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In-line and ultraestable spatiotemporal characterization of constant and time-varying optical vortices

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During the last decades, the generation and study of optical vortices has gained great interest due to their multiple applications such as optical tweezers or optical machining among others [1]. However, the complex set-ups and the high dependency to external perturbations of conventional spatiotemporal characterization techniques [2] complicates their study.

In this contribution, we present the study of constant and time-varying optical vortices using an in-line, robust and ultraestable spatiotemporal characterization technique [3]. The spatiotemporal technique is based on the properties of birefringent uniaxial crystals in order to obtain a bulk lateral shearing interferometer which combines spectral and lateral interferometry. Furthermore, the temporal reference required by our technique is obtained using amplitude swing [4], making the whole system robust against external perturbations. We have taken advantage of the high stability of the whole system, associated with its compact configuration, to characterize temporally and spectrally the wavefronts of optical vortices with constant and time-varying orbital angular momentum (OAM).

The optical vortices were generated using a Ti:Sapphire pulsed laser (central wavelength around 800 nm) and nanostructured plates commonly known as s-waveplates. As explained in [3], depending on the incident beam properties after the s-waveplates we can either generate constant optical vortices or two delayed vortices with an average time-varying OAM. On one hand, in the left part of Fig.1 (Exp. 1) it is shown a snapshot of the spatiospectral characterization of a constant OAM vortex of $\ell=+4$, which corresponds to the second harmonic of an optical vortex of $\ell=+2$. On the other hand, in the right part of Fig.1 (Exp. 2) they are shown three temporal snapshots of the spatiotemporal characterization of the average structure of two delayed optical vortices with different OAM ($\ell=+2$ and $\ell=0$). In t_1 and t_3, the individual vortices of $\ell=+2$ and $\ell=0$ are observed, respectively, whereas t_2 corresponds to its superposition. These results were found to be in good agreement with theoretical simulations [3].

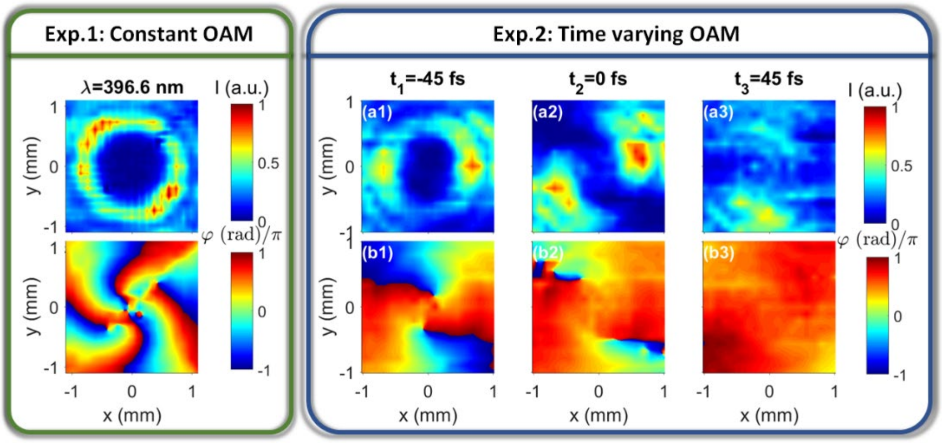

Fig. 1. Green box [Exp. 1]: spatiospectral characterization of a pulsed optical vortex of $\ell=+4$. Blue box [Exp. 2]: spatiotemporal characterization of two delayed optical vortices of $\ell=+2$ and $\ell=0$ for three different times of the pulse.

In conclusion the compact and ultraestable set-up of our spatiotemporal technique enables to easily characterize temporally or spectrally the wavefronts of complex spatiotemporal pulsed beams such as optical vortices. Moreover, the spatiotemporal technique can be used in all the transparency range of the birefringent crystals, so we believe it could be a key tool to ease the characterization of ultrafast phenomena.

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