Title
Structured Light

Author
Lee, Wonhee

Publication Date
2022-12-08

Structured Light

Wonhee Lee[1]

[1]*Department of Electrical and Computer Engineering, University of California Los Angeles, 2021 Los Angeles, CA 90024, USA*
**wonheel1@g.ucla.edu*

Abstract: Structured lights have become leading research filed recently. Although it is not easy to obtain this structure of light beams, there are several methods to obtain this, and advanced applications of it is also highly expected.

INTRODUCTION

Photons has multiple degrees of freedom, including frequency/wavelength, time, amplitude, phase, polarization, and spatial structure. Controlling these physical dimensions of photons fueled fundamental advances and applications in light-related field. Not just these traditional features, but also manipulating the spatial structure and spatiotemporal structure of light waves enabled the generation of various special light beams, known as structured light in broad sense. In this paper, methods of generation and detection of structured light beams will be introduced. Figure 1 are different types of structured light beams.

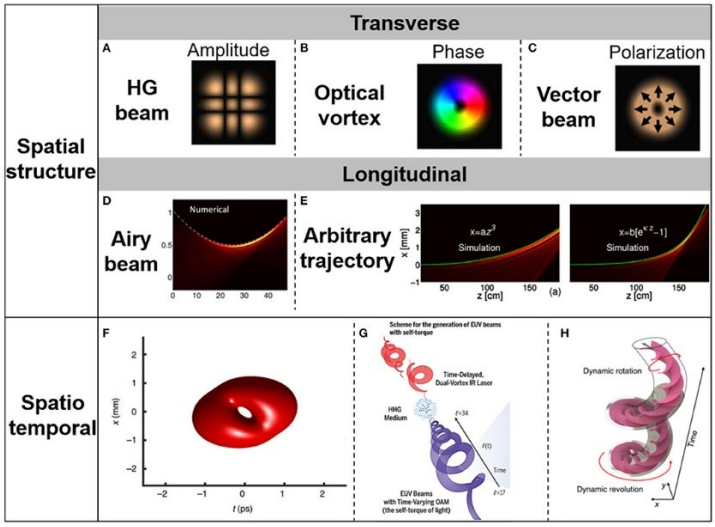

Fig. 1. Introduction of different types of structured light beams.

METHODS

Creating a structured light requires amplitude and phase control of each polarization vector in the optical field. The sum of two components with differing spatial properties gives rise to vector states of light with spatially inhomogeneous polarization structures. Since structured vector beams are just the sum of two structured scalar beams, the traditional toolkit for scalar beams can be applied separately and then added interferometrically. This exploits dynamic phase only. Geometric phase can also be exploited through subwavelength structures on metasurfaces, or large-scale structures in liquid crystals to induce a phase change that differs for each polarization, so that the vector beam is created directly.

Due to the reciprocity of light, detecting structured lights is generally the opposite of creating them. Unraveling the phase, amplitude and polarization recovers the initial beam. A simple single-pixel detector or coupling to a single-mode fiber allows quantitative analysis of the field by modal decomposition. Using two-step lossless conformal mapping can make these approaches more efficient by sorting various modes deterministically. Such mode sorters have been developed and applied to Laguerre-Gaussian, Hermite-Gaussian, and Bessel beams. The notion of quantum states of structured light offers a particularly intriguing angle on detection. To produce two photons entangled in their spatial modes, a Gaussian pump excites a spontaneous parametric down-conversion (SPDC) process in a nonlinear crystal. But the state is not defined until it is measured which means the entanglement could be expressed in any spatial mode. The post-selection of one pattern versus another collapses the state into the one that's measured. Because many spatial mode sets are orthogonal and complete, they form a natural way to express the entanglement.

RESULTS AND INTERPRETATION

Structured lights have become a significant field due to their unique nature, despite being proposed years ago. Light beams of a specific nature can be generated and used in many applications at the frontier by manipulating the properties of light beams, for example, optical communications, optical sensing, micromanipulation, quantum information processing, super-resolution imaging, etc.

CONCLUSIONS

We reviewed the generation of structured light beams. Structured light beams have already been used in various applications. It is a cutting-edge field, accessing new degrees of freedom and tailoring the structure of photons with interesting applications.

REFERENCES

1. Lemons, R., Liu, W., Frisch, J. C., Fry, A., Robinson, J., Smith, S. R., & Carbajo, S. (2021). Integrated structured light architectures. Scientific reports, 11(1), 1-8.K. Gallo and G. Assanto, "All-optical diode based on second-harmonic generation in an asymmetric waveguide," J. Opt. Soc. Am. B **16**(2), 267–269 (1999).
2. Wang, J., & Liang, Y. (2021). Generation and detection of structured light: a review. Frontiers in Physics, 9, 688284.
3. Shen, Y., Zhan, Q., Wright, L. G., Christodoulides, D. N., Wise, F. W., Willner, A. E., ... & Forbes, A. (2022). Roadmap on spatiotemporal light fields. arXiv preprint arXiv:2210.11273.