Characterization of Scattering From Nanoparticles Using Far-Field Interferometric Microscopy

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Abstract: Analysis and simulations show that coherent confocal microscopy techniques, such as Optical Coherence Microscopy, can be used to estimate the polarizability tensor of an imaged nanoparticle. The estimation process is robust to noise and defocus.

OCIS codes: (100.3200) Inverse Scattering; (110.1758) Computational Imaging; (180.3170) Interference Microscopy.

1. Introduction

Scattering from nanoparticles is a useful phenomenon (e.g., [1]) that is described by a polarizability tensor relating the incident and scattered fields. This tensor is transpose symmetric and is therefore defined by six parameters. Here it is shown that these six elements can be robustly estimated using far-field coherent confocal microscopy systems, such as those routinely used in Optical Coherence Microscopy.

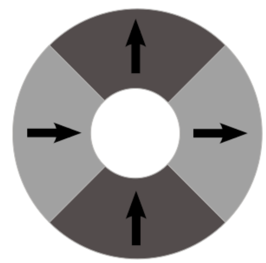

Fig. 1. The pupil-plane field

2. Analysis

Using a coherent microscope with a high numerical aperture and a simple vector-beam shaper allows the polarizability to be estimated from a single confocal image. The profile of the beam shaper is shown in Fig. 1 – the entrance pupil is divided into quadrants and each quadrant contains a unit-amplitude, linear polarization state in the direction of the arrows. Instrument modeling [2], shows that the data S can be described in the Fourier domain by,

$$S(\mathbf{q};k) = \sum_{\zeta\beta} h_{\zeta\beta}(\mathbf{q};k)\alpha_{\zeta\beta}(k), \qquad (1)$$

where k is the wavenumber, $\mathbf{q}$ are the Fourier-domain coordinates, ζ and β both index the Cartesian axes, α is an element of the polarizability and h is the Fourier domain response to a given element of the polarizability. The functions h, for the vector beam of Fig. 1, are shown in Fig. 2. The forward model of Eq. 1 can be efficiently inverted to give an estimate of the polarizability tensor from the data [2]. This inversion process can be applied absent knowledge of the nanoparticle position, and is robust to noise and uncertainty in the focal plane position.

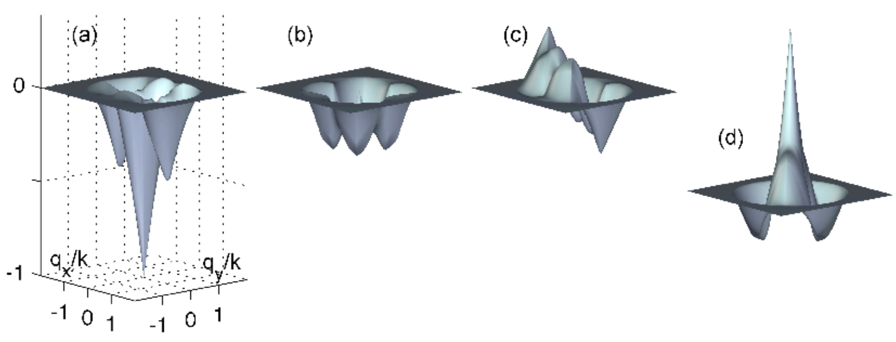

Fig. 2. Fourier-domain responses of the *xx* (a), *xy* (b), *xz* (c), and *zz* (d) tensor elements. The *yy* and *yz* responses are found by a $\pi/2$ coordinate rotation of the *xx* and *xz* responses respectively.

3. References

[1] J. Aaron, E. de la Rosa, K. Travis, N. Harrison, J. Burt, M. José-Tacamám, and K. Sokolov, "Polarization microscopy with stellated gold nanoparticles for robust, *in-situ* monitoring of biomolecules," Opt. Express **16**, 2153-2167 (2008).

[2] B. J. Davis and P. S. Carney, "Robust determination of the anisotropic polarizability of nanoparticles using coherent confocal microscopy," submitted to JOSA A (2008).