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Super Backscattering through Plasma Surface Wave Engineering

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The scattering of light is a fundamental problem in physics. While the optical response of a tiny object is typically negligible, as described by the Rayleigh scattering law. Fortunately, a large scattering cross section can be achieved by constructing a resonance, commonly known as LSPR (localized surface plasmon resonance), which occurs in plasma material[1]. By carefully designing such resonances, superscattering can be further achieved, with a scattering cross-section several times that of a single channel scattering limit.

Superscattering engineering, which optimizes the maximum scattering cross section by designing the particle structure while preserving energy conservation and central symmetry, has been experimentally realized in various of systems such as microwaves, acoustic waves, and water waves since its introduction. However, the development of superscattering focuses on the enhancement of the total scattering cross section while ignoring other scattering characteristics. Recently, various of structures for superscatterer have been proposed, but most of which are typically constructed with negligible backscattering, in sharp contrast to its significant forward scattering, which limits further applications.

In this work, we reexamine this ignored phenomenon in a 2D rotational symmetric superscattering system and find that this unusual behavior can be attributed to the superposition of resonant modes in adjacent angular momentum channels. In the process, we outline a general perspective on the inherent relationship between the forward and backward scattering and mode combinations and confirm that the presently designed superscatterrs exhibit trivial backscattering characteristics. We show that backscattering can be enhanced in quadratic form depending on the number of properly overlapped modes, and it can be shown that backward scattering is maximized for a given number of resonant modes. In principle, arbitrarily large backscattering can be achieved depending on the specific design of the superscatterer. This design can be achieved by regulating the dispersion relationship of plasma surface waves. Specifically, we will demonstrate enhancing backscatter beyond the reach of single channel by combining three nonadjacent resonant modes in such a model, i.e., super backscattering.

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References

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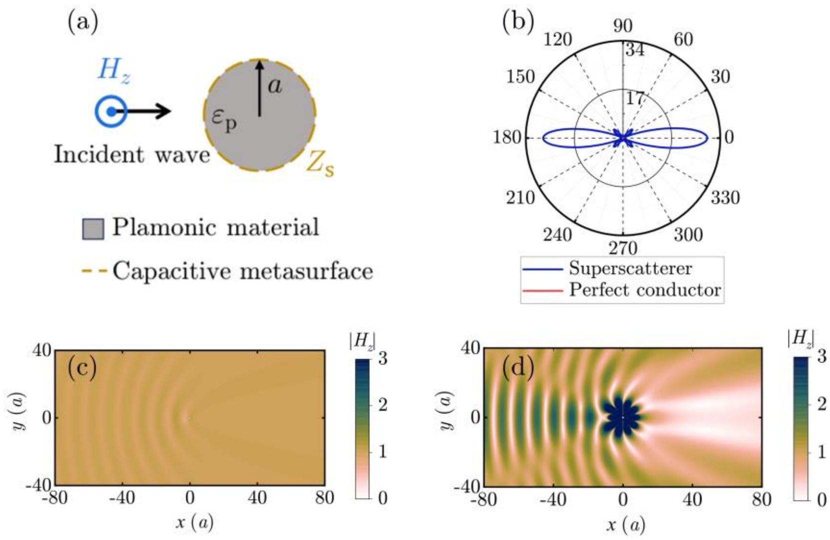

Figure 1. (a) Schematic of H-polarized plane waves impinge on the nanorod. The scatterer is a plasmonic column with a relative permittivity of ε_{p} and a radius a, covered by a capacitive metasurface with impedance Z_{s}. (b) Comparison of far-field scattering cross sections of the PEC scatterer and the superscatterer. (e) and (f) are $|H_z|$ profiles of plane waves incident from the left to a PEC scatterer and the superscatterer, respectively.