Numerical study of Local Density of States in Photonic Crystal Waveguides

Alisa Javadi ,
Niels Bohr Institute,
University of Copenhagen, Denmark
Quantum Photonics Group
www.quantum-photonics.dk
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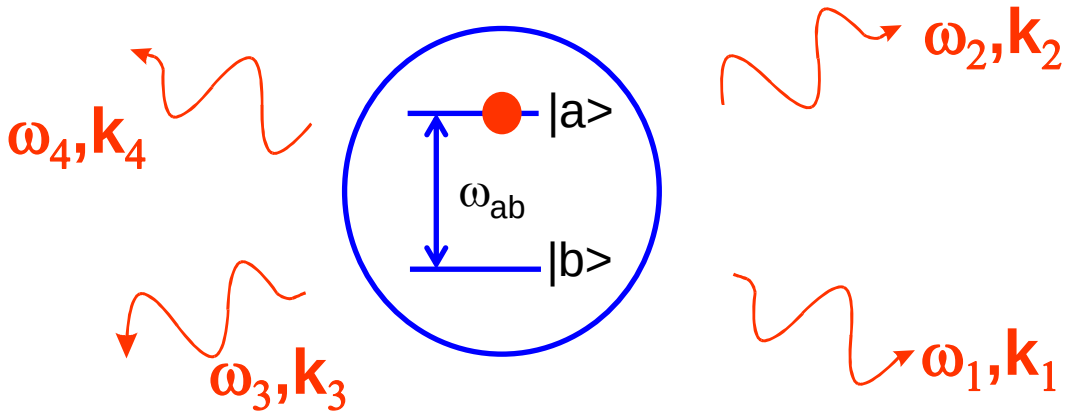
Light and matter Interaction



The decay rate is proportional to the LDOS:

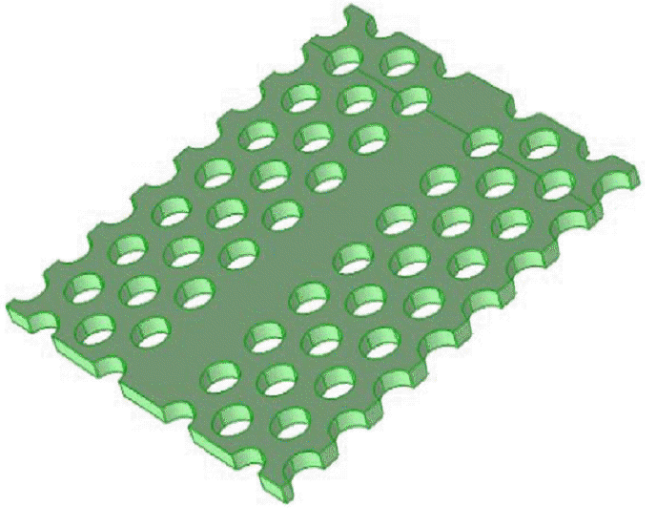
$$\gamma(\omega,\vec{r}) = \frac{\pi\omega}{3\hbar\varepsilon_0} d^2 \times \rho(\omega,\vec{r})$$

emitter: dipole moment

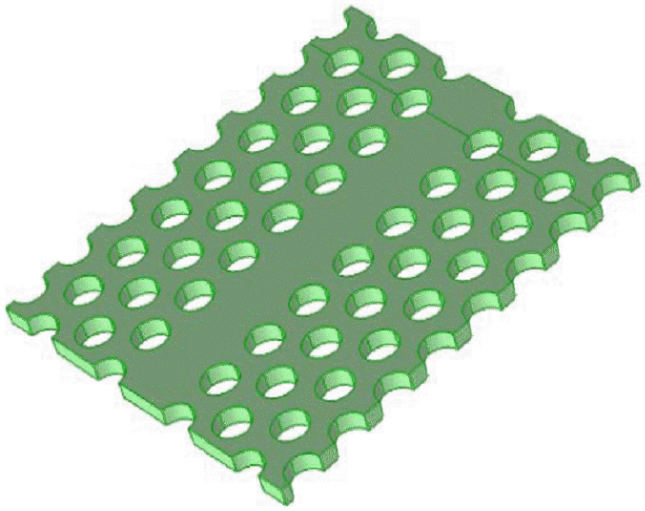
environment: LDOS

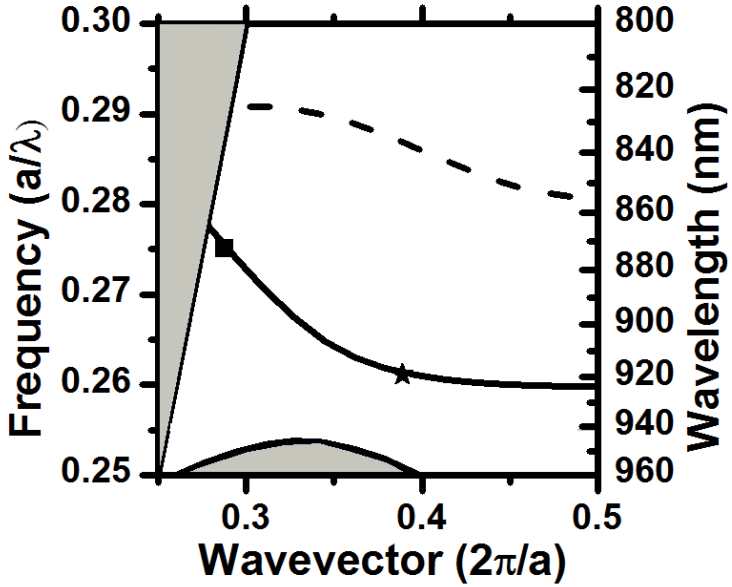
$$F_p = \frac{\gamma}{\gamma_0}$$

Photonic crystal waveguide



Photonic crystal waveguide





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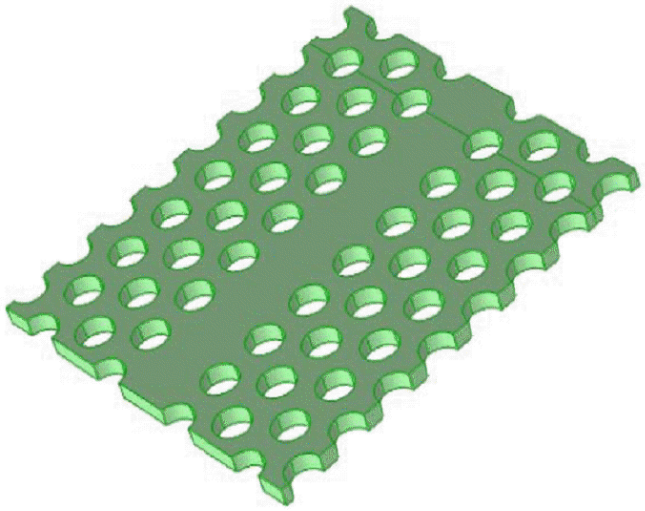
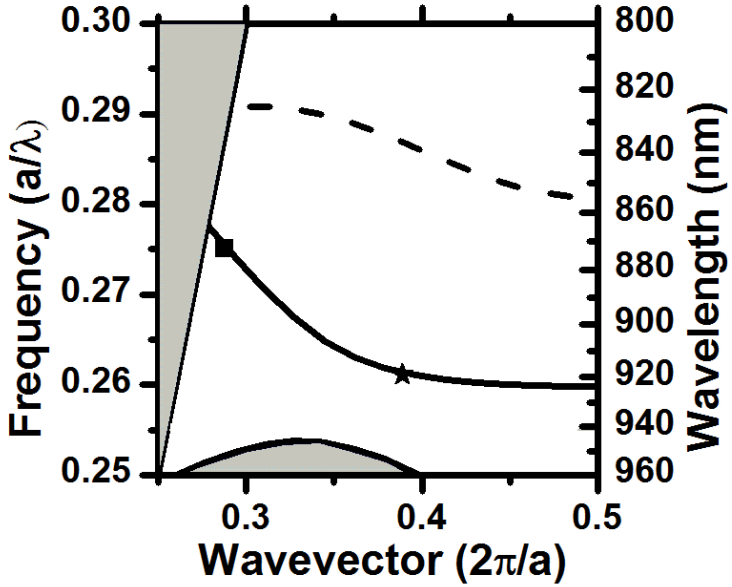
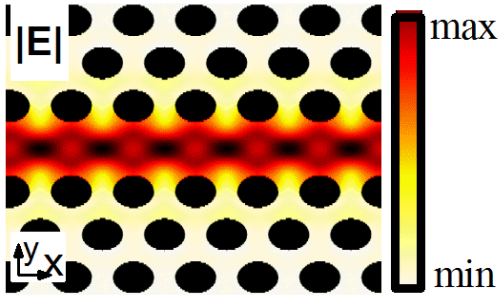
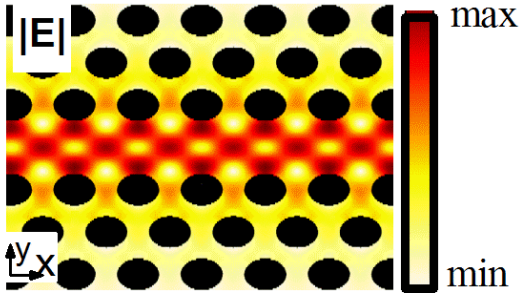


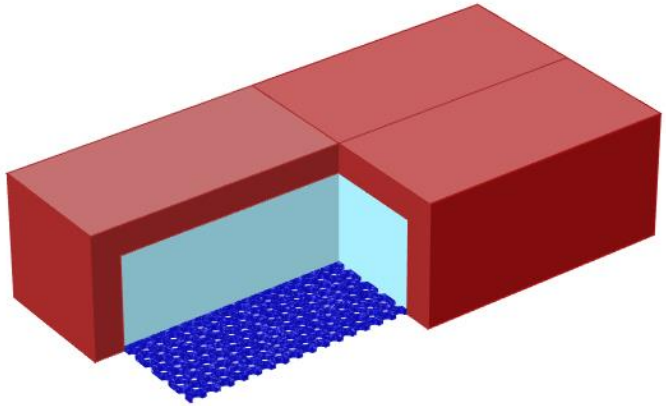






Simulation Details

Simulation Domain:



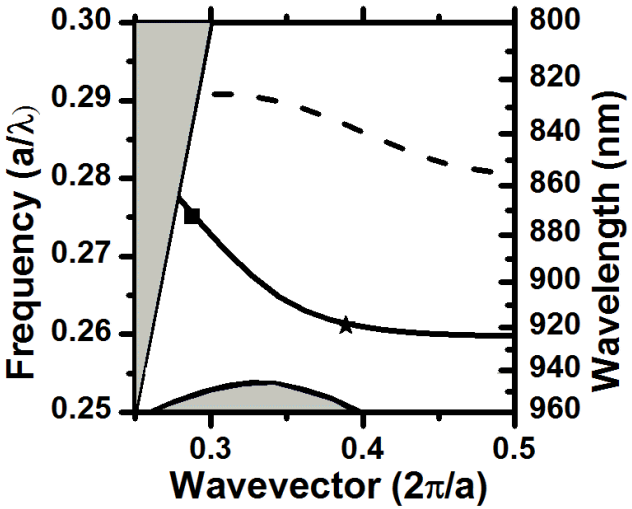
COMSOL features used:

- PMLs and Scattering boundary conditions on all boundaries.
- PMC at the center of simulation domain.
- Dipole point sources.
- Post processing: Various integration and evaluations

Study Types:

- Eigen value study
- Frequency domain study

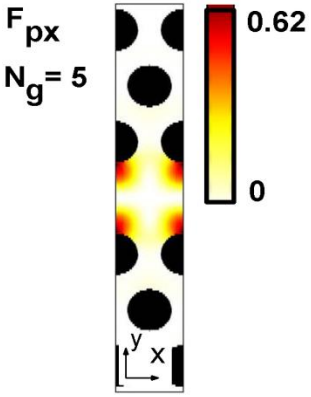
Power coupled to a WG mode

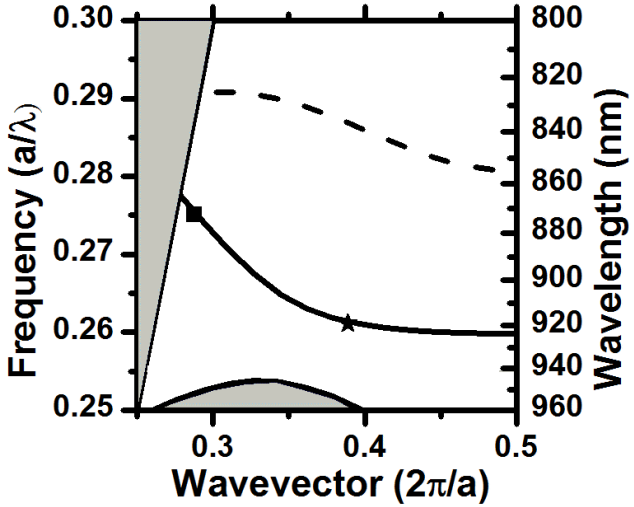


$$P = \frac{3 * \pi * {c_0}^3 * \varepsilon_0 * \left|\vec{E}.\vec{d}\right|^2}{\omega^2 * \int re\left(\vec{E} \times \vec{H}^*\right).\vec{x}\, ds} * P0$$

Power coupled to a WG mode

X oriented dipole





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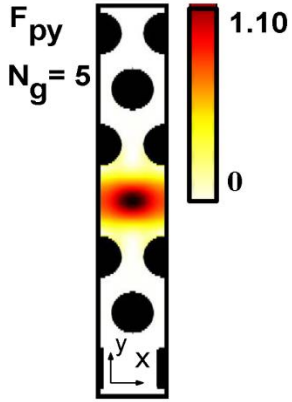

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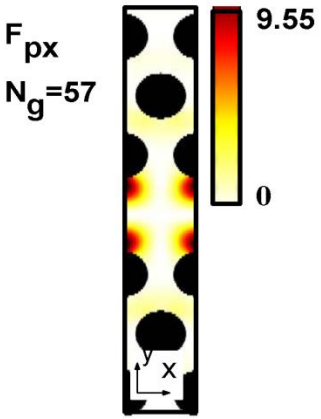

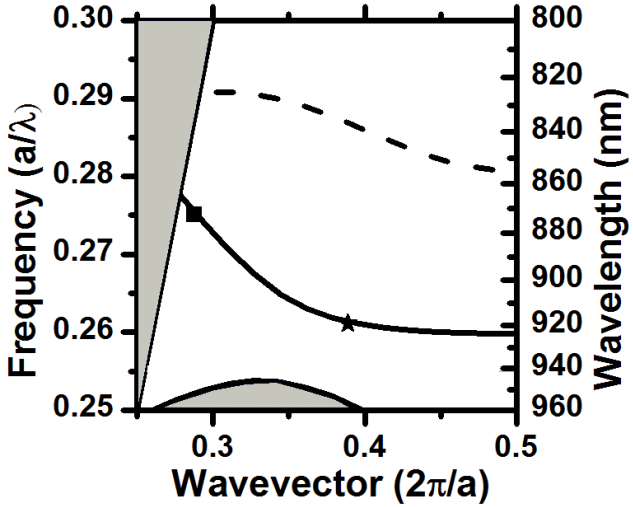

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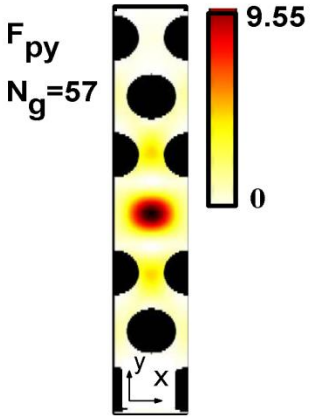

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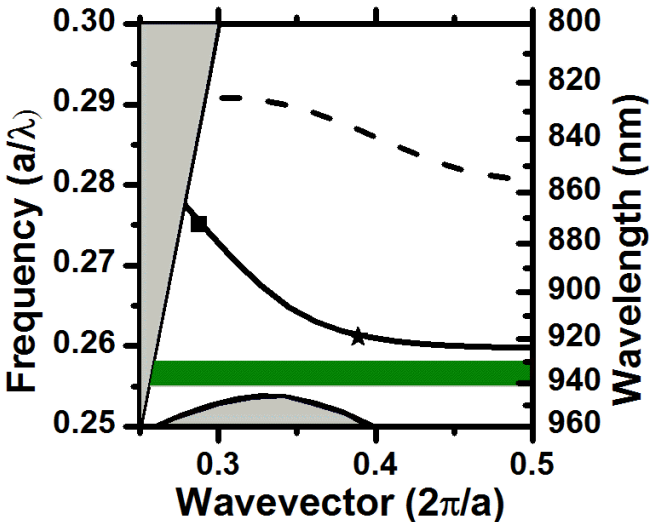
Purcell factor for dipoles in the band gap.



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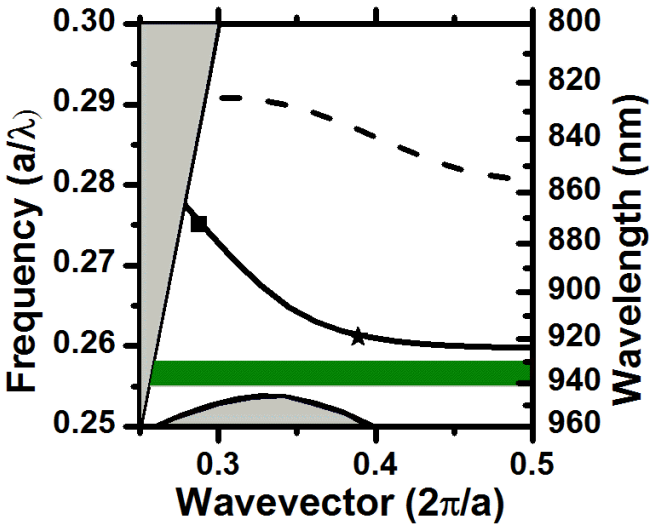

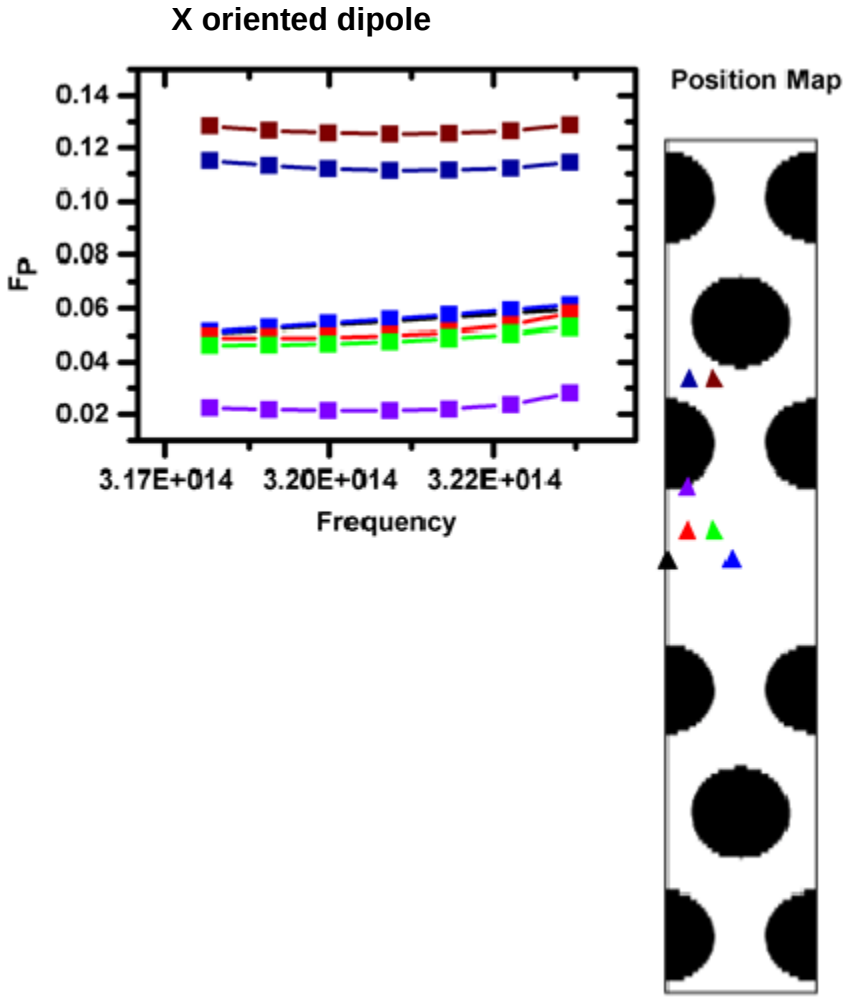

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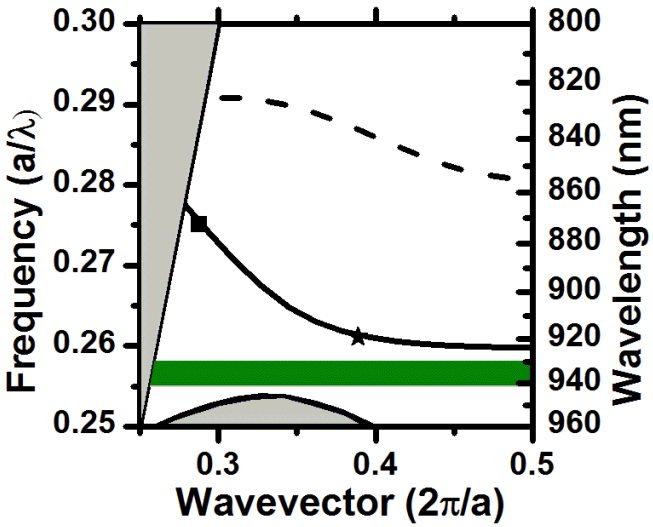

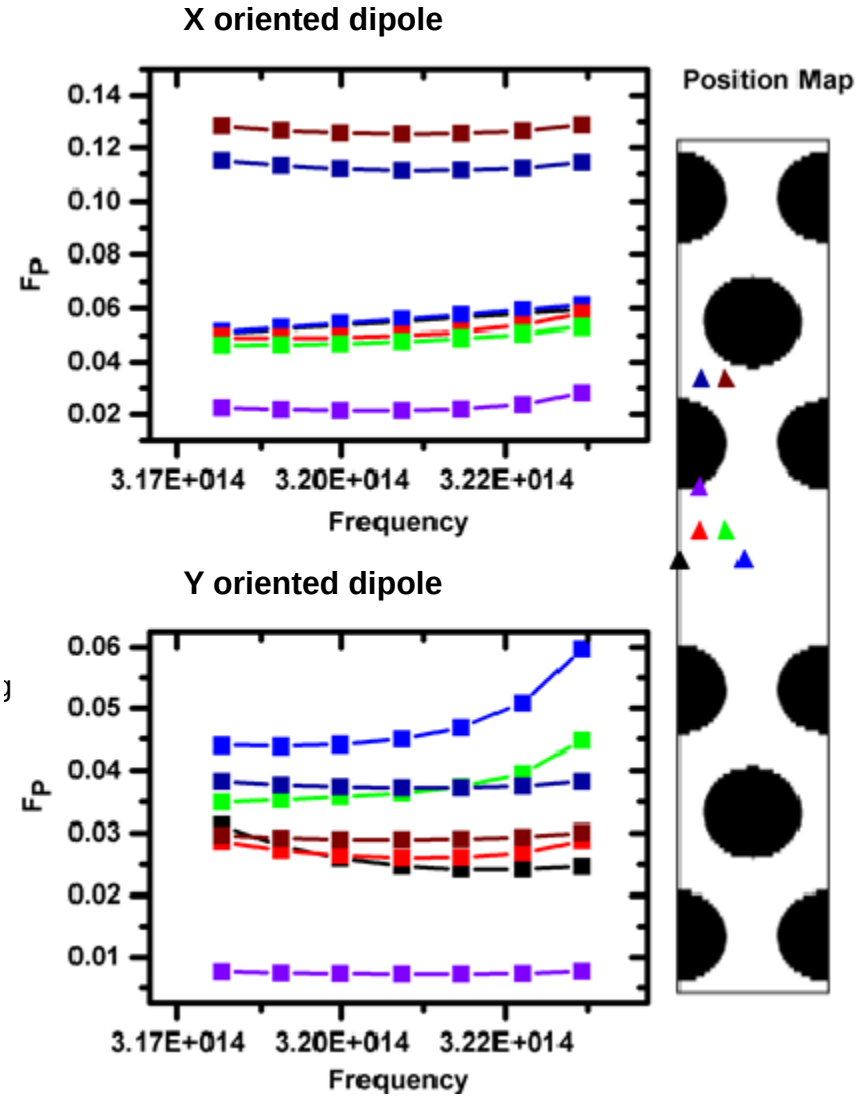

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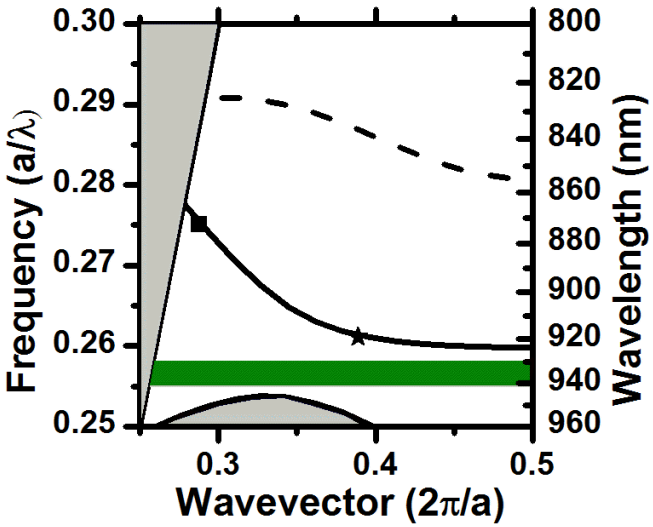
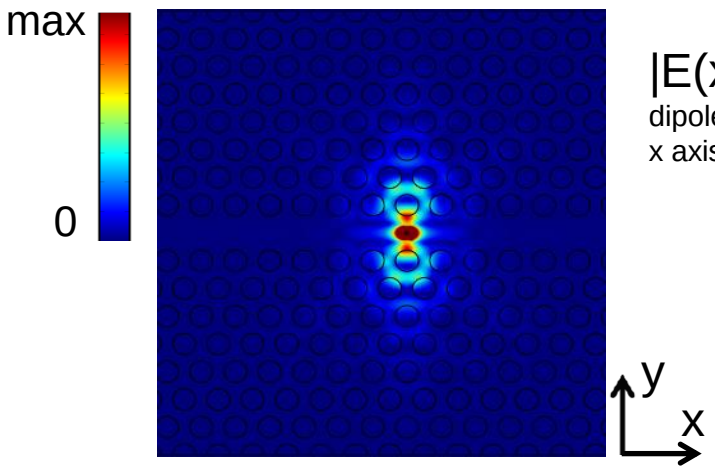
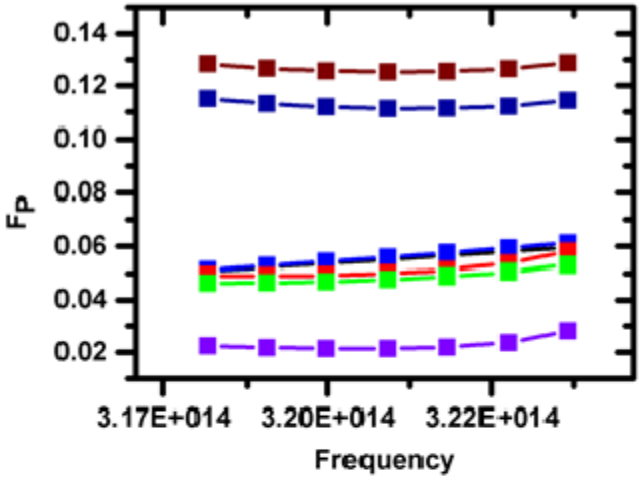


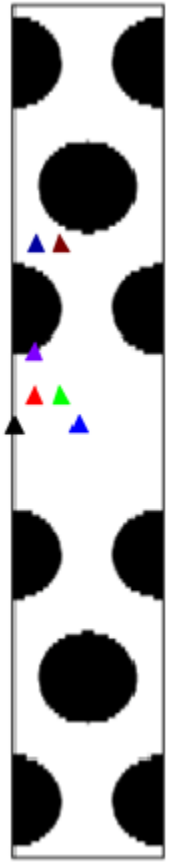


|E(x,y)| for dipole oriented along x axis

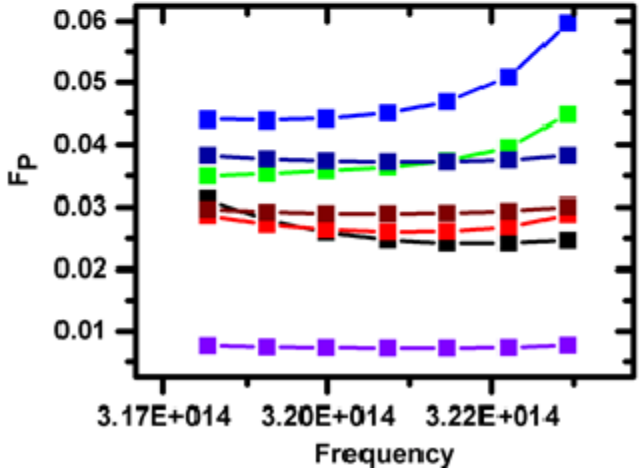
X oriented dipole



Position Map



Y oriented dipole



Conclusion

1. We use COMSOL to calculate coupling strength to different modes in nanostructured environments.

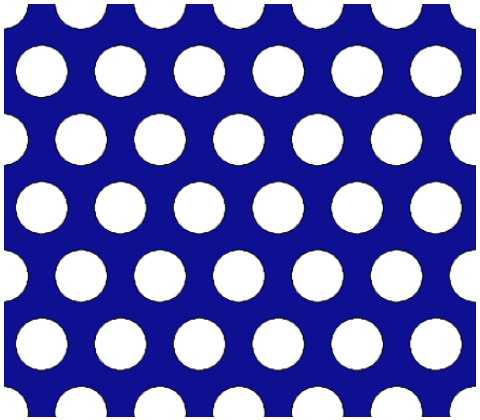
2. The results also show, very robust, highly suppressed interaction with radiation modes and also very broadband enhanced coupling to the waveguide mode when in resonance with the primary mode of the waveguide.

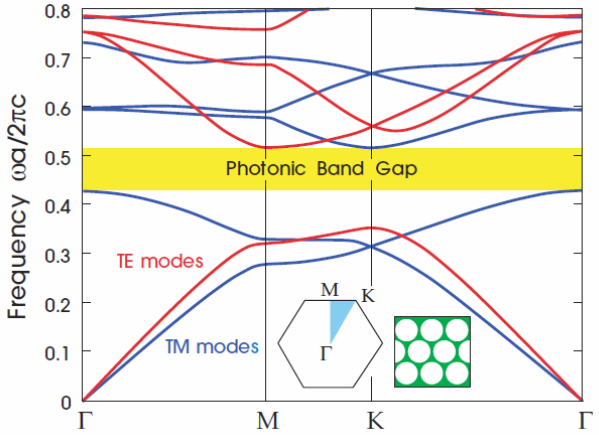
Thanks for your attention

For a recent review of some of our work, see:
Lodahl and Stobbe, *Solid-state quantum optics with quantum dots in photonic nanostructures,* Nanophotonics 2, 39 (2013).

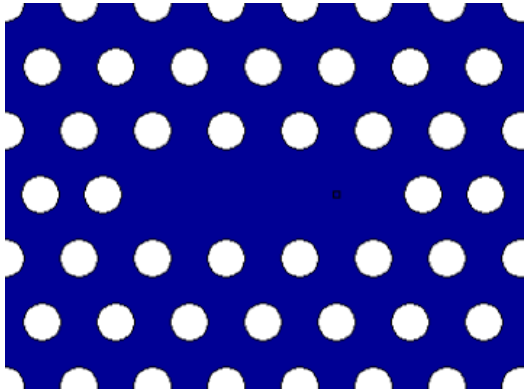
Photonic Crystals

2D Photonic crystals

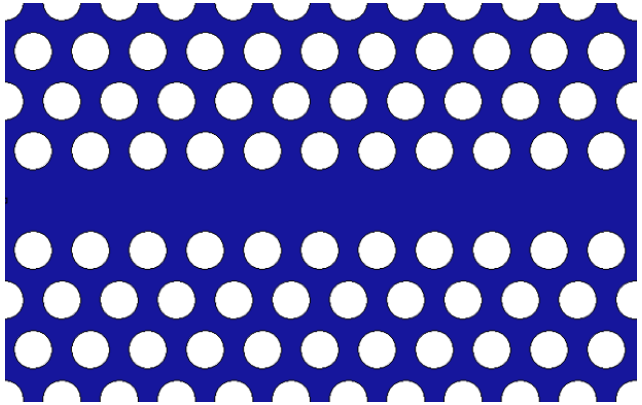




Cavity



Waveguide



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