Identification of analytical singularity in non-plasmonic nano-sensing system

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Article

Keywords: biomedical physics, fundamental physics, nanosensors, nanoparticles

Posted Date: February 25th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-244069/v1>

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Abstract

Nanosensors based on small particles are essential in the advancement of countless areas involving biomedical and fundamental physics. While the Clausius-Mossotti relation reveals the natural advantage of plasmonic nanoparticles as a singularity-generating device with the possibility of achieving ultra-high sensitivity, practical issues such as metallic losses and sensor configuration often preclude them from being considered as the ideal nanosensor. Non-plasmonic, or dielectric nanoparticles, though have distinct advantage in small material loss and design flexibility, cannot have a pole in the Clausius-Mossotti relation. Here, we demonstrate how such limitation on dipolar resonance of a dielectric nanoparticle can be fundamentally overturned if the nanoparticle is placed in an assisting dielectric cavity. Using the pseudo-orthonormal eigenmode method (POEM), we pinpoint the singularity of such non-plasmonic system in the complex frequency plane. The framework of the study provides not only analysis of the underlying physics, but also generates a set of guidelines to facilitate the device optimization in the real world. For numerical simulation, we use finite-difference time-domain (FDTD) method to demonstrate giant sensitivity of the structure when it operates around the pole.

Full Text

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Figures

Figure 1

Pinpointing the pole for the C-NP system

Figure 2

The all dielectric R + NP nansensor and the effect of the ring.

Figure 3

Effect of the nanoparticle.

Figure 4

pole identification for the R + NP structure with optical gain.

Figure 5

ultra-sensitive nanosensor based on gain-assisted R + NP structure.

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