USING A VECTOR SLEPIAN BASIS IN HIGH NUMERICAL APERTURE FOCUSING

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Besides evaluating the Debye–Wolf integral [1] numerically, several closed-form bases have been proposed for the calculation of the focal field of a strongly-focused monochromatic beam.

A notable example is the expansion of the angular spectrum (“far-field”) of the incoming radiation in terms of vector spherical harmonics (VSHs), an orthonormal, complete, tangent vector basis on the unit sphere [2, 3]. Its advantage is that the focal field (“near-field”) of the corresponding basis functions, the so-called vector multipole fields take a simple closed form [4]. However, for inverse problems, the VSHs are of limited usefulness as their energy is spread over the entire solid angle. Thus, similarly to Maniar and Mitra, we solve Slepian's concentration problem [5] for a spherical cap in terms of the VSHs [6], i.e. a variational problem seeking orthonormal basis functions (“vector Slepian functions”) which are linear combinations of the VSHs but whose spatial power distribution is optimally concentrated into the solid angle subtended by the high NA lens as viewed from the focal point. The new basis turns out to be both orthonormal on the unit sphere and orthogonal on the spherical cap.

We shall demonstrate the series expansion of the illumination in terms of the vector Slepian functions and the electric field in the focal volume resulting from the expansion for several examples, including linearly polarized and cylindrical vector beams [7]. A comparison with the numerical evaluation of the Debye–Wolf integral will also be presented.

References: