Dispersion equation in a periodic array of resonant scatterers.

(Dated: October 4, 2023)

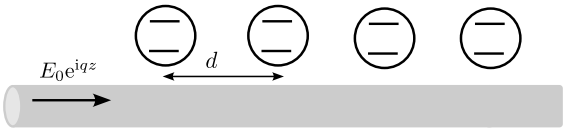

FIG. 1 Periodic array of resonant scatterers coupled to the waveguide.

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):

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

where

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

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

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

is the Bloch vector.

Goal: Plot the color map of reflection coefficient vs frequency (x-axis) and the array period (y-axis) for $N = 20$, $\gamma/\gamma_{1\mathrm{D}} = 10^{-2}$. The period varies in the range $0.8\pi c/\omega_0 \ll 1.2\pi c/\omega_0$, the frequency ranges from $\omega_0 - 20\gamma_{1\mathrm{D}}$ to $\omega_0 + 20\gamma_{1\mathrm{D}}$.

Answer: Blue lines show the edges of the photonic band gaps found from the condition $\mathrm{Im}\, K = 0$. Clearly, the reflection coefficient is at maximum inside the band gaps.

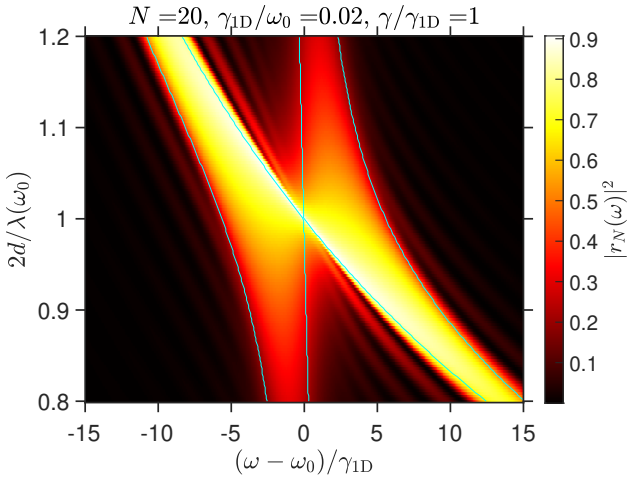

FIG. 2 Reflection coefficient from a resonant periodic structure vs period.

References

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