Topologinio krūvio tvermės dėsnis pusinio topologinio krūvio sūkuriams antros harmonikos generavimo procese

Topological charge conservation of optical vortices with half integer topological charge in the process of second harmonic generation

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Transformations of wavefront dislocations have been studied in nonlinear regimes. It was shown that for OVs (i.e. screw dislocations) the law of conservation of topological charge (TC) holds in the form of $l_1 + l_2 = l_3$ during nonlinear processes. Conservation of integer TC was shown for the processes of second harmonic generation (SHG) [1], sum- (difference-) frequency generation [2], nonlinear wave mixing [3]. Wavefront of OV with fractional TC has the form of mixed screw-edge dislocation. These dislocations are unstable and, upon propagation, decay into unit-charged OVs in the far field.

We demonstrate collinear SHG performed with optical vortex with fractional topological charge $|l|=1/2$. During this process we examine the law of conservation of topological charge. Despite the instability of optical vortices with $|l|=½$, we observe counterintuitive charge doubling. In the second harmonic we observe optical vortex with topological charge $|l|=1$. The conservation of topological charge is confirmed by both numerical simulations and the experiment.

Topological charges of first and second harmonic optical vortices were measured by the setup based on interferometer of Mach–Zehnder (Fig. 1). Fundamental beam (FB, λ=1064 nm) with a Gaussian profile was split into two beams namely, signal and reference. The signal beam the fractional-charge OV with $l=½$ was generated as a result of conversion of circularly polarized Gaussian beam, with wavelength λ=1064 nm, on the S-waveplate manufactured for λ=532 nm. The horizontally polarized OV was sent to the nonlinear crystal (KTP) to generate second harmonic (SH) beam. Two identical KTP crystals were used in both branches of the setup. The reference Gaussian beam was used to produce the interference pattern with the SH beam.

Intensity distribution of the FH is shown in Fig. 2 (a). Interference patterns of FH and reference beam are shown Fig. 2 (b, c). The interference fringes indicate that a beam has the phase shift π between different areas of the beam, referring to TC $l_1=½$.

Intensity distribution of the SH beam is shown in Fig. 3 (a). Interference patterns of SH and reference beams are shown in Fig. 3 (b, c). The forked interference pattern indicates that the SH beam carries optical vortex. Initial OV with $l_1=½$ has integer TC $l_3=1$ in second harmonic. The experimental results are in the good agreement with theoretical predictions.

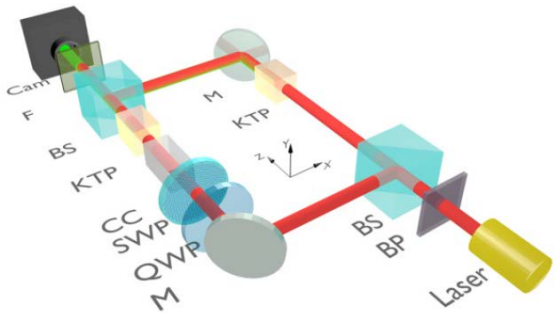
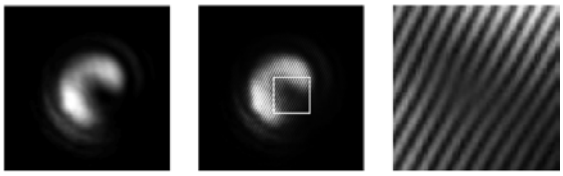


Fig. 1. Experimental setup. BP - Brewster thin-film polarizer, BS - beam splitter, M - mirror, QWP - quarter waveplate, SWP - S-waveplate, CC - calcite cube, KTP - nonlinear crystal, F - filter, Cam - CCD camera.

(a) (b) (c)

Fig. 2. CCD-acquired images of (a) the FH OV of topological charge $l = ½$ and its (b, c) interference with reference pattern.



(a) (b) (c)

Fig. 3. CCD-acquired images of (a) the SH OV of topological charge $l = 1$ and its (b, c) interference with reference pattern.

Keywords: optical vortex, fractional topological charge, second harmonic generation, law of conservation of topological charge.

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