Dispersion law in the periodic array of emitters

(Dated: January 16, 2024)

The dispersion law for a waves propagatin in the infinite periodic array of emitters reads (Albrecht *et al.*, 2019; Ivchenko, 1991)

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

Here, ω_0 is the resonant frequency, c is the speed of light, γ is the nonradiative decay rate, γ_{1D} is the radiative decay rate.

Goal: Simplify the dispersion law in the limit $K \ll 1$, $\omega d/c \ll 1$ and rewrite it in the form $K^2 = \omega^2\varepsilon_{\text{eff}}(\omega)/c^2$. Obtain the expression for the effective medium permittivity $\varepsilon_{\text{eff}}(\omega)$. Plot on the same plot the dispersion law obtained exactly and in the effective medium approximation for $\omega_0 d/c = 0.5\pi$ and $\omega_0 d/c = 0.97\pi$ (take $\gamma_{1D}/\omega_0 = 10^{-2}$).

Hint:

References

Albrecht, A., L. Henriet, A. Asenjo-Garcia, P. B. Dieterle, O. Painter, and D. E. Chang, 2019, New Journal of Physics **21**(2), 025003, URL `https://doi.org/10.1088/1367-2630/ab0134`.

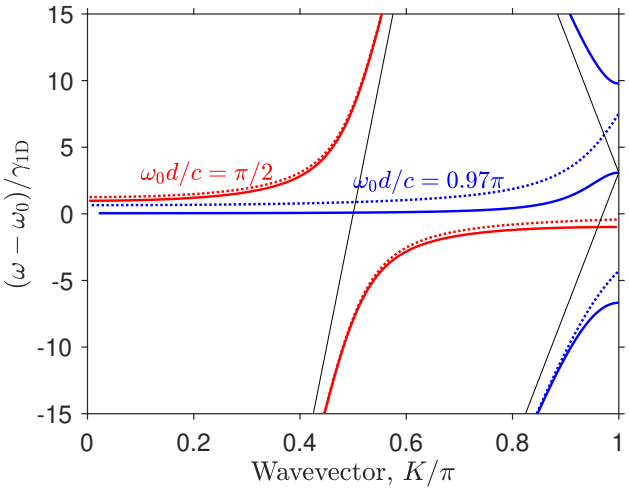

FIG. 1 Dispersion law in the array of emitters.

Ivchenko, E. L., 1991, Sov. Phys. Sol. State **33**(8), 1344.