Master PICS,
TD #1: Photonic and phononic crystals

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1 2D photonic crystals

Consider a 2D artificial crystal as depicted on slides 15 and 22 of the lecture notes, made of air holes in silicon.

1. Consider first a TE (transverse electric) photonic crystal, with equation given slide 17. Study and understand script `band_TE.edp`. What is the output and how is it organized?
2. Plot the TE band structure using either gnuplot (example script `bs_photonic.plt`) or matlab/octave (example script `bs_plot.m`). Is there a complete band gap?
3. Observe the Bloch waves (eigenmodes) at the X point of the Brillouin zone (example script `modes_TE.edp`). Can you observe the symmetries of the eigenmodes?
4. Consider now a TM photonic crystal. What is changed compared to the TE case? Write a script `band_TM.edp` producing the band structure as text file `bs_TM.dat`.
5. Plot the TM band structure. Is there a complete band gap?
6. Write a script `modes_TM.edp` to plot the Bloch waves (eigenmodes) at the X point of the Brillouin zone. Any differences with the TE case?

2 Finite 2D phononic crystal

Consider a cylindrical barrel filled with water. We place an hydrophone (or transducer) inside the barrel to generate a beam of acoustic waves.

1. Study and understand script `acoustic_source_free.edp`. What situation is it representing? What is the boundary condition on the barrel walls? Change the operation frequency to observe how the acoustic field changes. Can you explain why the situation produces a *speckle* pattern (that is, a random or chaotic interference field)?

2. Study and understand script `acoustic_source_radiation.edp` that produces the image on slide 20. What is the external boundary condition? Can you understand how it works and why there are no more reflections?

3. Study and understand script `acoustic_grating.edp`. What situation is it representing? Change the operation frequency to observe how the acoustic field changes.

4. Modify the previous script in order to study the scattering of an acoustic beam on a single steel rod. Change the radius of the rod and observe the changes in the scattered field.

5. Create a script to study a phononic crystal of 7 rows by 4 columns, with rods of radius $r = 0.4$ and lattice constant $a = 1$ (in normalized units of the previous scripts). Change the operation frequency to observe the existence of a phononic band gap. Try to estimate the starting and exit frequencies of the band gap.

3 Phononic band structure

The weak form of the phononic band structure for pressure (acoustic) waves is given on slide 21. Inspire yourself from the photonic `band_TE.edp` script to write a script that generates the phononic band structure of the 2D crystal of the previous section.

4 Phononic crystal waveguide

Start from the script obtained at question 2.5 to study a phononic crystal waveguide similar to the one on Figure 1. What are the conditions to obtain waveguiding from a phononic band gap? Change the operation frequency to observe the how the waveguiding function evolves.

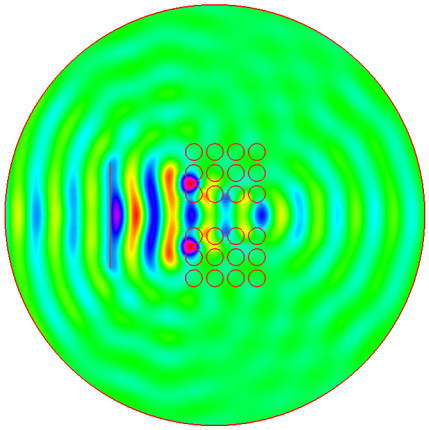

Figure 1: Phononic crystal waveguide.