Boundary Effects of Weak Nonlocality in Multilayered Dielectric Metamaterials

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Multilayered metamaterials composed of periodic stacks of alternating, deeply subwavelength dielectric layers are known to exhibit *negligibly weak* spatial-dispersion (nonlocal) effects. Therefore, conventional homogenized approaches based on (local) effective medium theory (EMT) usually provide a quite accurate description of their optical response. However, recent theoretical and experimental studies (H. Herzig Sheinfux *et al.*, Phys. Rev. Lett. 113, 243901, 2014; S. V. Zhukovsky *et al.*, Phys. Rev. Lett. 115, 177402 2015) have pointed out that, under certain critical illumination conditions, weak nonlocality may build up strong boundary effects that are not captured by local EMT modeling. In particular, the optical transmission (and reflection) of a finite-thickness slab of such metamaterial may differ substantially from the local EMT prediction, and may become ultrasensitive to the spatial order and/or size of the layers as well as to the addition or removal of a very thin layer.

In this study, we propose a simple and physically incisive modeling of the above boundary effects, in terms of error propagation in the iterated maps of the trace and anti-trace of the optical transfer matrix of the multilayer. Our approach directly relates the geometrical and constitutive parameters of interest to a set of meaningful observables through simple closed-form expressions. Besides elucidating the underlying mechanisms, this directly enables the identification of critical parameters and regimes, and naturally suggests possible nonlocal corrections capable of capturing the effects.