Title: Applications and Optimizations of Bessel Beams for Confocal Microscopy

Author: Daniel Gliksberg

Abstract:

Standard confocal microscopy uses a Gaussian beam to excite fluorescent dye that has been injected into a biological sample. The light emitted by the sample is sent back through the microscope, split off, and then sent through a pinhole and into a light detector. The pinhole prevents out-of-focus light from passing through, and the light that reaches the detector is then used to re-create the sample in a three-dimensional, high-resolution model. However, on its own this method is not enough to accurately map biological samples. The use of a single laser beam causes photobleaching, permanent damage to the fluorescent dye, and photodamage, damage to the sample caused by the beam. Because standard beams are suboptimal, different imaging methods have to be used in order to increase microscope resolution.

A quasi-Bessel beam can be easily made by passing a Gaussian beam through an axicon. These beams, although not truly non-diffractive, are functionally non-diffractive over a limited distance. Bessel beams also extend the focus of a beam of light from a point to a line, allowing for more efficient light use when scanning samples. These beams, when used in a confocal microscope, also reduce photobleaching and photodamage.

The design for a confocal microscope proposed in this paper uses a quasi-Bessel beam generated by an axicon and Gaussian beam combination to scan biological samples (e.g. heart tissue samples). The goal of this proposed design is to narrow the focus of the beam as much as possible while minimizing energy loss over the course of the system, accomplished in part by the implementation of Bessel beam microscopy over Gaussian beam microscopy.

Overall energy loss over the course of the proposed system is 37.436%, with an almost flat scan plane that allows for the effective use of computer-adjusted mirrors to move the laser through the sample, rather than physically moving the entire system.