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Exploring Probabilistic Amplitude Masks for Effective Generation of Complex Phase Profiles in Photo-Thermo-Refractive Glass

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Introduction. The utilization of phase masks in optical applications has seen significant advancements, particularly in the production of masks with arbitrary phase profiles. While simple masks inducing constant phase shifts have been devised, the challenge lies in creating masks with intricate phase profiles, including gradients and sharp transitions. This study explores the use of probabilistic amplitude masks to achieve arbitrary spatial dependence in phase masks recorded in Photo-Thermo-Refractive (PTR) glass. A conventional amplitude mask, typically binary in nature, proves insufficient for this purpose due to diffraction-induced washout in sharp transition regions. To address this limitation, a novel approach involving probabilistic amplitude masks is introduced, designed specifically to exploit diffraction effects during recording [1].

Main part. The study employs a contact copy technique with a broadband incoherent UV source to alter local intensities during the recording of phase elements. Grayscale amplitude masks, critical for achieving desired phase profiles, face challenges in practical implementation due to high cost and limited resolution. A new type of amplitude mask, referred to as a probabilistic amplitude mask, is proposed, overcoming cost constraints and providing a viable alternative. These masks are designed using a quasi-random distribution of opaque and transparent pixels, creating a quasi-continuous phase distribution in PTR glass [2]

The investigation extends to the optimization of probabilistic amplitude masks, addressing pixel size considerations. Simulations reveal that smaller pixel sizes, around 1 µm, yield the best representation of desired phase distributions. The study delves into the effects of quasi-uniform illumination, particularly on probabilistic masks, highlighting potential quality reduction in phase masks, especially in regions with phase discontinuities.

The practical implementation of probabilistic masks is detailed, comparing them to grayscale masks in generating optical vortices and Fresnel lenses. The study emphasizes the cost-effectiveness of probabilistic masks and their ability to produce optical vortices with fidelity comparable to grayscale masks. However, challenges arise in applying probabilistic masks to Fresnel lenses, where focusing efficiency is compromised, especially for shorter focal lengths.

Conclusions. In conclusion, probabilistic amplitude masks present a promising avenue for cost-effective production of complex phase profiles in PTR glass. While their application in generating optical vortices demonstrates comparable fidelity to grayscale masks, challenges exist in achieving high focusing efficiency in Fresnel lenses. Further research is required to optimize probabilistic masks for specific applications and enhance their performance in generating intricate phase profiles with improved focusing efficiency. The study opens avenues for exploring economical alternatives in the field of phase mask technology.

References:

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