S Saghafi et al., J Phys Chem Biophys 2018, Volume 8
DOI: 10.4172/2161-0398-C1-028

5th International Conference on

Theoretical and Applied Physics

July 02-03, 2018 | Vienna, Austria

Laser modal analysis, an effective tool in reshaping a multimode laser beam into an optimized thin light sheet used in ultramicroscopy imaging technique

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The solutions of the wave equation provide adequate information about the beam phase and amplitude at any point. In physical optics, the exact solution of the wave equations (e.g. Helmholtz equation), is generally impractical, thus approximations are used; the paraxial approximation applies when the beam waist is large relative to the wavelength and the angle of divergence is small. The multipole expansion method provides solutions to the wave equation. Any solution of Maxwell's equation can be expressed as the summation of incoming and outgoing electric and magnetic multipole fields. The superposition of any two solutions is also a solution, and this is referred to as the principle of superposition. The electromagnetic field at a point far from a focus is described by expansion of the diffraction integral into a series of functions such as Gegenbauer polynomials or spherical Bessel functions. This method has been used to investigate the effects of different amplitude weighting, and can be extended to truncated Gaussian beams or systems with spherical aberration. Defining an arbitrary field as the modal superposition of individual fields, and employing the angular spectrum method (Fourier optics) in the framework of wave optics, can provide accurate results for the propagation of each component. The field characteristics can be described by a superposition of the propagated components. Using the current solutions of the paraxial wave equation enables to describe the propagation of an arbitrary laser beam from near- to far-field. Based on the modal analysis method, we analyse the output beam of a diode pumped solid state (DPSS) laser emitting a multimode beam. Using the experimental data, the individual modes, their respective contributions, and their optical parameters are determined. We have designed a mode modulator unit that includes different meso-aspheric elements and a soft-aperture to reshape the multimode beam into a quasi-Gaussian beam through the interference and superposition of the various modes. The converted beam is guided into a second optical unit comprising achromatic-aspheric elements to produce a thin light sheet for ultramicroscopy. This sheet is significantly thinner and exhibits less side shoulders compared with a light sheet directly generated from the output of a DPSS multimode laser. The method to generate a reconstructed Gaussian beam from multimode lasers that is described in this paper may help to decrease the price of ultramicroscopy systems, making them more affordable for scientists needing lasers with different wavelengths.

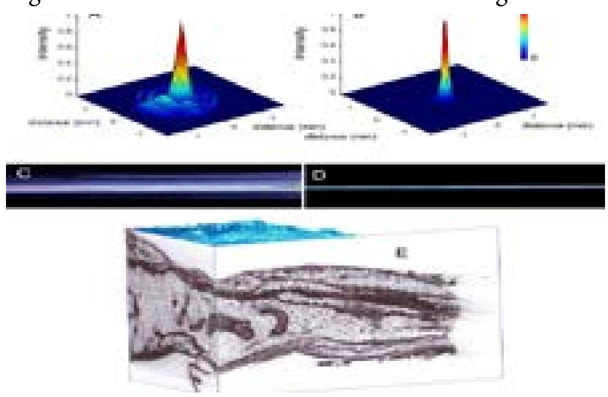

Figure 1: The spatial intensity profile of the: A) a multimode Laser, B) a modulated multimode laser emitting constructed Gaussian beam, and the light sheets produced by : C) a multimode laser, D) a modulated multimode laser E) 3D-image of a cancerous tissue. 1. S Saghafi, K Becker, C Hahn and H U Dodt (2014) 3D-Ultramicroscopy utilizing aspheric optics. J Biophotonics 7(1–2):117–125.

Biography

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