Mie scattering for Superconducting In grain

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Moriwaki *et al.* succeeded in trapping single Indium particle in superconducting state in quadrupole magnetic field by using Meisner effect [1]. They performed an experiment to measure Mie scattering by irradiating CW laser to spherical In superconducting particle trapped in the magnetic field. By analyzing the experiment by comparing the results with calculations using classical Maxwell's equations for a homogeneous spherical particle. From this study they revealed its optical properties. However, in their calculation "Meissner effect" (phenomenon that the magnetic field is excluded from a superconductor below critical Temperature) was not considered.

In order to clarify the effect of expulsion of the magnetic field to the photon due to Meissner effect to Mie scattering, we developed a calculation code based on the following formulae derived by Choy and Stoneham[2]. The intensities as functions of angle θ in perpendicular polarizations are defined as,

$$i_s(\theta) = \left| \sum_{n=1}^{\infty} \frac{2n+1}{n(n+1)} (a_n \tau_n(\theta) + b_n \pi_n(\theta)) \right|^2, \quad i_p(\theta) = \left| \sum_{n=1}^{\infty} \frac{2n+1}{n(n+1)} (a_n \pi_n(\theta) + b_n \tau_n(\theta)) \right|^2$$

where

$$\pi_n(\theta) = \frac{P_n^1(cos\theta)}{sin\theta}, \qquad \tau_n(\theta) = \frac{dP_n^1(cos\theta)}{d\theta}.$$

Where, $P_n^1(z)$ is associated Legendre polynomials, a_n and b_n are the amplitude coefficients which are the functions of diameter of particle and wavelength of incident laser. The intensities are related with the refractive indeces inside/outside of the particle.

In the presentation, we will present the numerical results and discuss the effect of expulsion of the magnetic field caused by Meissner effect on Mie scattering.

[1] S.Naoi, Master thesis at Univ. Toyama (2018).
[2] T. C. Choy and A. M.Stoneham, *J. Phys.: Condens. Matter* **2**, 2867-2871 (1990).