Title

Discrete is not a Phase - A Review Paper on Composite Beams

Author

Chen, Megan

Publication Date

2023-12-11

Discrete is not a Phase - A Review paper on on Composite Beams

Chen, Megan

University of California, Los Angeles
megchen168@g.ucla.edu

Abstract

This review paper explores the set up in Lemons et al. paper “Integrated structured light architecture” of composite beam shape formation, enabling flexibility with light’s properties (i.e. phase) to generate precise shape for applications.

Introduction

Here, an arrangement of lasers in a hexagonal ring surrounding a singular beam is examined, and they generate patterned beams formed in the far field to fit applications that require precise beam shapes, such as laser heaters. The precise generated shape in the far field is affected by several properties of light, such as amplitude, phase, and polarization. In this review, phase is one of two main factors manipulated in the following simulations. Previous state of the art focused on manipulating phase differences between beams have seen success in generating vortex and orbital angular momentum (OAM) beams, and to improve on this state of art other properties of light may be included in this analysis, such as those modeled in both the Lemons et al. paper and the simulations below. The other examined factor is the number of lasers, with a greater number of beams allowing more smooth and precise formation of shapes. Consider the analogy of a low polygon model as compared to a high polygon model in graphics, a similar analogy applies to the total number of beams. This is the effect of discretization for composing beams.

In the paper, other factors of manipulating the arrangement are described. The methodologies will be mentioned here for a more comprehensive review, but will not be the focus of the following simulations. Changes in polarization can create interesting interference patterns in polarization topography and Stokes projections. Modifying the phase front overall can allow a rotating beam shape, which may be useful.

Methods and Simulation

Using the MATLAB library *Coherent optics propagation and modeling* as created by Lemons and Carbajo, the results of the paper were simulated. The set up used the parameters of 1.55μm, and adjusted the phase offset and whether or not individual beams were on. The spacing was not explicitly given in the paper, so a spacing of roughly 3.5mm between beams was used, with a beamwidth of 1mm. This setup is meant to emulate the phase differences and number of channels used as shown in the examples of the paper, and to see if similar shapes can be simulated in the far field intensity of the laser sources. Overall the result is based off of the Rayleigh-Sommerfeld diffraction in the far field, as modeled in this library. Simulations are as below, N is the total number of beams (channels) used.

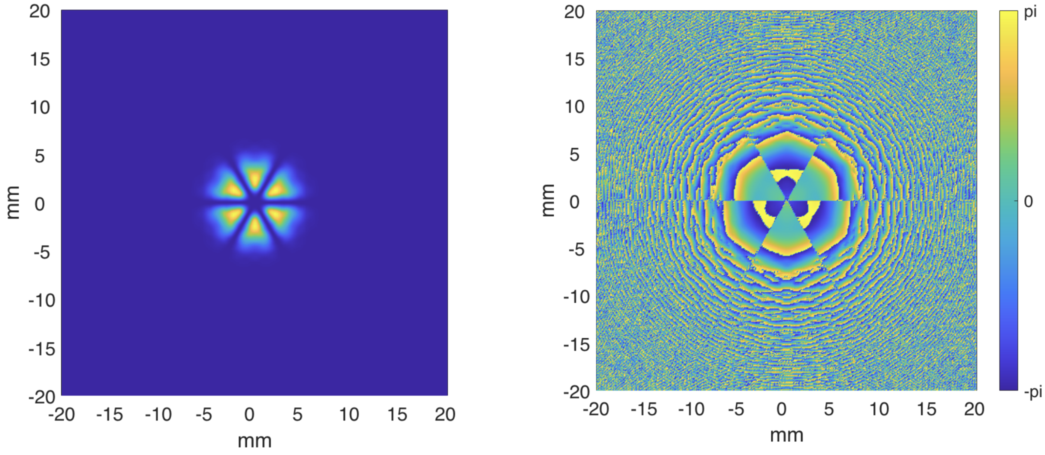

Figure 1. Far field intensity (left) and phase (right) of N = 7 alternating π and 2π phase, corresponding to Figure 2 Row 2 in the original paper.

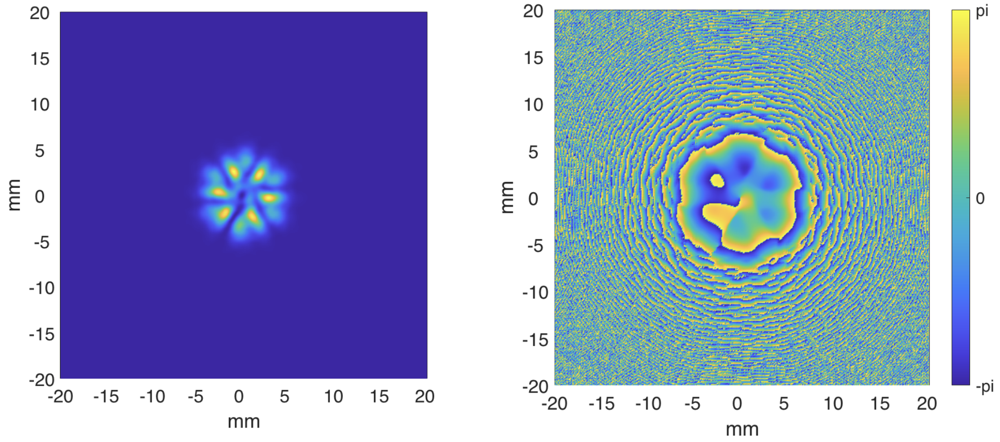

Figure 2. Far field intensity (left) and phase (right) of N = 7, phase increases by 0.25π from 0.75π to 2π to simulate an OAM beam, corresponding to Figure 2 Row 3 and Figure 5 Column 2 in the original paper.

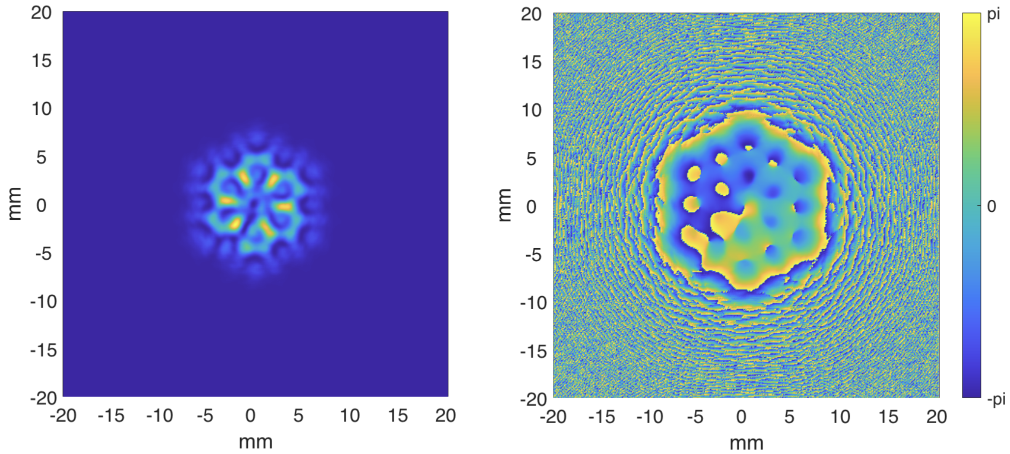

Figure 3. Far field intensity (left) and phase (right) of N = 19, phase increases by 0.25π in the second ring, and increases by 0.125π in the third ring, both from 0.75π to 2π for each ring to simulate an OAM beam, corresponding to Figure 2 Row 3 and Figure 5 Column 3 in the original paper.

Results and Interpretation

The MATLAB library used here was fairly user friendly for having an interface to input parameters for beams, and is fairly intuitive to use, as opposed manually programming new values upon simulation run. The library aided in the simulation process, but discrepancies still occur from light differences in precision in the models. The model applied in this paper is likely a generalized version of the simulations used in the original paper, and it should be noted that any inputted phase greater π is automatically offset by -2π, causing a phase shift of the generated beam, and all phase values are automatically rounded to 4 decimal points, contributing another point of imprecision. Another discrepancy arises visibly with the increased number of beams. For N = 19 the set up, both spacing and phase, was unspecified and liberties were taken to emulate. For the outer ring, for beams that are directly radially outwards as the inner ring will have the same phase, and for beams that are radially in between beams of the inner ring will have an in between phase. The spacing between beams in the outer ring remains the same as the inner ring.

Overall, ignoring the difference in color scale, the simulated results generated here and the observed plots in the paper in review have a fair semblance in shape for both phase and intensity in the far field, albeit rotated. The differences are more pronounced with the OAM beam in both the N = 7 and N = 19 discretization, and this is likely due to beam spacing being too sparse. Blotching and other hexagonal ripples appear and individual beams are observable in both the intensity and phase plots, likely caused by too little overlap in the far field. The spiral shape as demonstrated in the paper is still somewhat present in the phase plot, and a ring of intensity is also somewhat present in the intensity plot, but there is room for improvement. This can be improved by decreasing the spacing between beams and between rings. Even if the shape does not perfectly match, this shows the beginning formation of an OAM, and we can see an improvement in overall shape in the N = 19 plots as compared to the N = 7 plots.

Conclusions

From here, the effect of phases and discretization in this array of lasers is apparent and gives a dynamic, simple, and rapid way to adjust beam shape. Despite the output power being greater than needed for some applications, such a set up opens up possibilities in more refined beam shaping. This work expands the scope of light control and manipulations, and such dynamic changes may allow improvements and explorations in fiber optics, information processing, nonlinear photonics, and more. Future work may involve different formation shapes of the laser array to get different variations of beam shapes, on top of adjusting other properties as explored in the original paper not touched upon here.

References

1. Lemons, Randy, et al. "Integrated structured light architectures." *Scientific reports* 11.1 (2021): 796.
2. Lemons, R. & Carbajo, S. Coherent optics propagation and modeling. https://github.com/slaclab/CCPM/tree/1.0.0