When a Gaussian beam is focused by a lens, the beam is truncated by the pupil, and energy is lost. As the radius of the beam waist is increased, the size of the focal spot decreases, but more energy is lost. Some papers have assumed particular truncation ratios, without explaining why they made these particular choices. Electromagnetic focusing of plane-polarized, circularly-polarized, and radially-polarized Gaussian beams by an aplanatic lens of high numerical aperture is considered. It is found that, unlike the paraxial case, for an objective with a high numerical aperture there are optimum values for the truncation that maximize either the intensity at the focus for a given input power, or the intensity at the focus as compared with the side-lobe energy. For linearly-polarized illumination, the intensity at the focus for a given input power is optimized for a specific Gaussian beam truncation ratio, but increases monotonically with NA. The area of the focal spot (defined by the full-width at half maximum, FWHM) is optimized for a specific NA, but decreases monotonically with Gaussian beam truncation ratio. There is a global optimum (with respect to both truncation ratio and NA) for the intensity at the focus as compared with the side lobe energy.

Various performance parameters can be calculated directly from the pupil function, without the necessity for calculating the focal intensity distribution. These parameters include those that are measures of the intensity at the focus, and the transverse gain $G_T$, which is a measure of the parabolic radius of the focal spot [1-4]. A new parameter $P$ for comparing the purity of the longitudinal field for different illumination beams is introduced. For radially-polarized illumination, the transverse gain can be split into two parts, $G_{T\rho}$ and $G_{T\rho}$, originating from the longitudinal and radial fields, respectively. The overall transverse gain is reduced by the presence of the parasitic radial field. The polarization purity parameter is defined as $P = \exp(G_{T\rho} / G_T)$, where $0 \leq P \leq 1$. $G_T$ and $P$ are found to be greatest for illumination by what we have called an axial dipole wave (ADW) [3], and also increased by a central obscuration of the pupil. We also consider radial beam generation using polarization mode-conversion of a linearly-polarized Gaussian beam.

The concept of polarization purity is also applied to linearly-polarized illumination.

References