

# High quality factor cavities for TeraHertz emitter based on graphene

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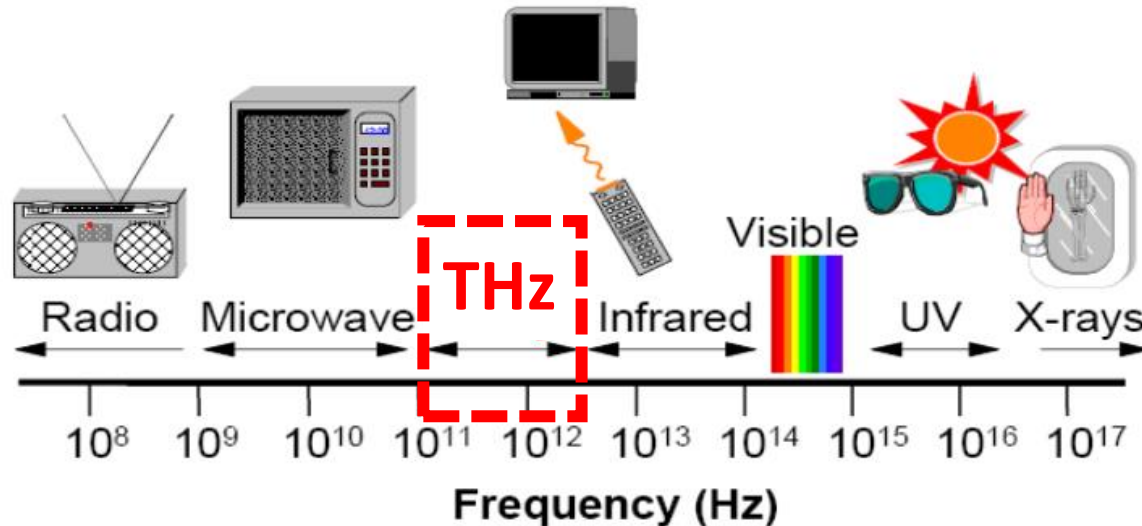
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de Physique  
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Journées de l'école doctorale – 25/10/20



# What are TeraHertz (THz)?

- An intermediate range of the electromagnetic spectrum:

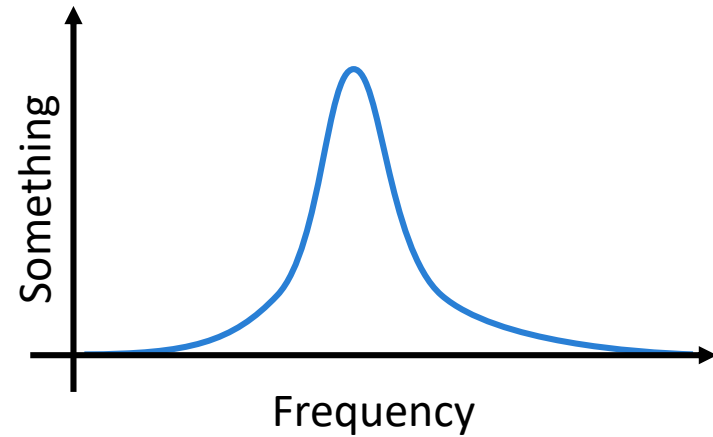


Very low energy photons : (300 GHz to 10 THz  $\leftrightarrow$  1 mm to 30  $\mu$ m  $\leftrightarrow$  1meV to 40 meV)

- Applications:
  - Imaging
  - High speed wireless telecom
  - **Spectroscopy:** large molecule conformation

# Cavity = Electromagnetic resonator

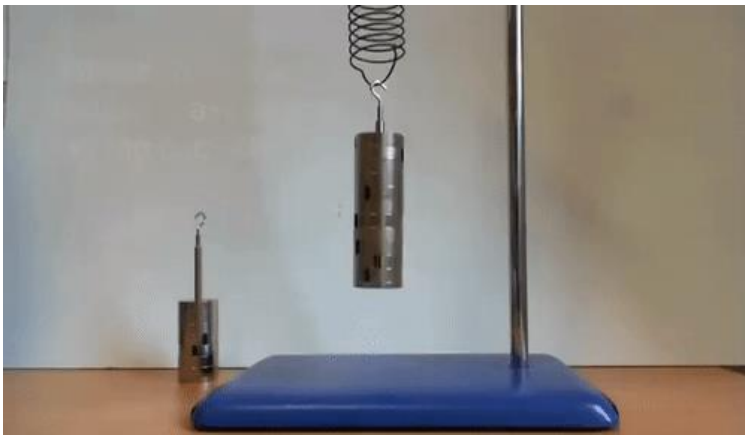
- What's a resonator?



- Usual mechanical resonators :

Spring-mass system

Guitar string



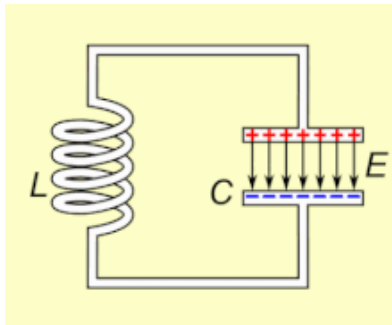
Localized components/intrinsic properties

Wave/propagation based

# TeraHertz resonators

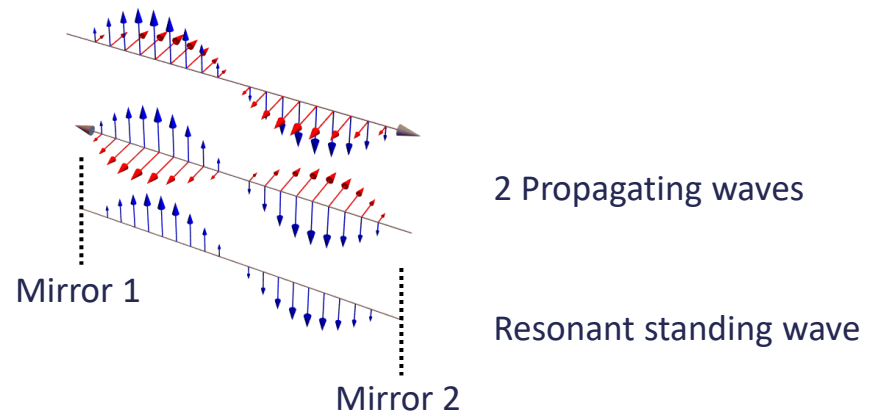
- Electromagnetics resonators: direct analogy

LC circuits



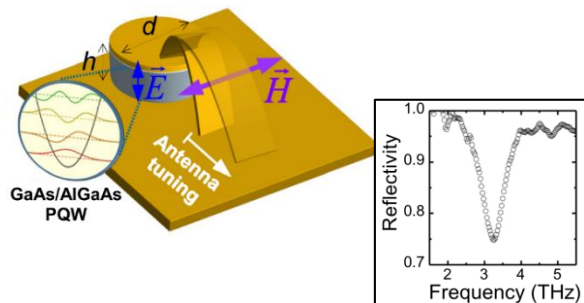
Analogy:  
Inductance/mass  
Capacitance/spring

Fabry-Perot cavity



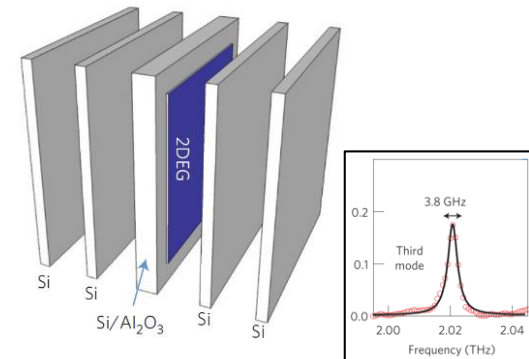
- THz resonators:

LC circuit meta-atoms



B. Paulilo et al., *Appl. Phys. Lett.*  
2016

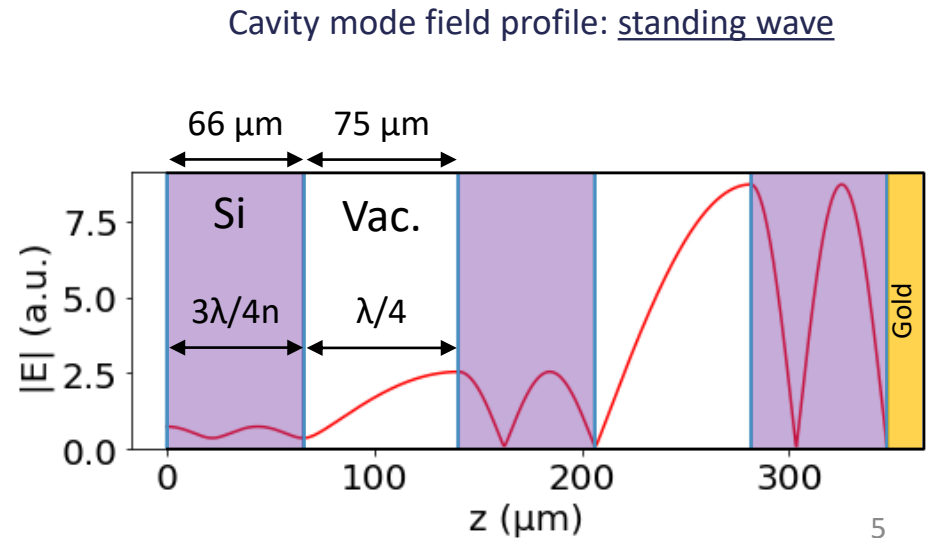
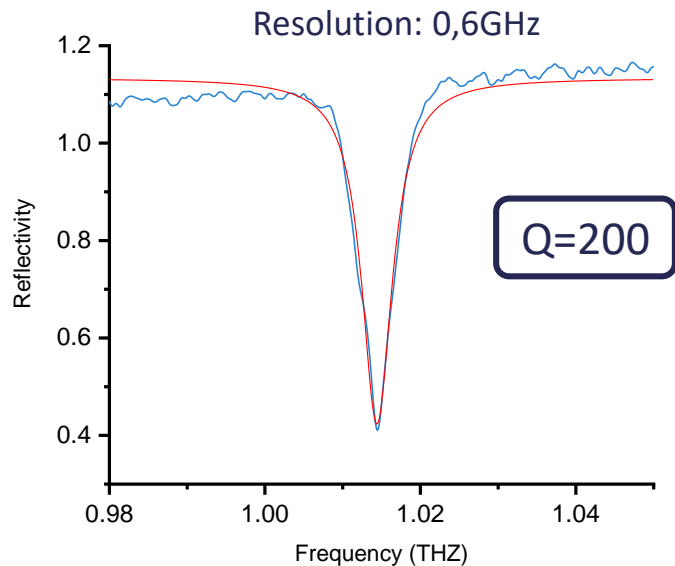
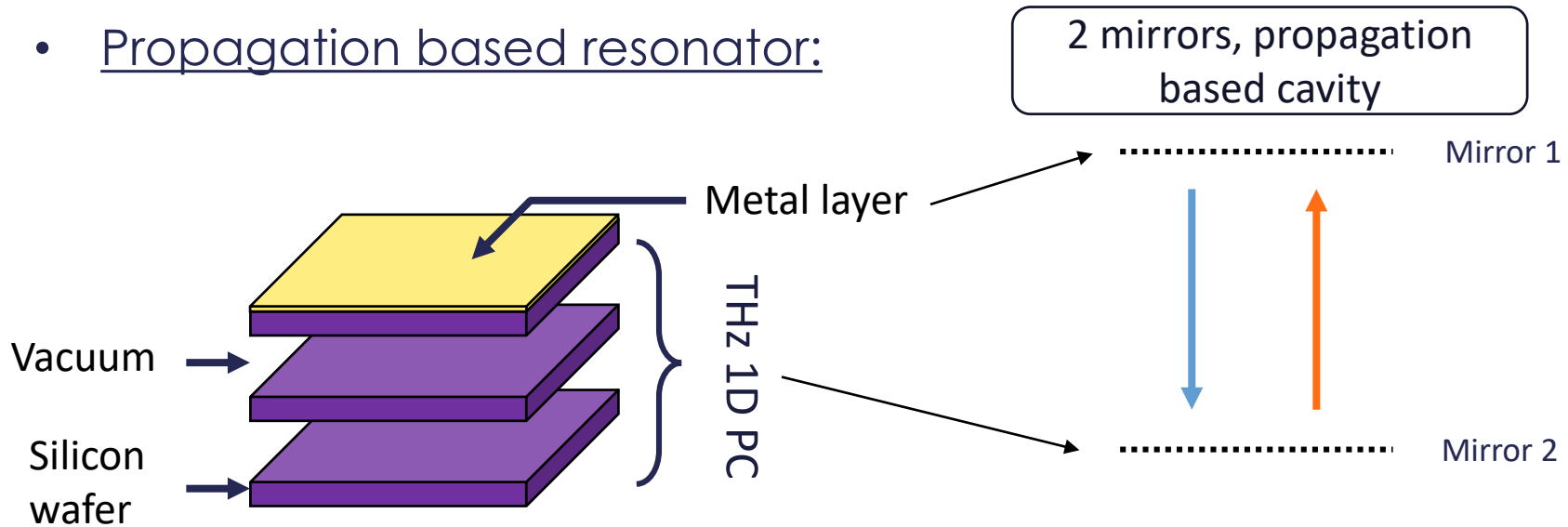
1D Silicon PC Fabry-Perot cavity



Qi Zhang et al, *Nature Physics*  
2016

# Our approach: The THz Tamm cavity

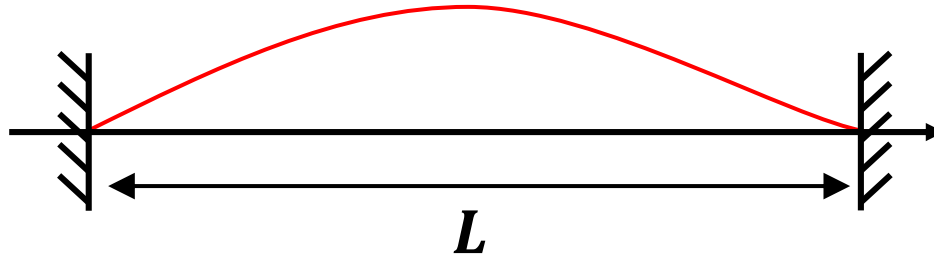
- Propagation based resonator:



# Mixing propagation and localized components

- Mechanical analogy: Guitar string

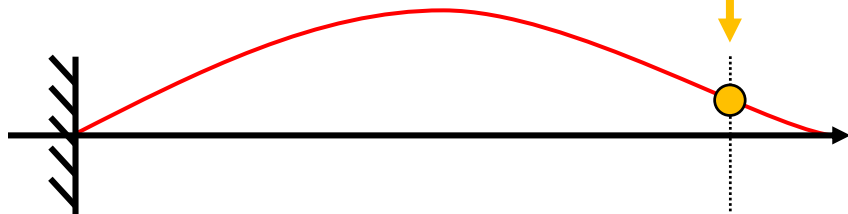
Basic case:



$$f_0 = \frac{c}{2L}$$

Mass-loaded string:

Finite mass weight

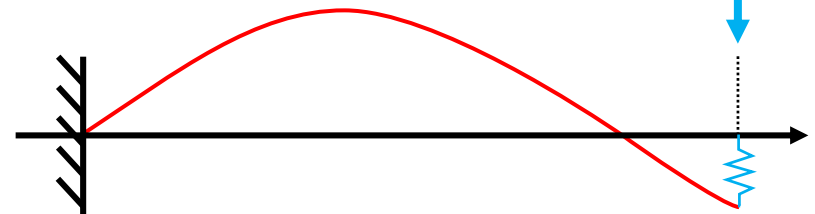


$$L^* > L$$

$$f^* < f_0$$

Spring-loaded string:

Finite stiffness spring

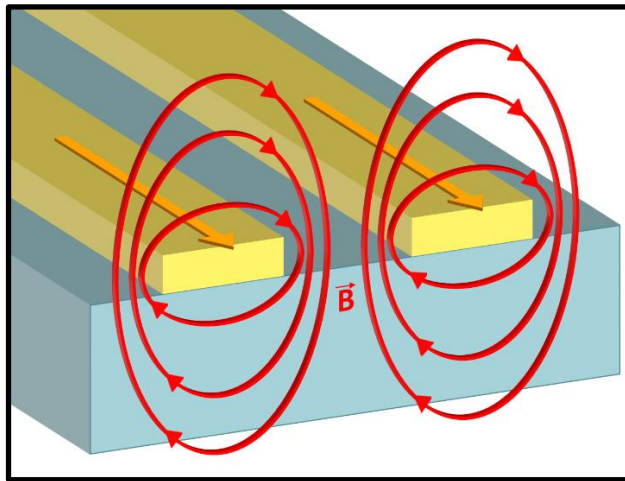
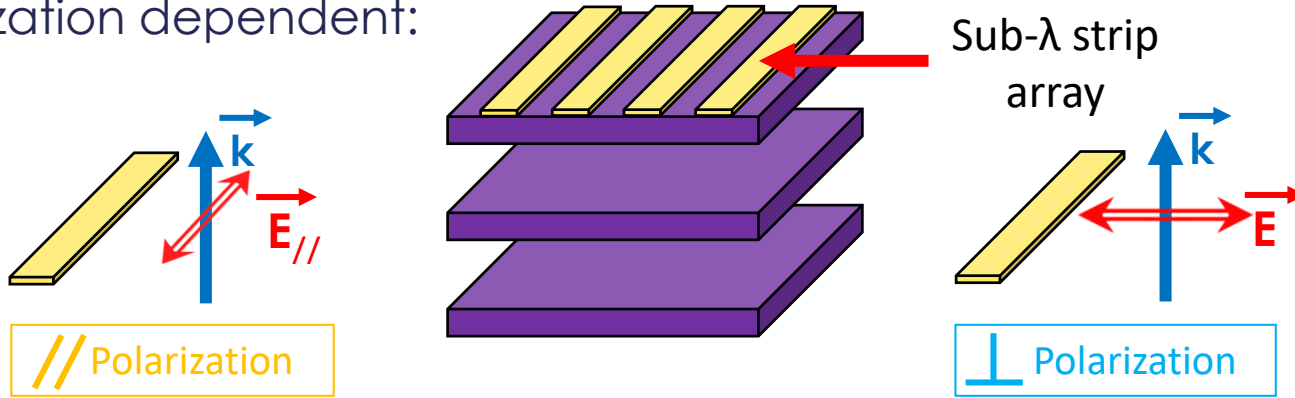


$$L^* < L$$

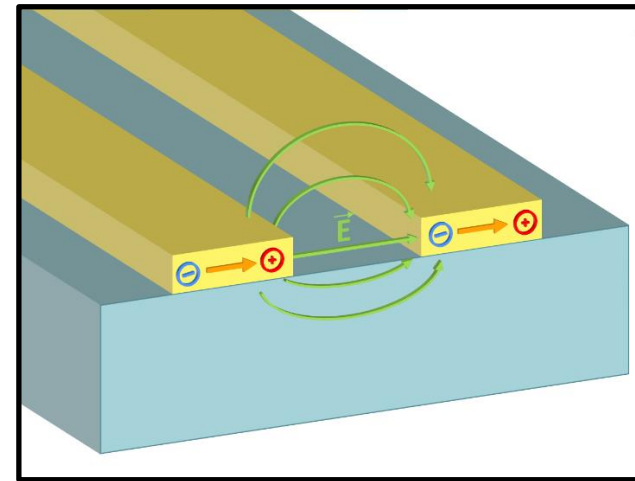
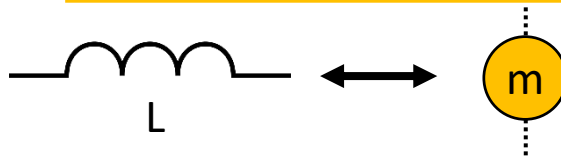
$$f^* > f_0$$

# Strip mirror Tamm cavity

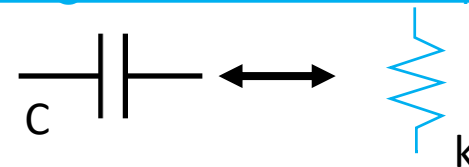
- Polarization dependent:



Parallel case  $\rightarrow$  Inductance

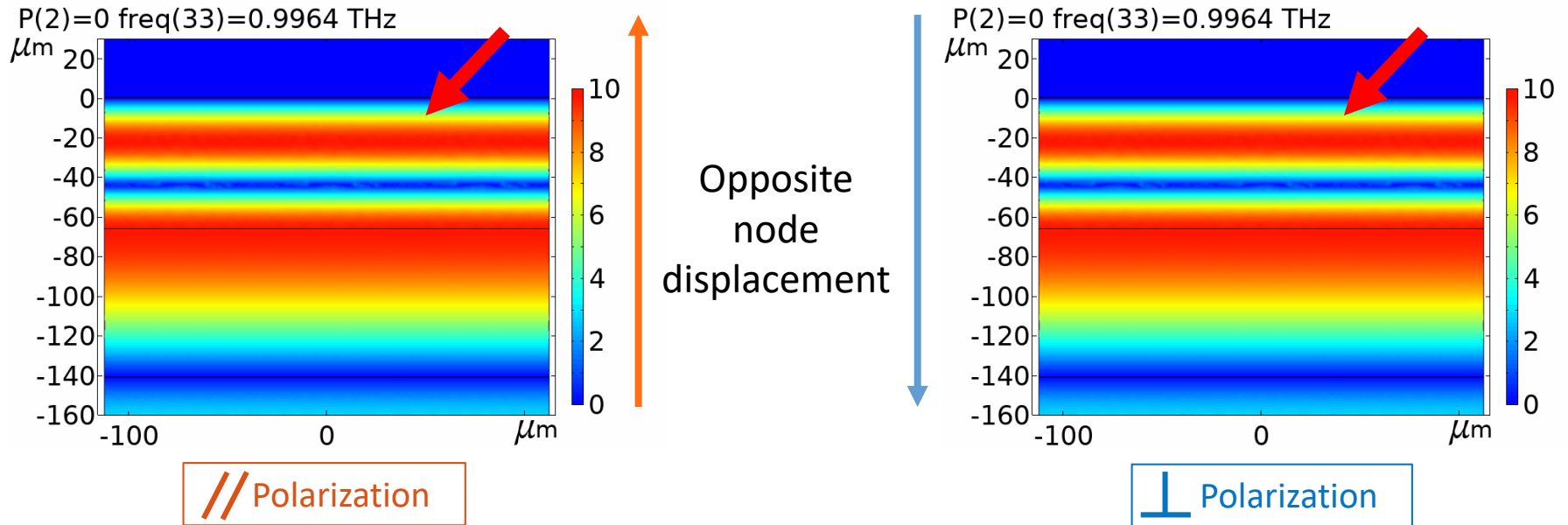


Orthogonal case  $\rightarrow$  Capacitor

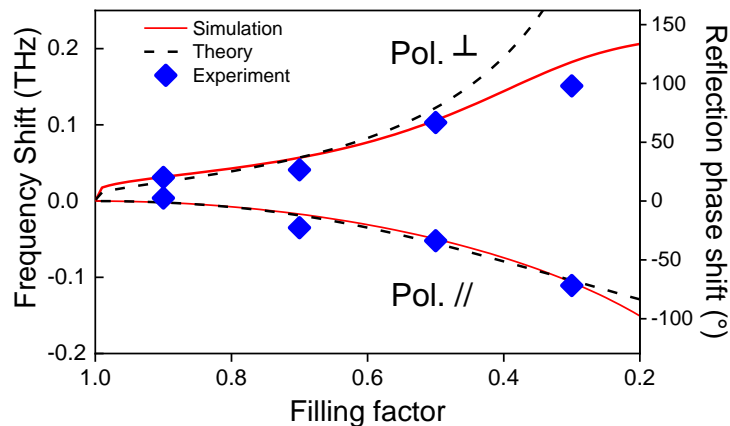


# Strip mirror Tamm cavity

- Electric field simulation :

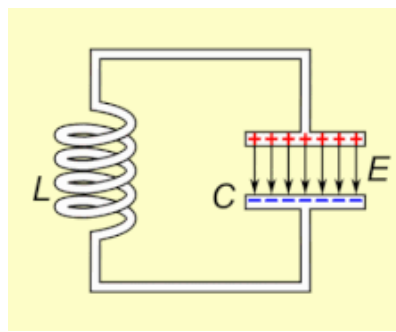
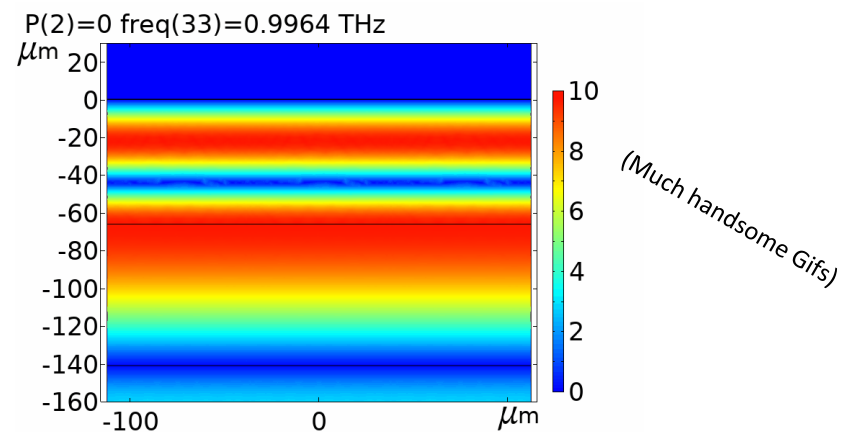


- Opposite resonance frequency shifts:

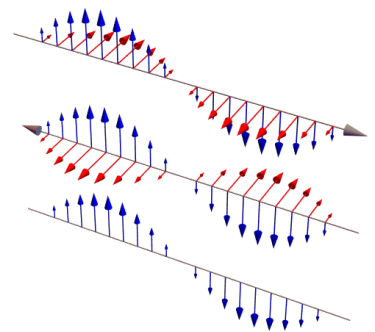




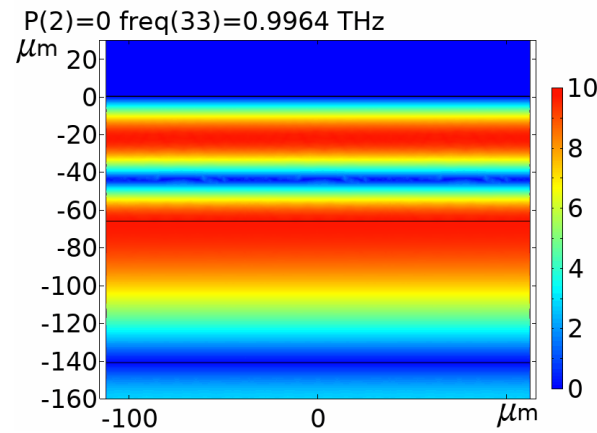
(Fourier transform le 100)



# Thank you for your attention !



(Physics rule you glue addict chemists)



(Very waves)

