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Generation Gauss-Bessel beams with vortex phase plates at formally inadequate wavelengths

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In the first studies of the generation of long-range quasi-non-diffracting Gauss-Bessel beams (GBBs) by creating and annihilating multi-charge optical vortices (OVs) [1-3], calibrated reflective liquid-crystal spatial light modulators are used. Because of their low damage threshold, they are not applicable with high-power laser beams. Vortex phase plates (VPs; phase plates which thickness is varying azimuthally) are an adequate solution of this problem. The limitation is, however, that each VP is designed to produce the desired integer topological charge (TC) at a specified wavelength. If the used wavelength is different, OVs with fractional TCs are created and the background beam becomes accordingly modulated.

In this work we report experimental results confirming that multiple optical vortices with fractional TCs can be successfully annihilated and zeroth- and first order GBBs can be successfully generated at even formally inadequate wavelengths.

We will report results on the generation of GBBs by using vortex plates (VPs) designed for 532nm, using laser beams at 445 nm, 532 nm, 633 nm, and 800 nm. The GBB propagation is followed from z=32cm behind the focus of the lens to 320 cm behind it. At each distance the experimental cross-section of the GBB is compared with a theoretical Bessel function. The close inspection of the data at z=32 cm shows best match between the experimental and numerical positions and relative intensities of the peaks for 532 nm and 800 nm. At 100 cm the best match can be seen at 532 nm and 633 nm. At 320 cm and at the largest distance 540 cm studied here, good agreement between the experimental and numerical data can be seen for 445 nm, 532 nm, and 633 nm. Summarizing these observations, one can conclude that the experimental and numerical radial profiles of the (Gauss-)Bessel beams match best for 532 nm – the wavelength for which the VPs are designed. Qualitatively the same holds for the data obtained for first-order GBBs. The data show, however, that zeroth- and first order GBBs can be generated with a reasonable good quality at formally inadequate wavelengths. Another argument in support of this statement are the low divergences of the generated GBBs at the formally "inadequate" wavelengths (151 μrad and 125 μrad for zeroth and 1-st order GBBs at 800 nm, respectively; 123 μrad and 106 μrad for zeroth and 1-st order GBBs at 633 nm).

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