible and near-infrared (VIS-NIR) with short pulse durations (tens of fs) have been utilized to generate extreme ultraviolet (EUV) light with OAM through high harmonic generation (HHG) [2]. In particular, it has been demonstrated that the combination of spin angular momentum (circular polarization) and OAM can be exploited to control the polarization and OAM of attosecond pulses [3].
Optical vortices are characterized by an azimuthal phase variation giving rise to a helical wavefront and a singular point of zero intensity. The azimuthal phase integrates to $2\pi l$ on a closed path around the singularity, for a nonzero integer l denominated the topological charge. The experimental realization of the ideas exposed in [2,3] relies on generating ultrashort optical vortices in the VIS-NIR to drive the HHG process utilizing special optical components such as spiral phase plates or spatial light modulators to imprint a helical phase on the incident beam. The imprinted phase is however dependent on the light frequency and therefore the imprinted helical phase corresponds to a well-defined topological charge for a single frequency. This leads to an effect known as topological charge dispersion, meaning that different frequency components carry different contents of topological charge.
In this work we will discuss how the properties of parametric amplification can be utilized to generate ultra-broadband optical vortices supporting few cycle pulses with a high degree of control of the topological charge content over the full bandwidth [4]. In particular we will show how the well-defined topological charge of a narrowband pump beam can be transferred to an idler or signal beam during parametric amplification. Furthermore we will explore some of the limitations of this idea.

References

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