Reflection from a periodic array of resonant scatterers vs N.

(Dated: February 11, 2025)

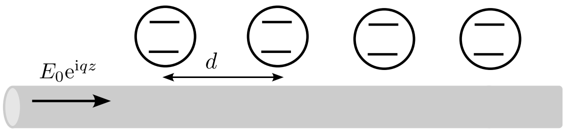

FIG. 1 Periodic array of resonant scatterers coupled to the waveguide.

We consider wave reflection from a periodic array of scatterers, shown in Fig. 1. The amplitude light reflection coefficient $r_N(\omega)$can be found from the following equations (Sheremet *et al.*, 2023):

$$t_N(\omega) = \frac{\widetilde{t}_1 \sin K}{\sin NK - \widetilde{t}_1 \sin(N-1)K} \tag{1}$$

where

$$\widetilde{r}_1 = e^{iqd} r_1, \quad \widetilde{t}_1 = e^{iqd} t_1, \quad t_1 = 1 + r_1, \quad r_1 = \frac{i\gamma_{1D}}{\omega_0 - \omega - i(\gamma_{1D} + \gamma)} \tag{2}$$

are the reflection and transmission coefficients from one emitter, $q = \omega/c$ is the light wave vector and

$$\cos K = \cos qd - \frac{\gamma_{1D}}{\omega_0 - \omega - i\gamma} \sin qd\,. \tag{3}$$

is the Bloch vector.

Goal:

- Derive the effective medium approximation, under which for $\gamma \gg \gamma_{1D}$ and $\omega d/c \ll 1$ one has

$$|t_N(\omega)|^2 = e^{-OD}, \quad OD = \frac{2N\gamma\gamma_{1D}}{(\omega-\omega_0)^2 + \gamma^2}\,. \tag{4}$$

- Plot the set of transmission spectra $|t_N(\omega)|^2$ vs normalized frequency $(\omega - \omega_0)/\gamma_{1D} \in [-5 \ldots 5]$ for $\omega_0 d/c = \pi$, $\gamma_0/\omega_0 = 2 \times 10^{-2}$ and $\gamma/\gamma_{1D} = 0.1$ (a) and $\gamma/\gamma_{1D} = 2$ (b). and $N = 1, 2 \ldots 10, 20$ (spectra for same γ have to be on the same plot).

Answer:

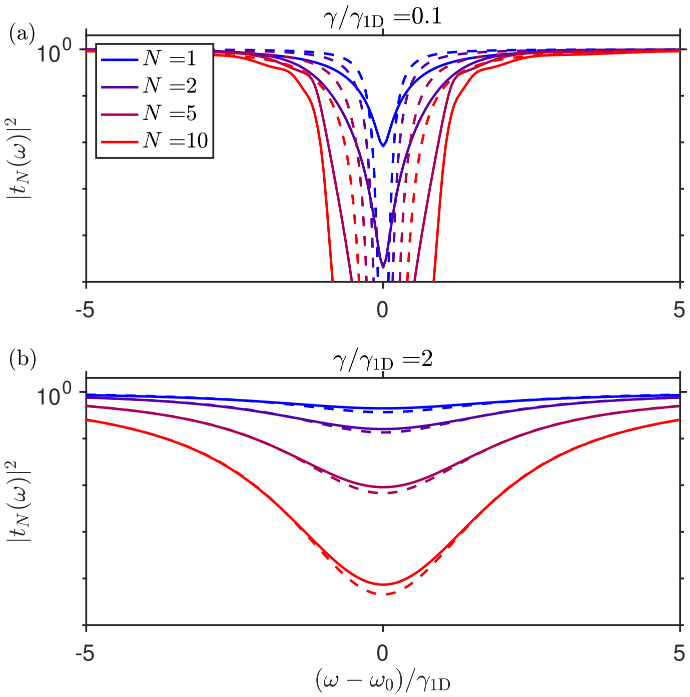

FIG. 2 Transmission spectra from the periodic structure for different values of N. Calculation has been performed for the spacing $\omega_0 d/c = \pi$, $\gamma_0/\omega_0 = 2 \times 10^{-2}$ and $\gamma/\gamma_{1D} = 0.1$ (a), $\gamma/\gamma_{1D} = 2$ (b). Solid lines have been calculated exactly, dotted lines correspond to the optical density approximation, Eq. (4)). The calculation demonstrations that the OD approximation works well for a large ratio γ/γ_{1D}.

References

Sheremet, A. S., M. I. Petrov, I. V. Iorsh, A. V. Poshakinskiy, and A. N. Poddubny, 2023, Rev. Mod. Phys. **95**, 015002.