Shape-independent ultra-subwavelength topological superscatterers

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Electromagnetic *scattering* is the physical process leading to the deviation of light from its straight trajectory due to localized non-uniformities/non-homogeneities in the host medium through which light passes. If the physical size *a* of this non-homogeneity is much smaller than the incident light, $a/\lambda \ll 1$, scattering is typically weak and dominated by the response of an induced electric dipole. Controlling and enhancing the interaction between electromagnetic radiation and individual subwavelength objects is of fundamental importance for light-matter interactions and has large practical significance for applications such as imaging, biomedicine, optical antennas, and metasurfaces. In this context, the scattering efficiency, i.e., scattering cross section normalized by the geometrical cross section of the object, is an important measure to quantify the strength of the electromagnetic interaction. Theoretically, it can be shown that, for a two-dimensional (2D) object of width 2b, the maximum scattering efficiency achievable through the electric-dipolar scattering channel alone is $\sigma_{2D} = \frac{\lambda}{\pi b}$.

In this work, we provide a complete analytical discussion of the anomalously-large light scattering that can be obtained from 2D ultra-subwavelength core-shell structures composed of gyrotropic materials (e.g., magnetized plasmas) and metals. While subwavelength superscattering objects were demonstrated in the past (e.g., Z. Ruan and S. Fan, "Superscattering of Light from Subwavelength Nanostructures," Phys. Rev. Lett., vol. 105, no. 1, p. 13901, Jun. 2010), here we propose a novel mechanism to achieve ultra-high scattering efficiency, beyond the dipolar-channel limit, *at any arbitrarily-low frequency*. This possibility is enabled by the emergence of a low-frequency resonant mode, with no lower-frequency cutoff, at the interface between a gyrotropic material layer and a metallic layer. In this way, it may be possible to lower the resonant frequency of a scatterer from, for instance, the optical frequency range to MHz frequencies.

In our talk, we will also present theoretical and numerical investigations showing that it is indeed possible to surpass the dipolar-channel scattering efficiency limit, at very low frequencies, by engineering the structure such that different subwavelength scattering resonances, e.g., dipolar and quadrupolar, are spectrally overlapped. Finally, we will show that the resonant effects discussed above are largely independent of the specific shape of the considered object: the scatterer could undergo continuous physical deformations without losing its resonant scattering properties. We will discuss how this robustness originates from the topological nature of the internal modes supported by the subwavelength scatterer. Our findings may open new intriguing directions in the design of extreme scattering effects for a variety of practical applications.