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Wiggles and Ripples in the Extinction of Two-Dimensional Active Scatterers

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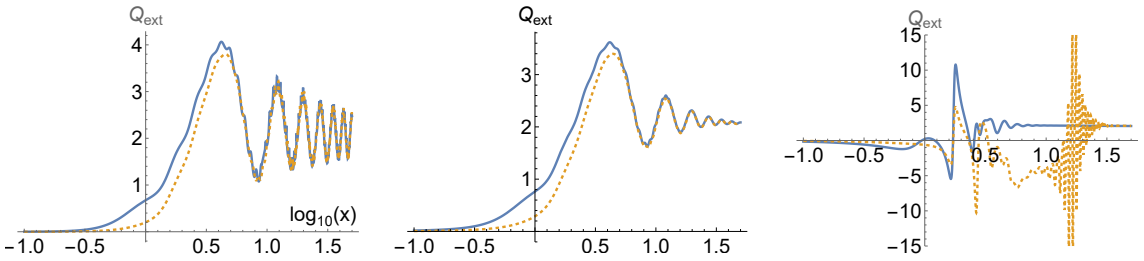
In this contribution, we present results of our studies on electromagnetic wave interaction with two-dimensional (2D) active (gainy) objects, as a continuation of our previous work on scattering, absorption, and extinction of active spheres and other three-dimensional objects [1]. The response of a 2D object corresponds to that of an infinitely long cylinder in three-dimensional (3D) space. The permittivity $\varepsilon = \varepsilon' - \mathrm{j}\varepsilon''$ of active medium is complex such that $\varepsilon'' < 0$ (following the time-harmonic notation $\exp(\mathrm{j}\omega t)$). When an active object is exposed to an electromagnetic wave, it scatters energy. A measure of the scattering is the cross section (for volumetric, 3D objects) and the scattering width (for 2D objects) [2]. An active scatterer displays gain, and hence its absorption cross section (width) is negative, leading to the conclusion that its extinction cross section (width) can be either positive, negative, or zero [1]. Figure 1 shows the extinction efficiency Q_{ext} of three different 2D disks (lossy, lossless, and gainy) as function of the size parameter $x = 2\pi a/\lambda$, defined with the radius of the disk a and the wavelength λ. The extinction depends on the polarization of the incident wave (the electric field can be either parallel or perpendicular to the axis of the cylinder, the normal of the plane of the 2D object). In the talk, we will focus on the behavior of the "wiggles" and "ripples" (long and short range oscillations in the extinction curves [3]) as the size and material parameteres of the disk vary. As the figure shows, for large scatterers, these wiggle and ripple variations vanish, and the extinction efficiency approaches the value 2 for both polarizations, according to the extinction theorem [4].



(a) $\varepsilon = 2$ **(b)** $\varepsilon = 2 - 0.1\mathrm{j}$ **(c)** $\varepsilon = 2 + \mathrm{j}$

Figure 1. Extinction efficiency curves for (a) lossless ($\varepsilon = 2$), (b) dissipative ($\varepsilon = 2 - 0.1\mathrm{j}$), (c) active ($\varepsilon = 2 + \mathrm{j}$) disks, as functions of the logarithm of the size parameter x. Parallel polarization (solid blue), perpendicular polarization (dashed orange), defined as the electric field with respect to the normal of the plane of the disk. (Note the different vertical scales in the three subfigures.) The wiggles (slow oscillations) modulated with ripples (fast oscillations) are most notable for large x values in the lossless case.

References

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