Resolution of Bessel-Gauss radially polarized beams in second harmonic generation microscopy

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We compare a tightly focused radially polarized beam with a Bessel-Gauss (BG) pupil function to a tightly focused linearly polarized beam with a Gaussian (G) pupil function for the case of second-harmonic generation. The electric field at the focus was calculated using a Debye approximation [1, 2]. $P(\theta)$ is either a BG or G pupil function as shown [2, 3],

$$P(\theta) = J_1\left(\frac{2\beta_1 \sin\theta}{\sin\alpha_2}\right)\exp\left[-\left(\frac{\beta_2 \sin\theta}{\sin\alpha_2}\right)^2\right], \quad (1)$$

$$P(\theta) = \exp\left[-\left(\frac{\beta_3 \sin\theta}{\sin\alpha_2}\right)^2\right], \quad (2)$$

where β_n is the fill factor of the beam [2]. We estimated this to be $\beta_1 = \beta_2 = \beta_3 = 1$ for our experimental setup. The theoretical values calculated for a radially polarized BG beam was 370 nm and 230 nm respectively. The resolution achieved through experiment was 348 nm and 222 nm respectively. Other types of pupil functions can be examined and in general, a uniform pupil function gives the 'best' resolution.

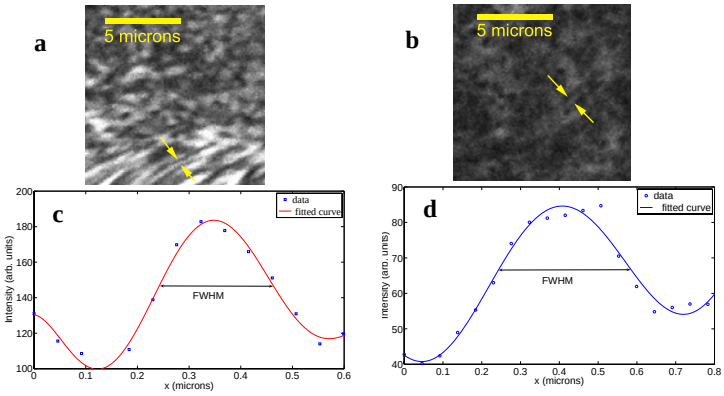

Figure 1: (a) and (b) SHG image of collagen fibre with linearly and radially polarized light respectively. (c) and (d) experimental resolution obtained from (a) and (b).

References

1. B. Richards and E. Wolf, "Electromagnetic diffraction in optical systems. II. Structure of the image field in an aplanatic system," Proc. Roy. Soc. Lond. Ser. A, 253, 358–379 (1959).
2. D.P. Biss, K.S. Youngworth, and T.G. Brown, "Dark-field imaging with cylindrical-vector beams," Appl. Opt., 45, 470–479 (2006).
3. E.Y.S. Yew and C.J.R. Sheppard. "Tight focusing of radially polarized Gaussian and Bessel-Gauss beams," Opt. Lett., 32:3417–3419, 2007