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# Theoretical and analytical investigation of radial carpet beams based on Gaussian beam illumination

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**Abstract**
This study examines the interaction of a coherent Gaussian beam with a separable two-dimensional optical structure, going beyond the plane-wave approximation, for practical applications that utilize the Gaussian beam profiles from lasers. We develop a more realistic framework to describe the optical beam diffraction, which better matches experimental conditions. Our results demonstrate that this process forms structured light beams and preserves their transverse shape and structure over longer propagation distances. This shape-invariance property renders them particularly valuable for precision-oriented and controlled applications in science and technology. The effect of the incident beam wavelength on the diffraction pattern of a binary radial phase grating is investigated. The analyses reveal that the intensity distribution exhibits azimuthal symmetry, and the number of the principal lobes in both the intensity and phase profiles of the diffracted field is twice the number of sectors in the binary radial phase grating. A comprehensive and practical diffraction framework, based on the Fresnel–Kirchhoff integral, is formulated in polar coordinates to describe Gaussian beam interaction with binary radial phase gratings. Based on this framework, the closed-form analytical expressions are derived for the resulting complex optical field.

**Keywords:** Diffraction, Grating, Radial Carpet Beam, Structured Light

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