Photonic Lantern Spectrometer

Tech ID: 34180 / UC Case 2024-786-0

BACKGROUND

Multimode optical fiber was first introduced in astrophotonics applications as “light pipes” to transport light from telescopes to instruments. The integration of multimode optical fiber helped to maximize light collection but offered little control over the propagation modes from the collected light, which affects the quality and speed of light transmission. Single-mode optical fiber used in interferometry proved invaluable for spatial filtering and wavefront correction, providing a stable, reliable, and flexible way to guide light in precision sensing and imaging. Photonic lanterns were conceived in the early 2000s to help bridge a gap between the light-gathering efficiency of multimode optical fiber and the precision of single-mode optical fiber. Photonic lantern devices have reasonably addressed the efficient conversion needs between multimode/ multi-modal and multiple single-mode light paths. However, challenges remain with respect to improving and scaling of photonic lantern devices, including coupling efficiency/losses, bandwidth limitations, and high-order mode (>20) capabilities.

TECHNOLOGY DESCRIPTION

To help address these challenges, a research team at UC Santa Cruz (UCSC) has developed a new approach to photonic lantern devices in order to serve as high-performance reconstructive spectrometers. UCSC’s device concept couples a lantern (or a cascade of lanterns) to a single-mode (or few-mode) input. As the single-mode propagates into the multi-mode section of the lantern it self-interferes and decomposes into higher-order modes in a wavelength-dependent fashion. These modes are then extracted by the UCSC lantern as single-mode outputs whose intensities can be imaged by a camera and used to infer the spectral content of the input signal. The modal decomposition is further made intelligent through trained algorithms in software. UCSC’s photonic lanterns can serve as reconstructive spectrometers without suffering traditional losses found in fiber-to-chip interfaces. Preliminary results from early experiments measuring diffuse CO2 and methane resulted in 10X better emissions accuracy than traditional utility-based heating estimates. In future directions, the spectral resolution and performance may be significantly improved by cascading lantern hierarchies, in addition to training neural network training and algorithmic development for related software.

APPLICATIONS

- research tools – astronomy/astrophysics
- gas sensing, detection
- medical imaging
- optical communications

FEATURES/BENEFITS

- Avoids difficulty of injecting light into a chip and imaging the output as compared to planar chip-based spectrometers.
- For many sensing applications (in concept) enables super efficient results through representative data capture and intelligent modeling.
- In certain applications, eliminates the need for tunable diode lasers that require highly precise wavelength control to target specific spectral features.

INTELLECTUAL PROPERTY INFORMATION

Patent Pending

RELATED MATERIALS

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OTHER INFORMATION

KEYWORDS

astrophotonics, photonics, photonic lantern, photonic lanterns, spectrometer, spectrometry, wavefront sensing, wavefront control, adaptive optics, multi-stage adaptive optics, photonic spectrographs

CATEGORIZED AS

- **Optics and Photonics**
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