Title
Generalized Laser Architecture for High-Powered Applications

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Studying the relationship between light and its environment requires the use of technology that can manipulate the spatio-temporal distribution of light and its "degrees of freedom." This study proposes a light architecture that allows for said manipulation - aiding in the development of light bullets - even in applications where high power levels are involved.

INTRODUCTION

Analyzing light's interaction with its surroundings allows us to better understand our world. Information on the environment can be extracted by studying the properties and behaviors of light in different domains, specifically time and space.[1] Recent development in the manipulation of light's spatio-temporal distribution has led to an increased interest in the study of structured light.

Light consists of various degrees of freedom, ranging from "amplitude, and linear, spin angular, and orbital angular momenta".[2] By controlling these characteristics, and imposing upon it a structure, we can better analyze the spatial aspects of light projection.

Previously, due to "the complexity of optical fields", the study of light projection - "generally in terms of interference" - had been heavily focused on linear optical elements.[3] However, recent growth in the application of nonlinear optical elements has heavily influenced the overall study and uses of structured light. When studying optical modulation, for example, one must take into account the intensity-dependent absorption coefficient, which is related to the nonlinear optical susceptibility of a material. The absorption coefficient decreases with increased light intensity; since the altering of light intensity plays a major role in the implementation of various light structures, it is clear that focusing on nonlinear optical properties is a vital part of analyzing the spatial-temporal distribution of light.[4]

One of the main tools used to alter the spatial-temporal distribution of light is spatial light modulators (SLM). An SLM is a device that projects varying modulation on a beam of light.[5] SLMs are therefore useful in engineering structured light, as they allow one to control the intensity and phase of a light beam in an image or Fourier space.[2] The devices, however, are not as reliable in high-power applications.[5]

To address the limitations of SLMs and other structured light devices, this study suggests, instead, using phased arrays to synthesize beams in high-power applications.

METHODS

The suggested experimental configuration consists of fiber-based beamlines with a common CEP-stabilized front end, light characteristic controls, and active locking via FPGA LOCSET using a single avalanche photodiode (APD) in the far-field (as detailed in Figure 1).[2] The setup allows for manipulation and monitoring of all the measurable field parameters - phase, amplitude, polarization state, and timing.

From polarization topography, the experimental results showed that pulses from the far field would result in Laguerre-Gaussian - circular and radial symmetry in the traverse plane - and helic shapes, a result that can also be seen when examining a basic Gaussian beam.[4]

To test this high-power application configuration, the study followed various methods; one of the most important ones being the carrier-envelope phase-stabilized front-end and beamline controls. In this method, a glass laser oscillator is used (with a feed-forward system) and beamlines are split, coupled, and put through nonlinear amplification.[2]

Optical modulation, or in this case cross modulation ("two or more optical beams are present"), is achieved based on a third-order susceptibility of the form $\chi^{(3)}(\omega = \omega + \omega' - \omega')$.[4] This results in optical-field-induced permittivity changes in a nonlinear optical material.

Another method used was multi-channel phase modulation. From the basic principles of photonics, one knows that phase modulation is important because "by controlling the optical phase while properly manipulating the optical wave, a desired modulation on any other field parameter can be accomplished."[3] It is also important to note that, with phase modulation, the magnitude and frequency of the carrier field remain constant, since phase is only affected by time.[3] Using phase modulation allowed for the development of an "optical phase error signal."

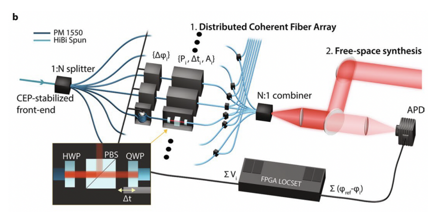

Fig. 1. The Experimental Configuration (Ref. [2], Fig. 1b).

RESULTS AND INTERPRETATION

This study showed how structured light could be better used in high-power applications through the use of phased arrays and synthesized beamlines. This new method takes advantage of nonlinear optical elements to increase the "expected damage threshold levels" of the structured light device.[5] The experimental configuration aims to provide a method to better study the spatial-temporal distribution of light.

CONCLUSIONS

1. The phased array configuration allows for the use of structured light devices in higher-power applications.
2. Configuration can be further developed with the application of more nonlinear optical elements.

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