PLIS (Photonic Lantern Illumination Source): an efficient light source for light sheet microscopy

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1. MOTIVATION

Fluorescence Microscopy has been crucial in the modern understanding of biological molecular processes. More specifically, techniques like laser scanning confocal microscopy or light sheet microscopy [1] provided high resolution up to the diffraction limit. These last techniques have been possible thanks to the good emitting properties of lasers. However, for many high-resolution microscopy applications some of the characteristics of lasers are not needed or even produce undesired effects. The narrow wavelength bandwidth is not needed in the fluorescence microscopy due to the wide spectral excitation band of the fluorophores. In fact, LED sources and super-continuum lasers result in a more gentle excitation of the fluorescence and therefore in the production of high S/N images. Furthermore, in certain techniques, based on elastic scattering imaging, TIRF or light-sheet microscopy, the temporal coherence of the lasers is not only not required but also it produces undesired interference patterns or structures that affect the image quality.
On the other hand, for all those imaging techniques, spatial coherence is a strong requirement to obtain the diffraction-limited illumination necessary for obtaining high-resolution images.

2. DESCRIPTION OF THE WORK

This work will introduce Photonic Lantern Illumination Source (PLIS), a novel light source for light sheet microscopy adapted to the special characteristics of this technique based on LEDs. LEDs are extended light sources emitting in a band of wavelengths completely non-temporally coherent. However, for several imaging applications, including light sheet microscopy, only spatial coherence is needed if the emission band matches the excitation spectra of the fluorophore. In addition, the spatial coherence is only needed in one dimension because the emission beam is actually a plane.
This work shows how to produce an efficient light sheet beam from an LED source using a device based in a photonic lantern [2]. PLIS provides diffraction limited optical sectioning and at the same time, the uncoherent nature of the LED minimizes the interference-derived effects (*e.g.* stripes in Light Sheet fluorescence imaging or speckle patterns in scattering imaging). In addition, the device provides an efficient and cost-effective alternative to lasers while keeping good optical sectioning performances. The results of the work provided four-channel (three different fluorescent markers and inelastic scattering) high-quality 3D images of biological samples.

References.

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