The field in the focal region of a high numerical aperture lens can be efficiently calculated by a multipole expansion of vector spherical harmonics [1, 2]. This approach is also useful for investigation of trapping forces [3]. It has been applied to optimizing the illumination to maximize electric field at the focal point [4, 5]. Here we extend this method to the cases of radially-polarized [5, 6], electric dipole [5, 7] and transverse electric (TE1) illuminations [8]. The strengths of the lowest order modes are given by simple expressions, and are shown in Fig. 1 for radially-polarized illumination and electric dipole polarization. To maximize the focal intensity we maximize the electric dipole (ED) term, while the magnetic dipole (MD) and electric quadrupole (EQ) terms contribute to the sidelobes. The method is also applicable to vortex beams.

Fig. 1. The strengths of the multipole orders ED, MD, EQ for a lens of angular semi-aperture \( a \), for radially polarized (left) and electric dipole illumination (right).

References