OPTICAL VORTEX GENERATION APPLIED FOR SENSING DISPLACEMENTS AND DEFORMATIONS

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A usual way of producing light beams with optical vortices is grounded on the utilization of holographic gratings with embedded phase singularity (EPS). This EPS usually represents a topological defect of the grating structure: one or more "broken" or "branching" grooves that disturb a standard pattern of rectilinear or regularly bended grooves. In other words, such gratings contain one or more bifurcation points near which the grooves form a characteristic "fork" structure [1, 2]. An incident beam with smooth wavefront (e.g., Gaussian beam) diffracting at this structure produces in the non-zero diffraction orders beams with helical wavefront components described by factor $\exp(im\phi)$ where ϕ stands for the polar angle, *m* is an integer number.

The spatial behavior of the diffracted vortex beam depends essentially on the detailed geometric scheme of the optical vortex generation. In this report, a comprehensive theoretical and experimental study of spatial parameters of the generated beam is presented. In accord with the results obtained, the transverse intensity profile in a whole, positions of its characteristic points (maximums and zeros of intensity as well as the "center of gravity" coordinates) and the overall directivity of a generated vortex beam are closely related with relative shifts and tilts of the incident beam axis with respect to the nominal grating axis as well as with the grating deformations.

Possible employment of these effects for creation and development of means for distant sensing the object displacements are discussed. In particular, a grating with EPS can be attached to a distant object and, in the nominal condition, enlightened by a Gaussian incident beam whose axis exactly coincides with the grating axis. A diffracted optical vortex beam is then circularly symmetric with respect to the nominal propagation axis. Any displacement of the object will then result in the incident beam misalignment and, as a consequence, deformation of the diffracted vortex beam, redistribution of its energy and variation of its "mean" direction (trajectory of the "center of gravity"). This result can be detected and measured by standard devices for the light beam examination (e.g., by a CCD camera associated with a PC) and after the elementary processing, the grating perturbation being a source of this deformation can be reconstructed. For example, deviations of the beam center of gravity carry unambiguous information on the magnitude and direction of the grating displacement. Sensitivity and dynamical range of such sensors can be adjusted by relevant geometrical scheme; the use of several diffracted beams of different orders enables to increase the measurement accuracy and to separate contributions caused by the object linear and angular shifts as well as shifts along different directions.

Comparison of the proposed approach with existing distant sensors of displacement testifies prospects for its further development and realization.

1. M.S. Soskin, M.V. Vasnetsov, "Singular optics", Prog. Opt. 42 (2001) 219-276.
2. A.Ya. Bekshaev, M.V. Vasnetsov, M.S. Soskin, "Light beams with angular momentum", Ukr. J. Phys.: Reviews 2 (2005) 73-113.