# Three-dimensional harmonic holographic microcopy using nanoparticles as probes for cell imaging: erratum

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**Abstract:** An error was made in calculating the polarization dependent second harmonic response of barium titanate nanoparticles. We have corrected the error and repeated the comparison with the experimental results.



**OCIS codes:** (090.1995) Digital holography; (160.4236) Nanomaterials; (160.4330) Nonlinear optical materials; (170.6900) Three-dimensional microscopy; (320.7110) Ultrafast nonlinear optics.

## References and links

1. C.-L. Hsieh, R. Grange, Y. Pu, and D. Psaltis, "Three-dimensional harmonic holographic microcopy using nanoparticles as probes for cell imaging," Opt. Express **17**(4), 2880–2891 (2009).

In the article [1] we calculated the polarization dependent second harmonic generation (SHG) response of a single 90-nm barium titanate ($BaTiO_3$) nanoparticle based on Eq. (3) and (4). The Eq. (3) is actually

$$P(2\omega) = \chi^{(2)} \cdot E_1(\omega) \cdot E_1(\omega) = \begin{bmatrix} d_{11} & d_{12} & d_{13} & d_{14} & d_{15} & d_{16} \\ d_{21} & d_{22} & d_{23} & d_{24} & d_{25} & d_{26} \\ d_{31} & d_{32} & d_{33} & d_{34} & d_{35} & d_{36} \end{bmatrix} \begin{bmatrix} E_x(\omega)^2 \\ E_y(\omega)^2 \\ E_z(\omega)^2 \\ 2E_y(\omega)E_z(\omega) \\ 2E_x(\omega)E_z(\omega) \\ 2E_x(\omega)E_y(\omega) \end{bmatrix}.$$

We have recently discovered that the factors of 2 in the calculation of Eq. (3) were missing. We corrected the mistake and plotted the normalized polarization dependent SHG responses of $BaTiO_3$ nanoparticles at different orientations in Fig. 1 (a). The corresponding estimated SHG cross section of a 90-nm $BaTiO_3$ particle is 465 – 4,820 GM. It should be noted that Fig. 1 (a) shows the total SHG power radiated by the three dipole moment components, and the radiation pattern is not uniform in space. To consider the non-uniform SHG radiation pattern, we use a simplified model: assuming the SHG power radiated by the axial (Z-axis) dipole moment is hardly collected. By excluding the contribution of the axial dipole moment, the theoretical calculation of the SHG polar response is plotted in Fig. 1 (b). The experimental result matches with the theoretical calculation when $\theta$ = 20 degree. With this simplified model on the collection efficiency, we calibrated the measured SHG cross section as 23,910-29,510 GM. The greater measured SHG cross section suggests the object under the measurement was either a particle of 125-nm diameter or a cluster of two properly aligned nanoparticles of equivalent volume.

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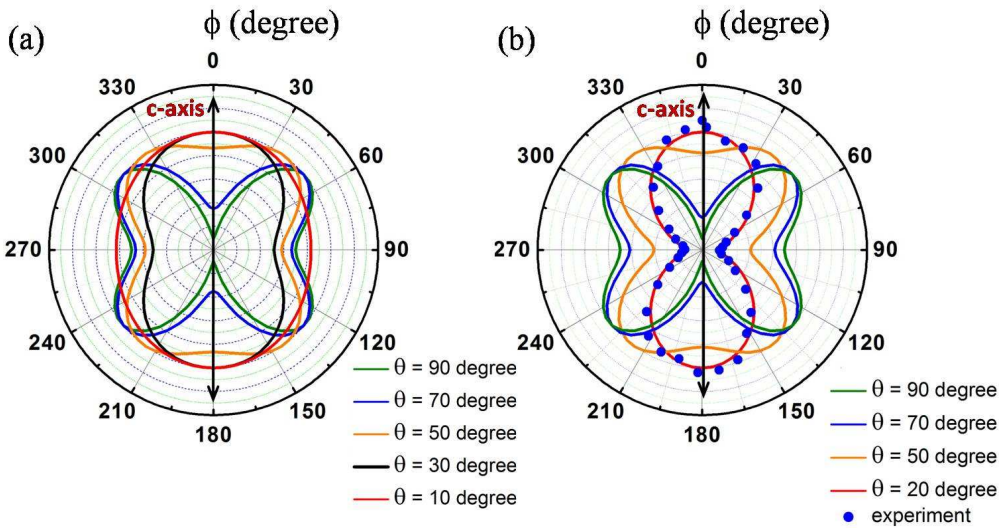


Fig. 1. Polarization dependent SHG response of an isolated $BaTiO_3$ nanoparticle. (a) Theoretical calculation of the normalized SHG polar response from a nanoparticle of various orientations. (b) Line: theoretical calculation of the normalized SHG polar response contributed from the transversal nonlinear polarizations of a nanoparticle of various orientations. Dots: experimental data. The black arrows in the polar diagrams indicate the projection of the c-axis of the nanoparticle on the XY plane.

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