Improvement of axial resolution using frequency-domain field confinement in confocal microscopy

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1. ABSTRACT
The generation of a frequency-domain focal spot, which is made by overlapping two different frequency beams axially, improves the axial resolution of fluorescence confocal microscope. Numerical results show that the axial FWHM of the IPSF is improved by factor of 1.75.

2. METHODS AND RESULTS
The lateral resolution beyond the diffraction limit using frequency-domain field confinement is proposed by M. Vaez-Iravani. [1] He overlapped the Airy discs of two focal spot laterally. Also we think that overlapping two focal spot axially improves an axial resolution. The basic principle is shown in Figure 1. The two slightly frequency-shifted beams are separated by certain distance axially. In the overlap region, the interference is happened. Thus the total IPSF is below.

\[ |a(z)\exp(j\omega_f) + b(z)\exp(j\omega_z)|^2 = |a(z)|^2 + |b(z)|^2 + 2|a(z)b(z)|\cos(\Delta\omega t) \] (1)

We ignore the high-order terms and the effects by lateral position. Figure 2 shows numerical results of non confocal IPSF and confocal IPSF. [2] The further the beams are separated the narrower FWHM of non confocal and confocal IPSF. However the high side lobes are generated. The FWHM of the IPSF is improved by factor of 1.75 maintaining maximum side lobes below 0.5

3. DISCUSSION
The other region not to be imaged is illuminated a photo bleaching problem may be critical.
