Title
Stokes Parameters in Integrated Structured Light Architectures

Author
Amianco, Charyn

Publication Date
2022-12-08

Stokes Parameters in Integrated Structured Light Architectures

Department of Electrical Engineering and Computer Science, University of California, Los Angeles
Charyn Amianco
charynamiancoo@g.ucla.edu

ABSTRACT
To explore the principles behind a laser architecture that produces light bullets using built-in programmable synthesized phase arrays, known as beamlines, which have their own unique field-amplitude, carrier-envelope (CEP), relative phase, and polarization.

INTRODUCTION
Structured photonics involves customizing light, in a spatio-temporal environment for a variety of applications. One of which is spatial modulators by adjusting the intensity and phase of a light beam in a Fourier space [1]. Unfortunately, there are some limitations that come with it, namely, uncontrolled pulse modulation, intensity distribution of light bullets, and carrier-envelope phase. In this case, synthesized phase arrays with built-in programmable structure are used to acquire a controlled structure of light bullets. These beamlines are manipulated to have a coherent relationship with one another and have unique spatio-temporal wavevector distribution.

METHODS
Polarization vector map calculations
The polarization state of an optical field is characterized based on the vectors of the optical field. In this case, the polarization vector map is obtained through polarization ellipse from the Stokes parameters $\{S_0, S_1, S_2, S_3\}$. Polarization ellipse, as we learned, is a general polarization state with any combination of major semiaxes (a) and relative phase (φ) values that are not combinations of either linear or circular polarization [2]. Each of the four parameters in the Stokes parameters provides different information. The first parameter describes the intensity of the beam, in this case, it is correlated to the size of the ellipse. The second parameter describes the polarization state (+1 for horizontal polarization and -1 for vertical polarization). The third parameter describes the polarization angle (+1 for +45° polarization angle and -1 for -45°). The final parameter describes the handedness of the ellipse(+1 for right-circularly polarized, -1 for left-circularly polarized).

To capture the Stokes parameters, seven images coming from seven channels have each of their projection images be captured by quarter-wave, a half-wave plate, InGaAs camera and a polarizing beam splitter. A quarter wave plate is made out of anisotropic material, in which the medium has two different indices of refraction and eigenvectors, that is used to convert a linearly polarized wave to an elliptically polarized wave. On the other hand, a half-wave plate is used to rotate the polarization angle of any linearly polarized wave. Last, a polarizing beam splitter is used to split one beam into two or more beams.

We can also calculate the eccentricity, tilt, and chirality to find the polarization ellipse using the formula below.

Eccentricity

$$e = \sqrt{\frac{2\sqrt{S_1^{\ 2}+S_2^{\ 2}}}{1+\sqrt{S_1^{\ 2}+S_2^{\ 2}}}}$$

Tilt

$$2\theta = tan^{-1}\frac{S_2}{S_1}$$

Chirality is calculated based on the sign of S_3

To measure the power of the beam, the linear polarizer is placed in the beam path. Then, we record the power then the transmission axis is aligned horizontally, vertically, and at +45° angle to the horizontal. This will generate the first three Stokes parameteres. Then, we place the quarter-wavelength plate between the beam and the linear polarizer whose transmission axis is at +45° angle to obtain the last parameter. After manipulating the angles, and polarity of the beams, the projection images are normalized to the original images in order to maintain the same field of projection. The images will be synthesized in free space and arranged to form a photodiode. This way, a programmable composite can be produced by the photodiodes that act as an optical detector, also known as polarization topography.

RESULTS AND INTERPRETATION

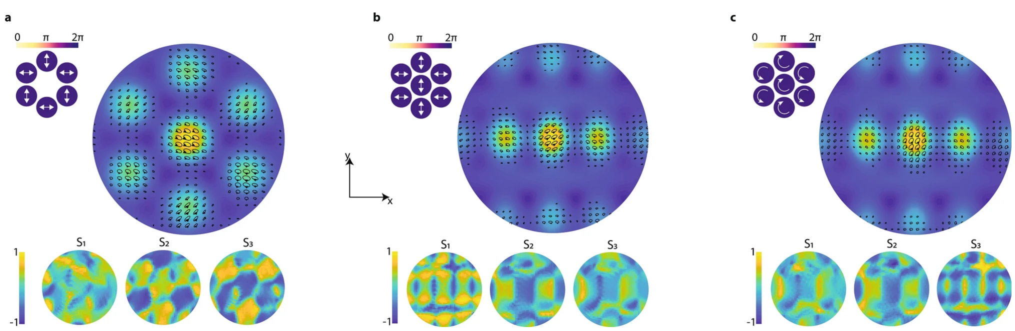

Figure 1. Polarization Topography results for alternating linear (a), asymmetric linear (b), and asymmetric circular polarization coherent synthesis (c)

From the figure above, we can observe the results of polarization topography of the beam. In the first topography, the relative phase of channels is varied without modifying the CEP. The result is a change in phase-front due to the change in relative phase. On the other hand, if LOCSET is present and CEP is shifted, then the result is a helical phase-front rotating along the propagation axis [1].

CONCLUSIONS

Essentially, we have found a way beams can be engineered to produce a laser architecture that can deliver programmable laser pulses made from coherent beamlines [1]. This laser architecture can be used in holographic technology in medical, AI, entertainment, and many other industries.

REFERENCES

1. Lemons, Randy, et al. "Integrated structured light architectures." Scientific reports 11.1 (2021): 1-8.
2. Liu, Jia-Ming. *Principles of Photonics*, Cambridge University Press, New York (2017).