

# Nanoscale Photonic Structures in Fibre Form

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- **PCF guidance mechanisms [4]**
- **Guidance by metallic nanowire arrays**
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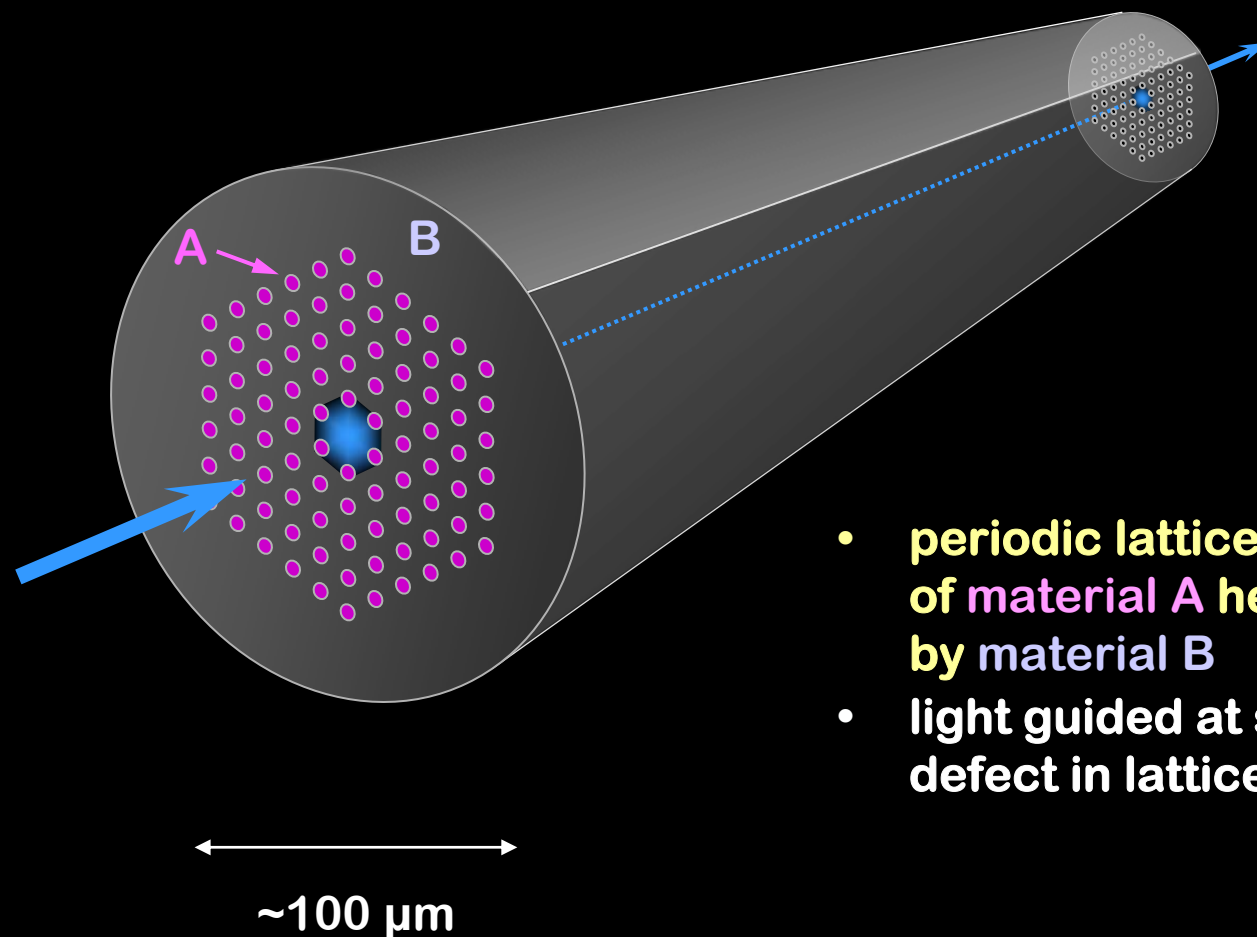
[www.pcfiber.com](http://www.pcfiber.com)

10<sup>th</sup> October 2007



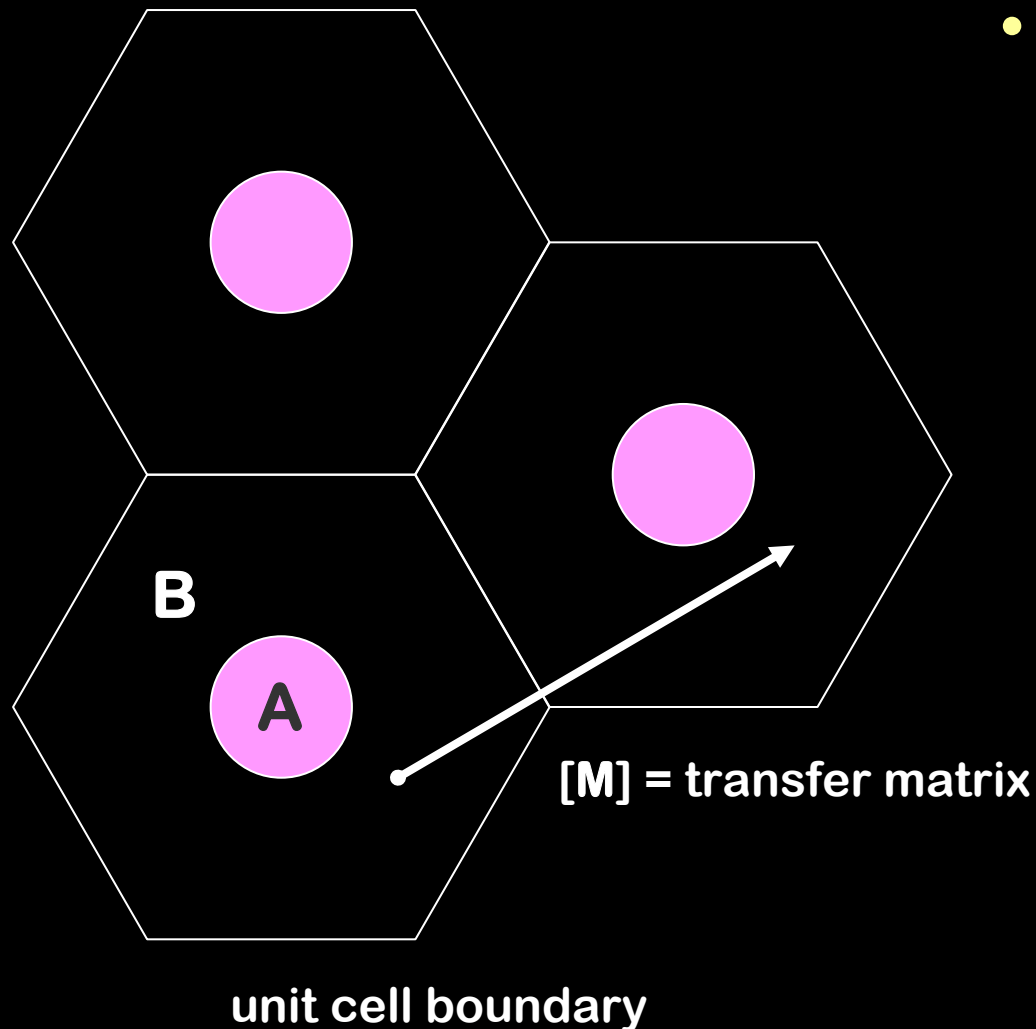
# Guidance Mechanisms

# Generalised PCF guidance



- **periodic lattice of strands of material A held in place by material B**
- **light guided at structural defect in lattice**

# Unit cells & evanescence

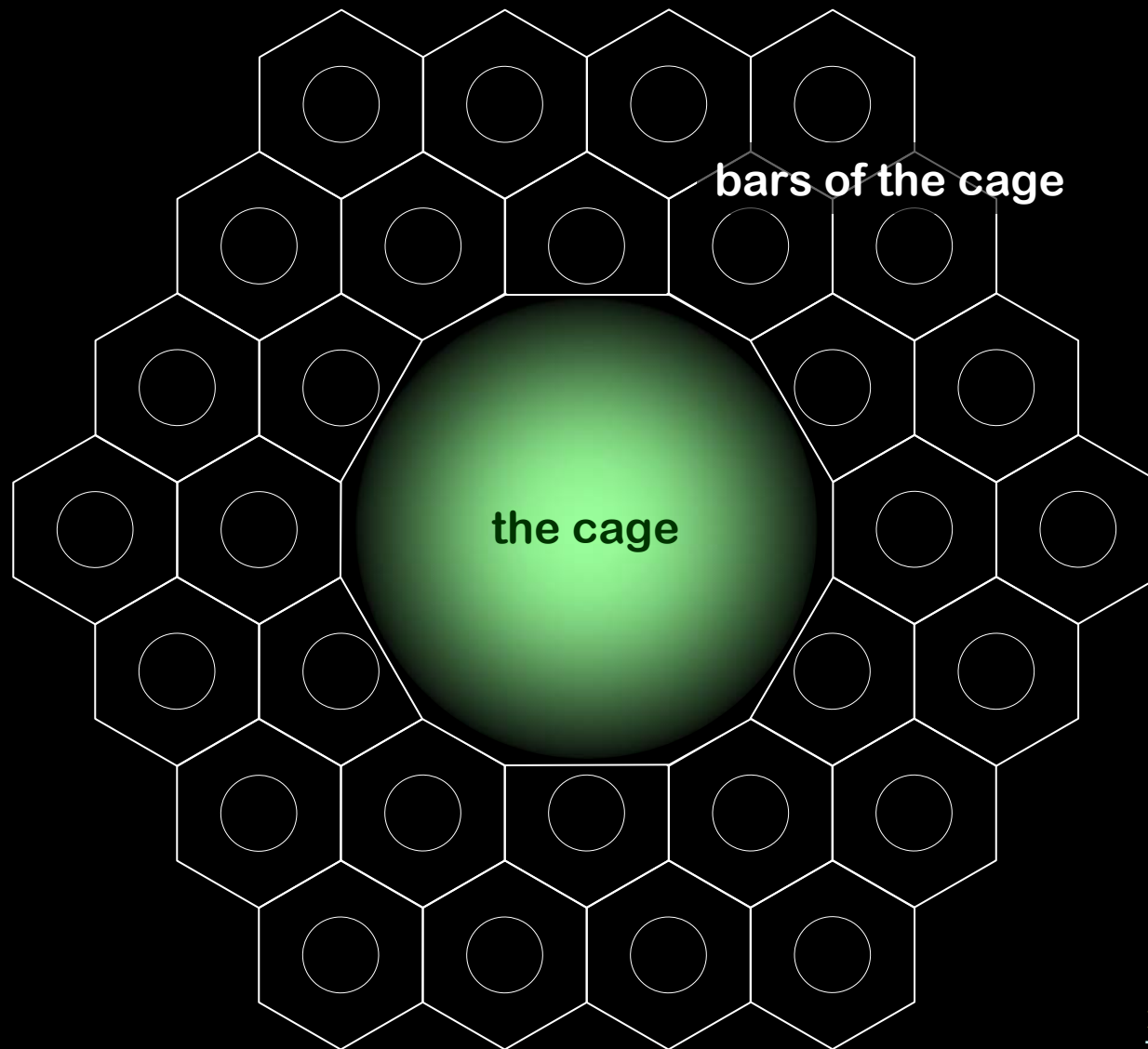


- Bloch wave transfer matrix  $[M]$ :

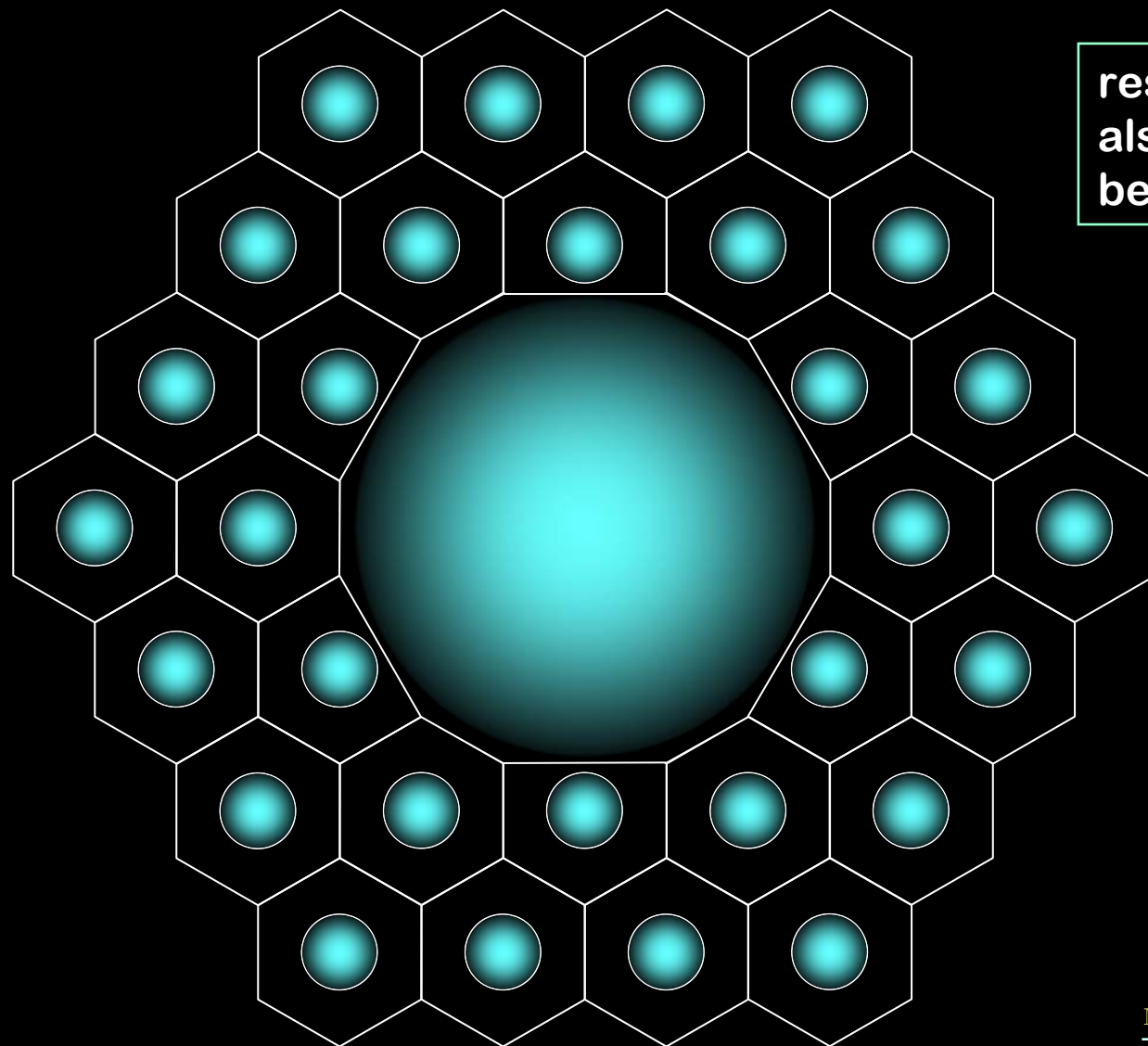
$$\lambda \lambda^* = 1$$

- real eigenvalues: evanescence
- complex eigenvalues: propagation

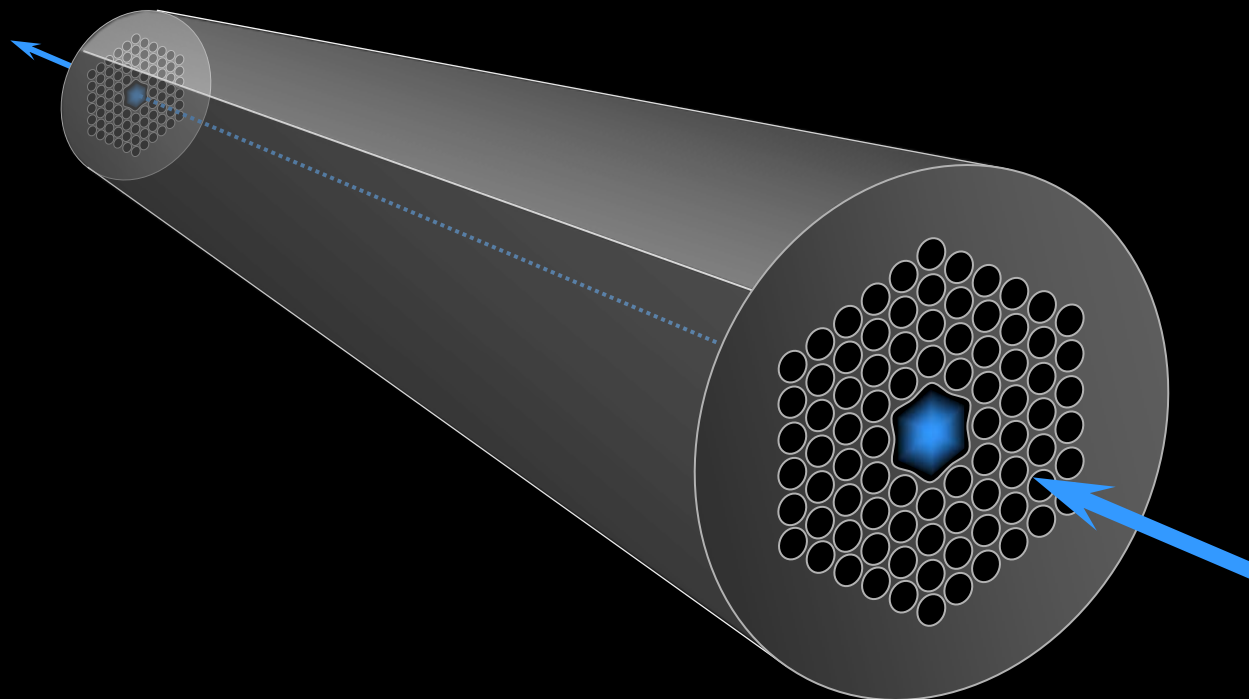
# Building a cage for light



# Leakage via cladding resonances



# Hollow-core PCF



~100  $\mu\text{m}$

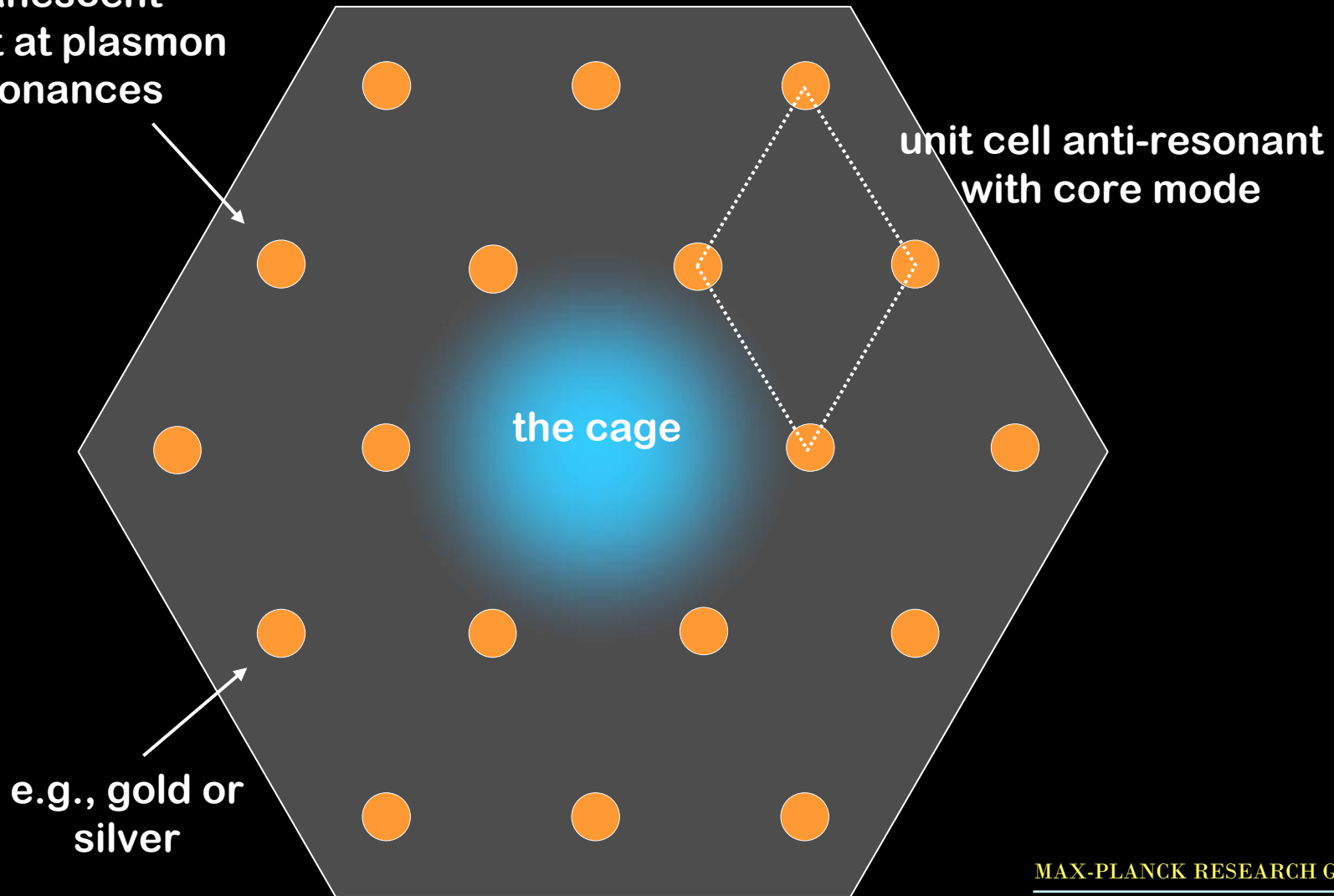
traps light by creating a complete 2D photonic band gap in the cladding



# Metallic Nanowire Arrays

# Metal nanowire arrays

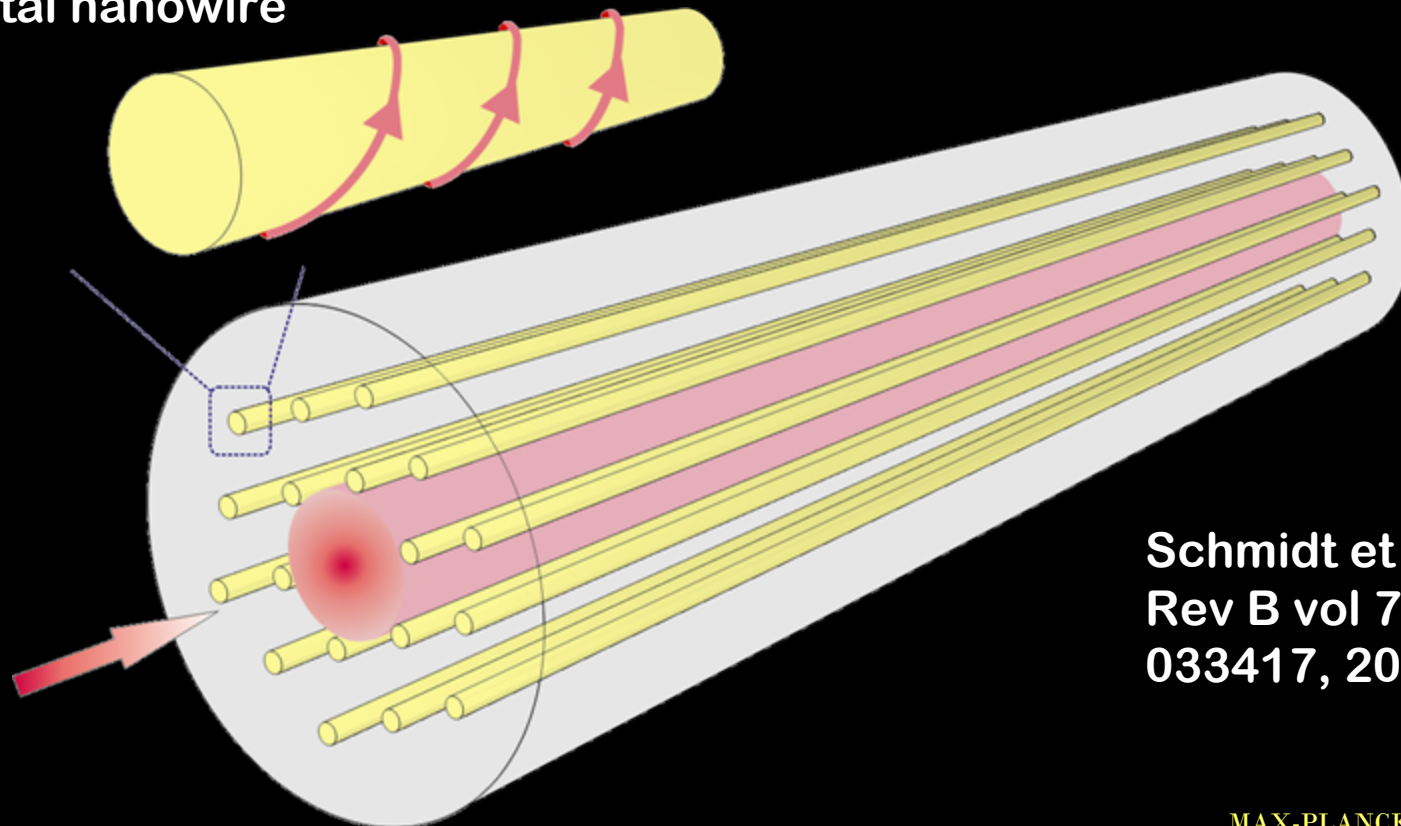
evanescent  
except at plasmon  
resonances



# Spiralling surface plasmons

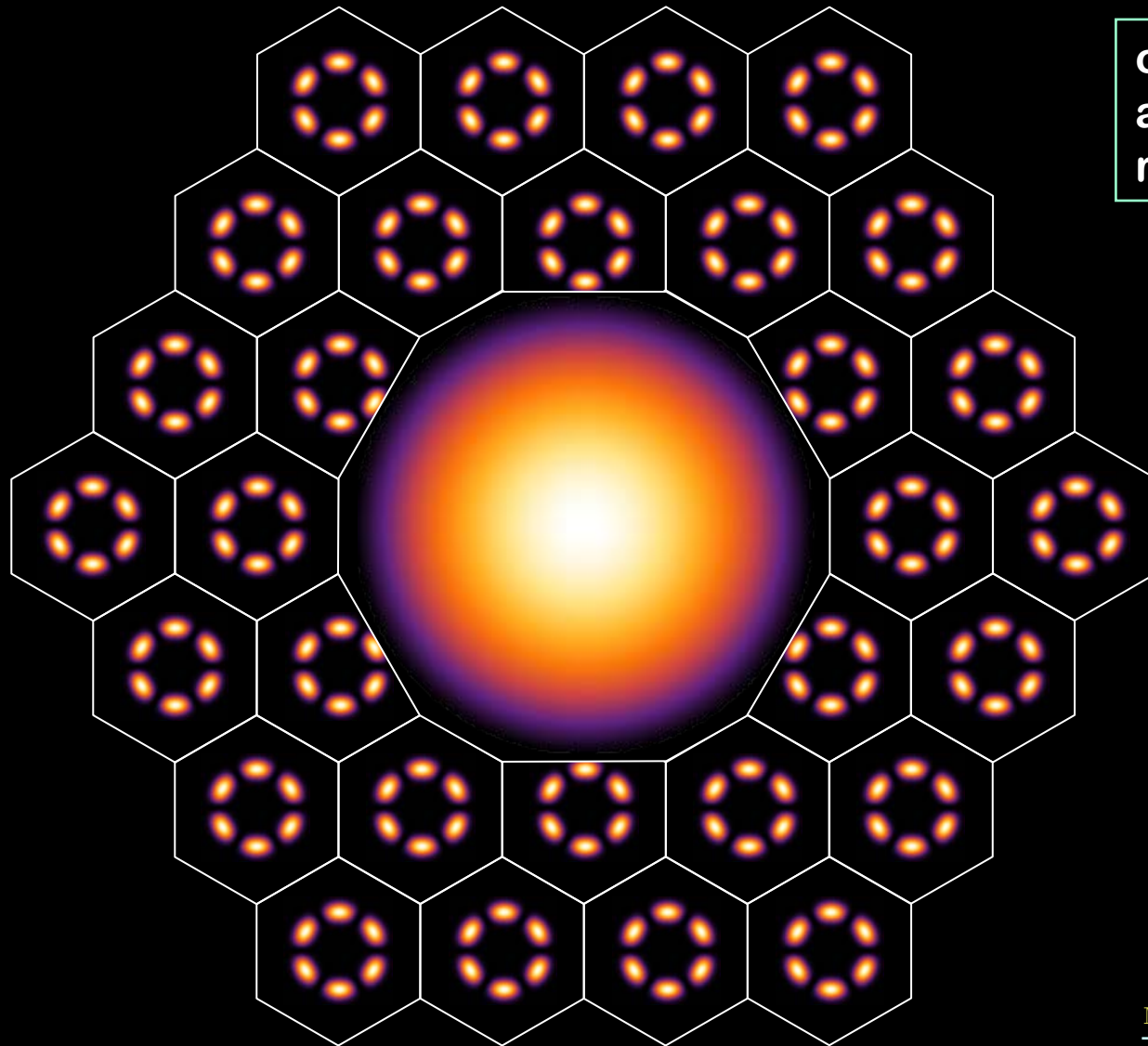
small number of discrete modes  
form when wire is narrow

metal nanowire



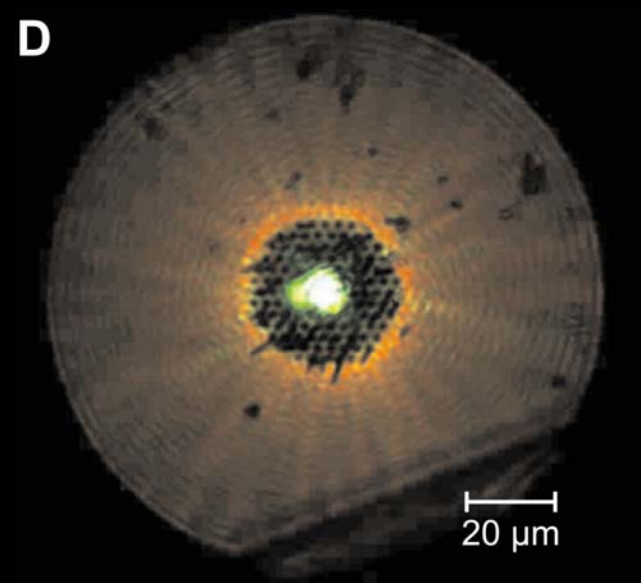
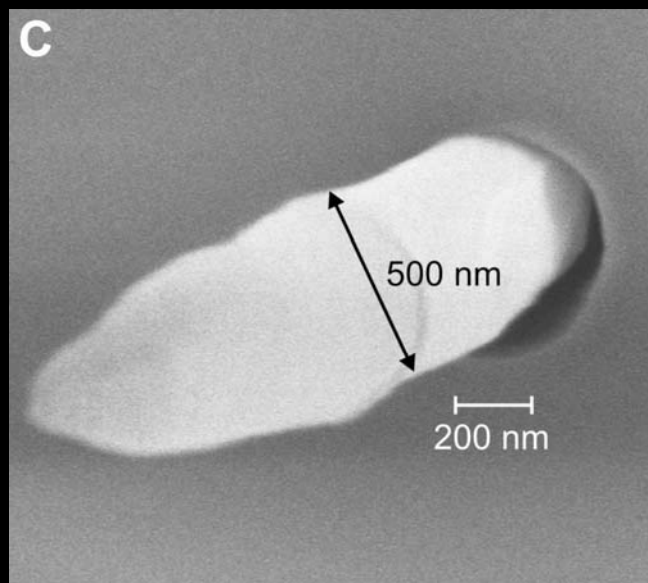
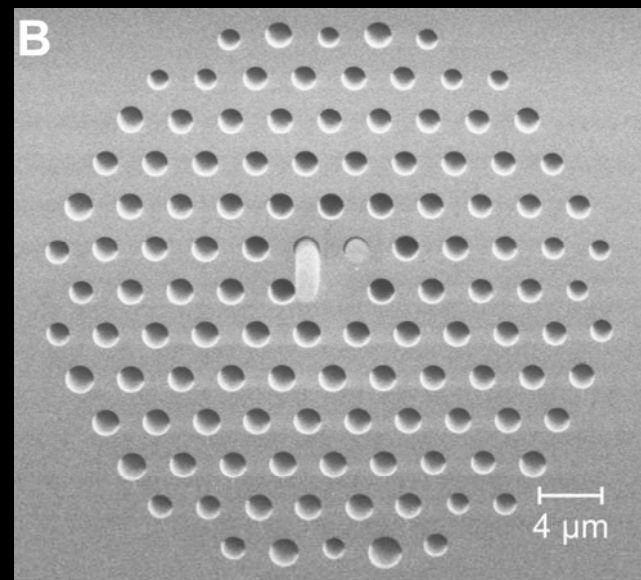
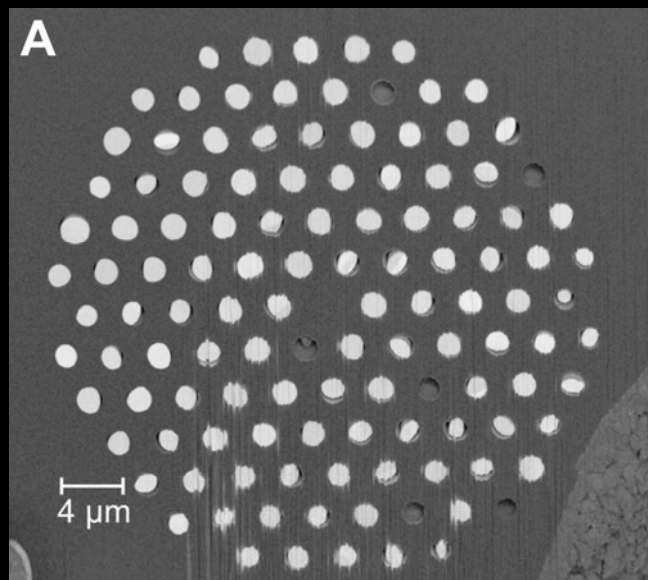
Schmidt et al: Phys  
Rev B vol 77 art  
033417, 2008

# Surface plasmons on nanowires



core light leaks  
away at plasmon  
resonances

# Metallic nanowire arrays

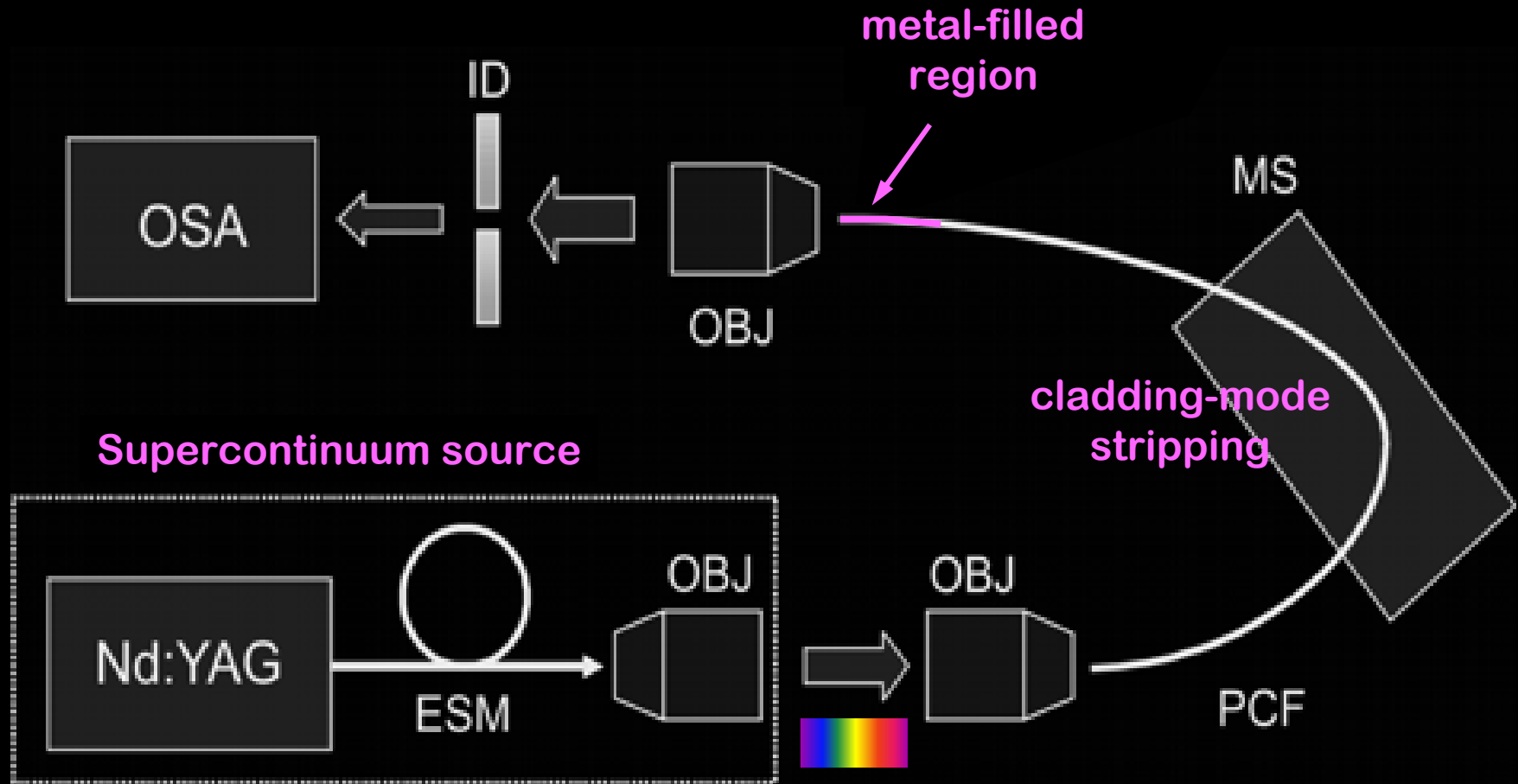


Schmidt et al: Phys  
Rev B vol 77 art  
033417, 2008

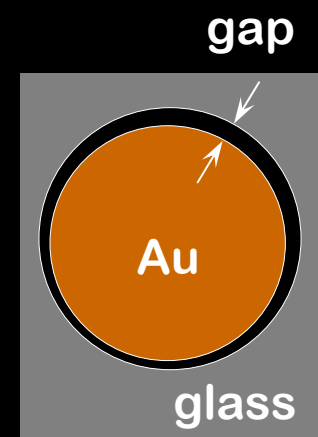
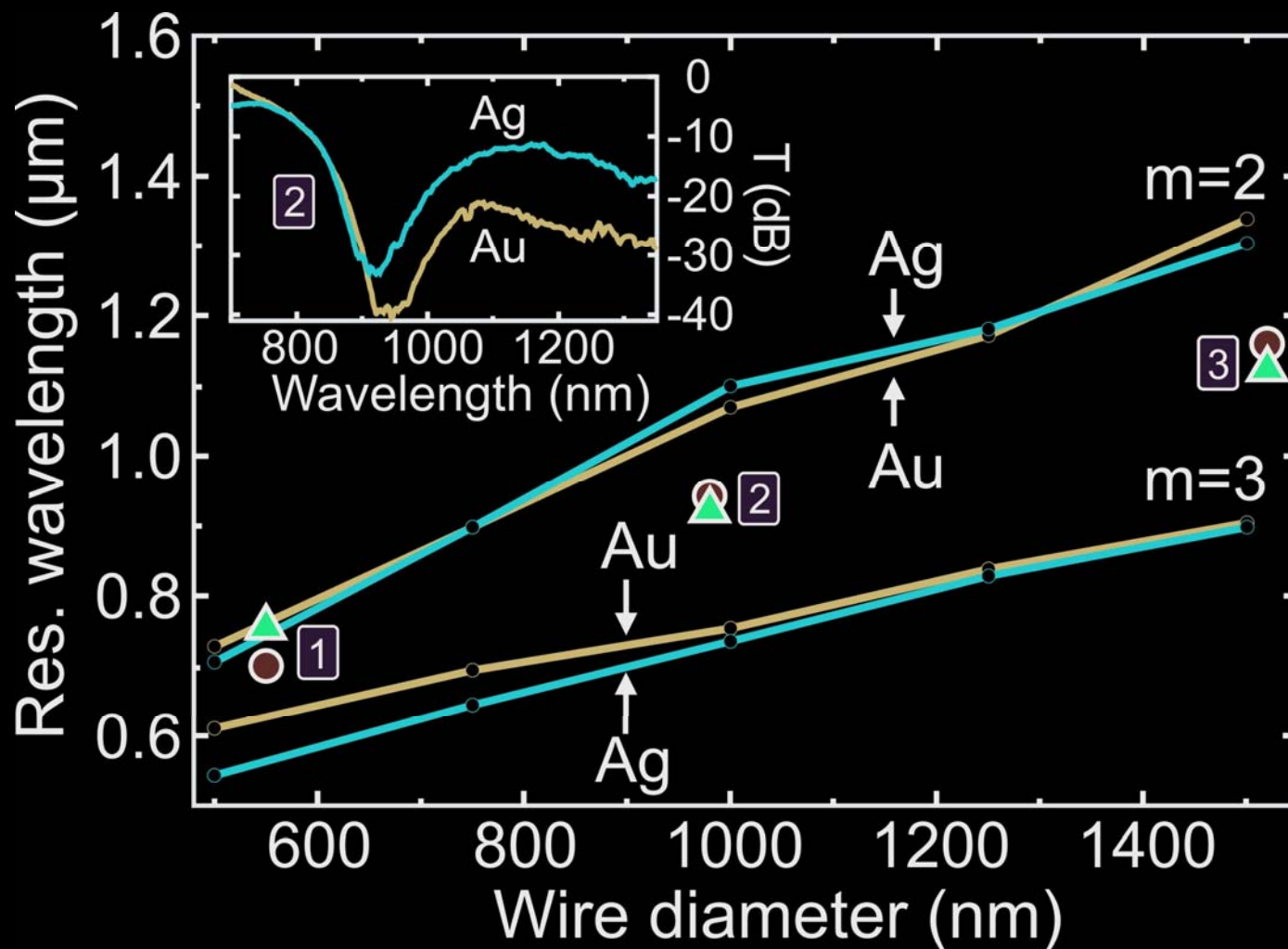
Poulton et al.,  
Opt. Lett. v32  
p1647 (2007)

# Experimental set-up

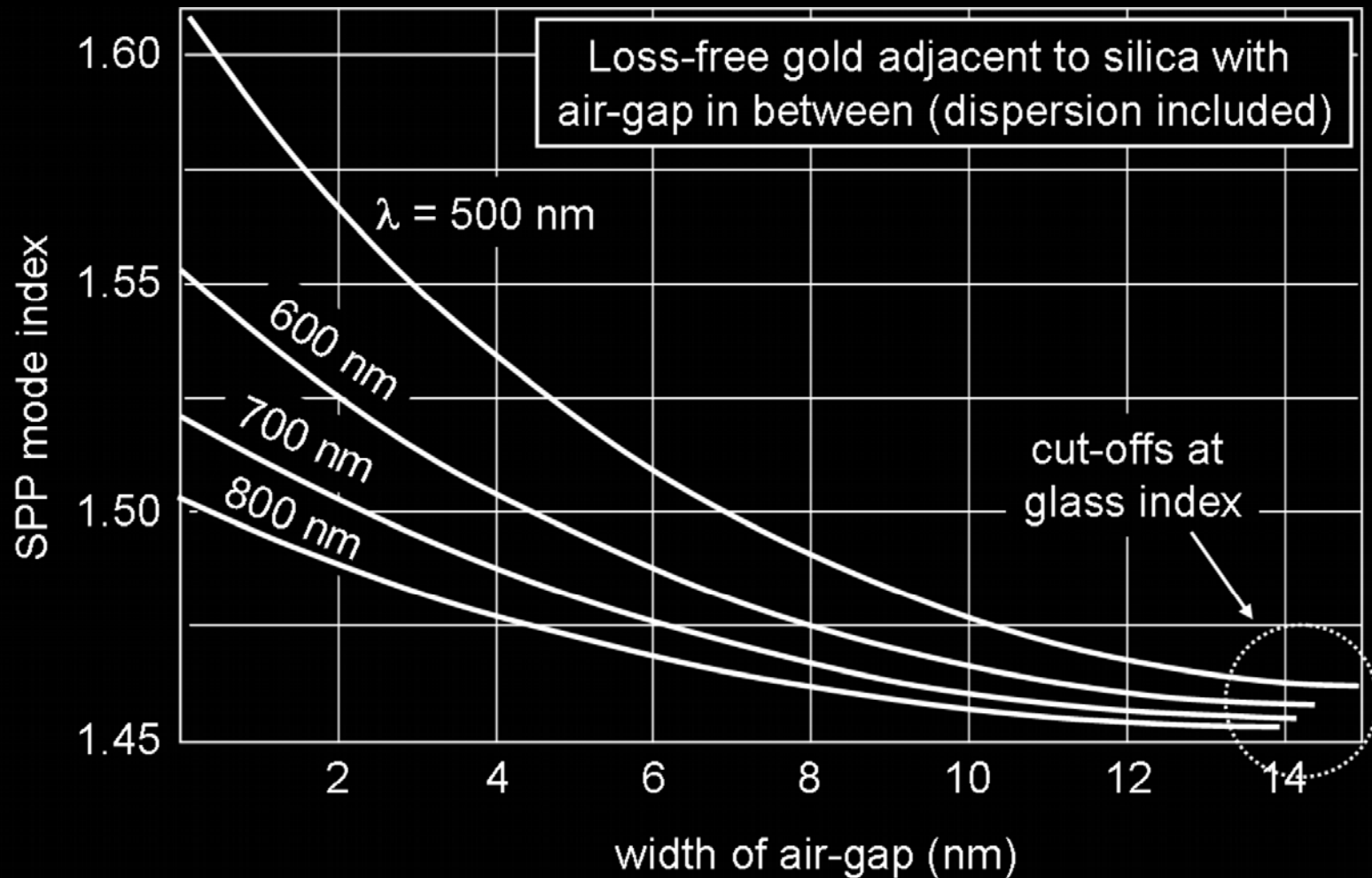
Phys Rev B vol 77  
art 033417, 2008



# Loss spectrum



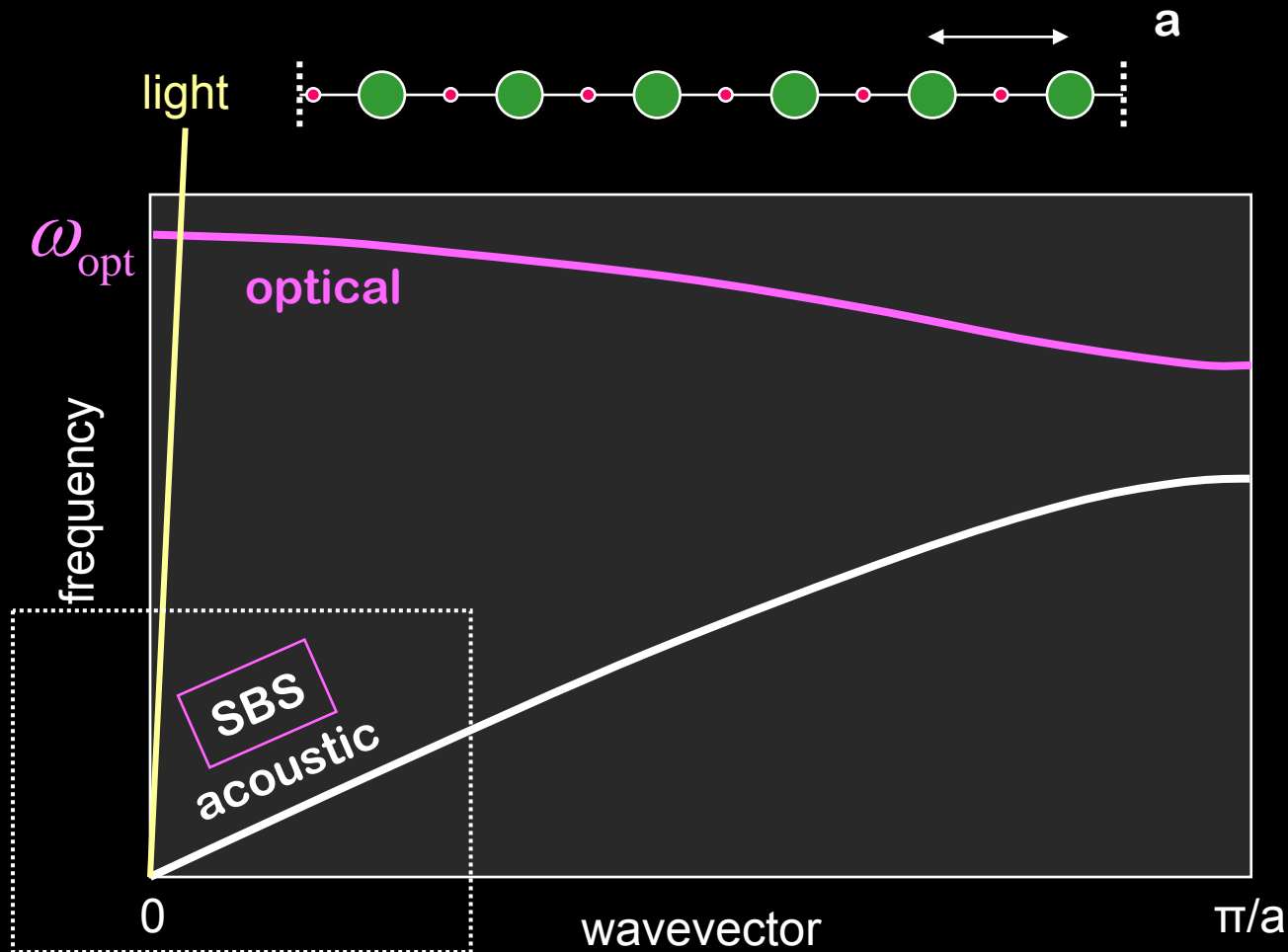
# Effect of air gap





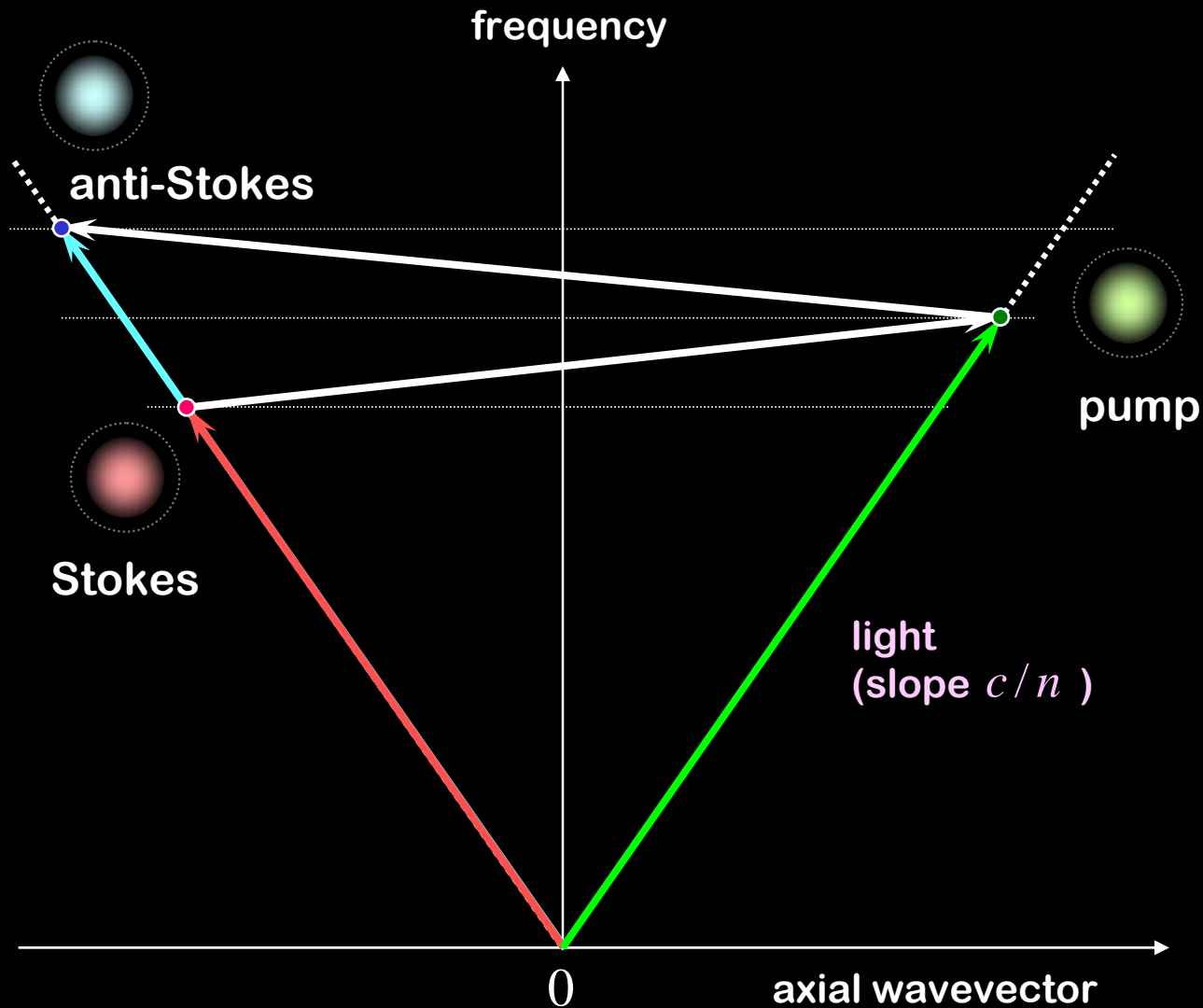
# Sound-Light Interactions

# Phonon dispersion



# Brillouin scattering

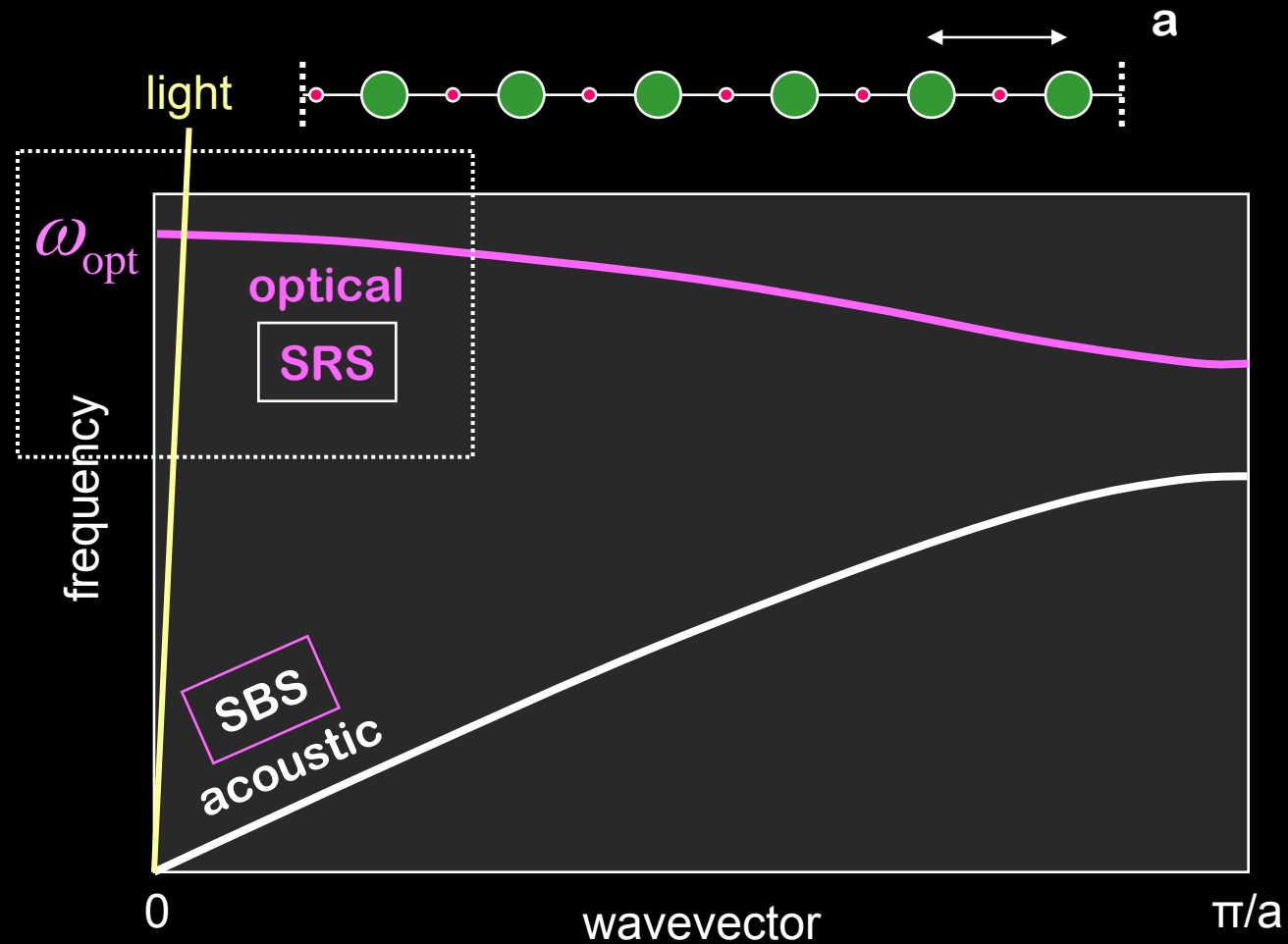
Dainese et al., Opt. Exp. 14, 4141, 2006



very large  
phonon  
momentum  
needed

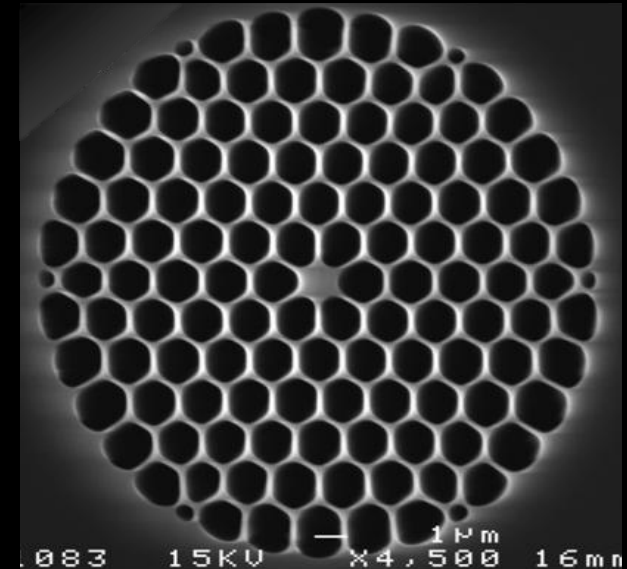
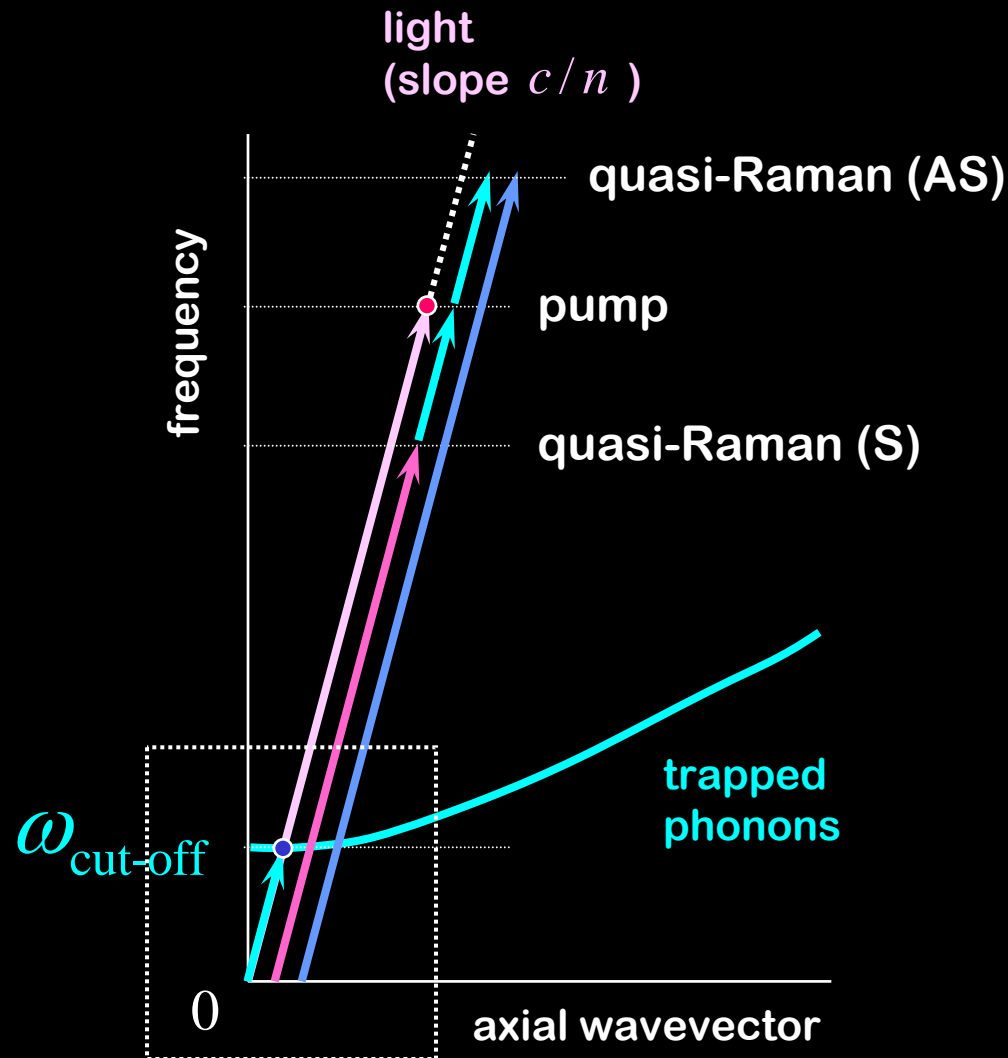
frequency  
shift changes  
with pump  
frequency

# Phonon dispersion



# Sound trapped in 1100 nm core

Dainese et al., Opt. Exp. 14, 4141, 2006



frequency shift  
independent of pump  
frequency

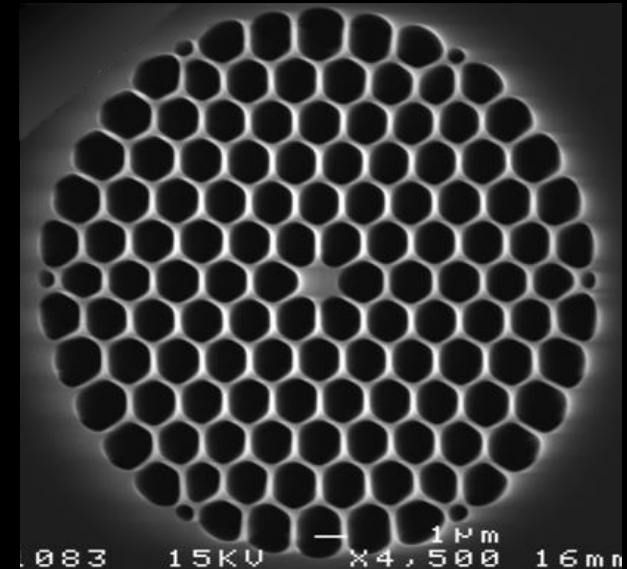
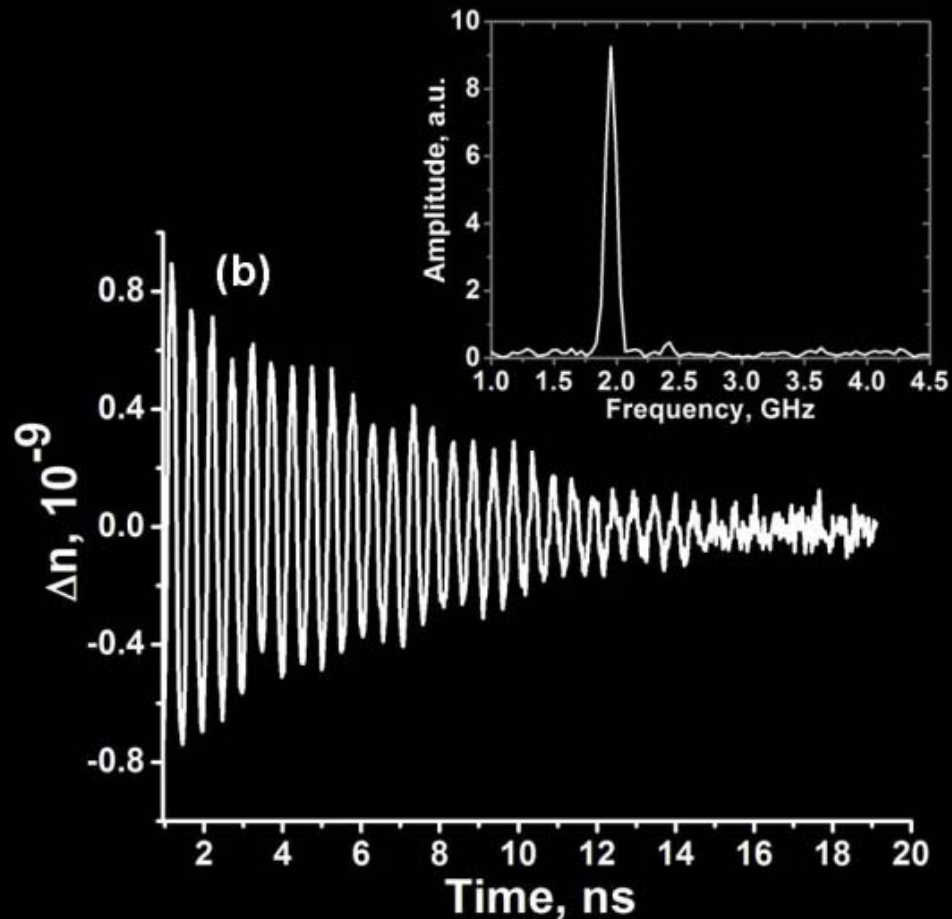
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# Photoacoustic measurements

Dainese et al., Opt. Exp. 14, 4141, 2006

100 ps pulses launched with CW probe at a different wavelength

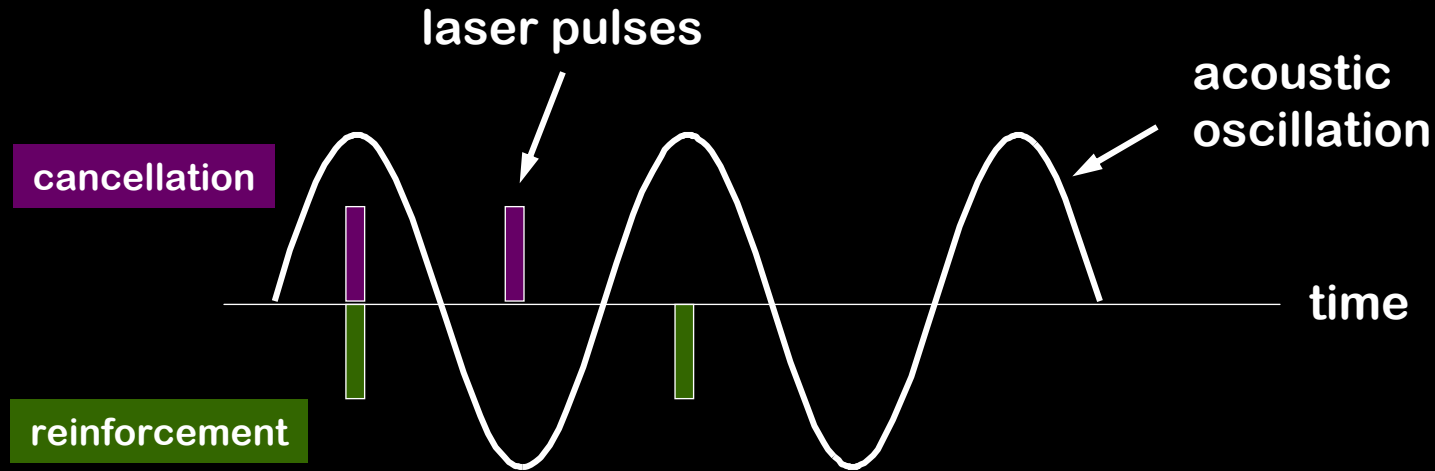


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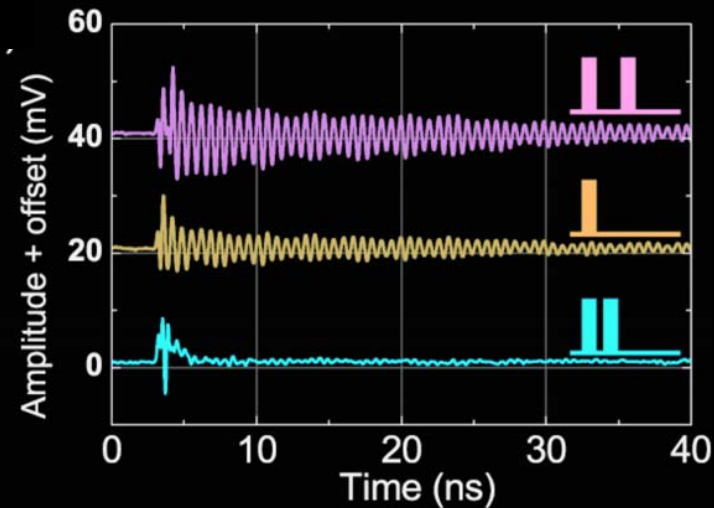
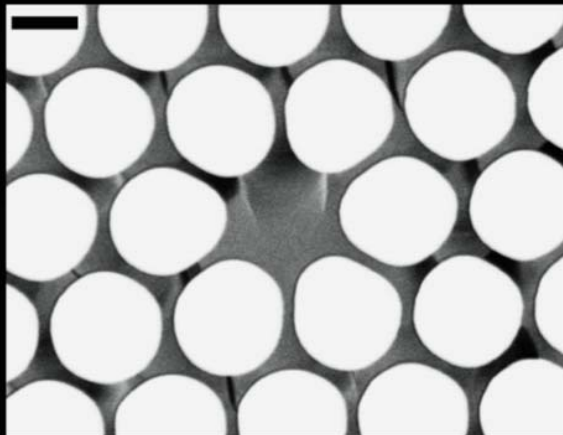
Institute for Optics  
Information and Photonics  
University of Erlangen-Nuremberg

# Coherent control of phonon resonances

Wiederhecker, PRL 100, 203903 (2008)



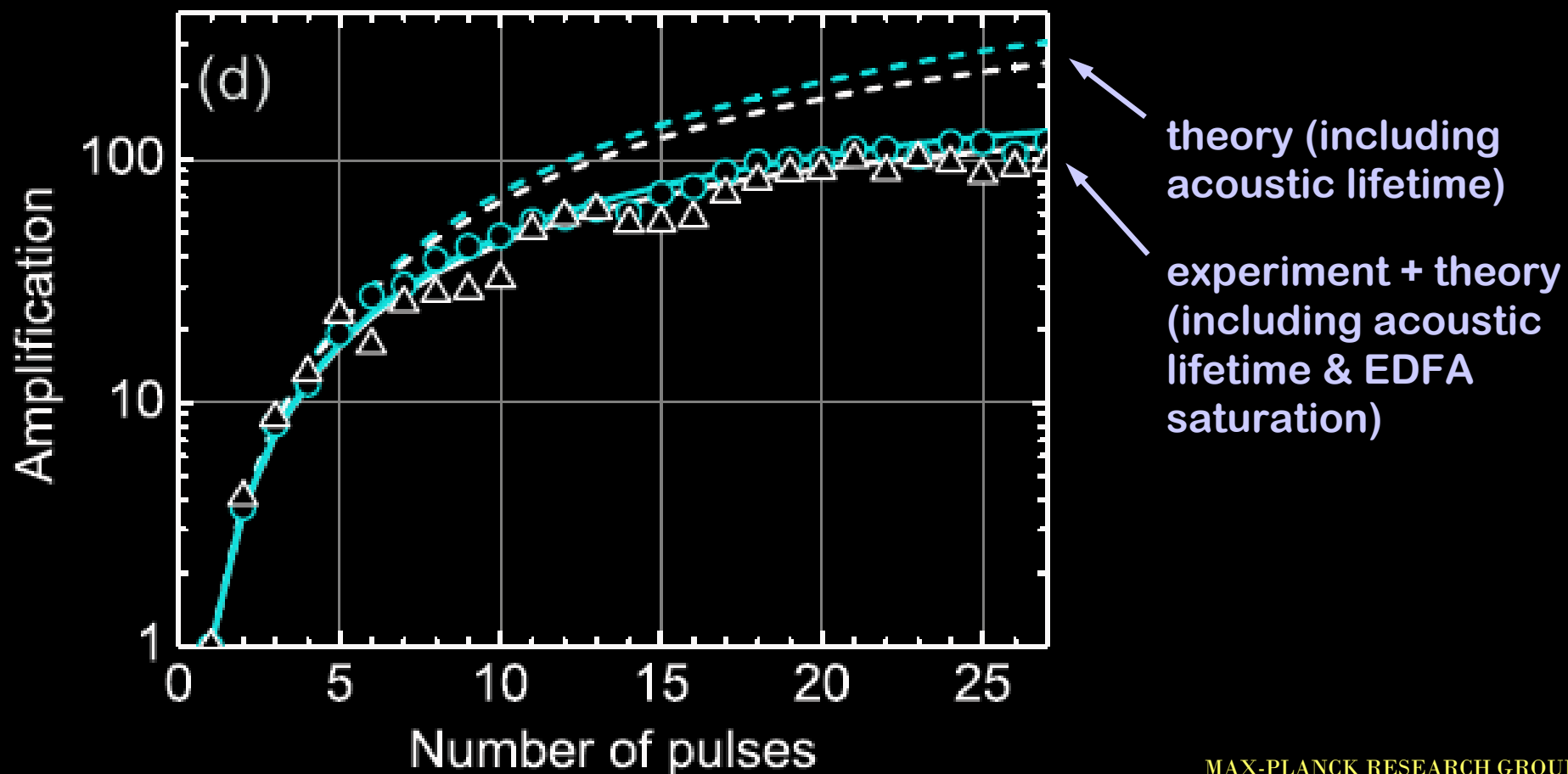
1  $\mu\text{m}$



# Growth with number of pulses

PRL 100, 203903 (2008)

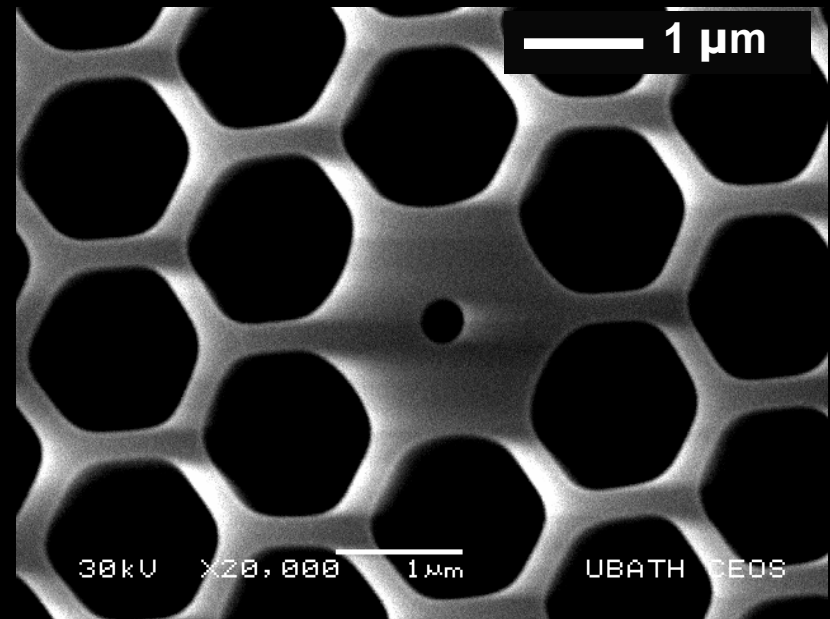
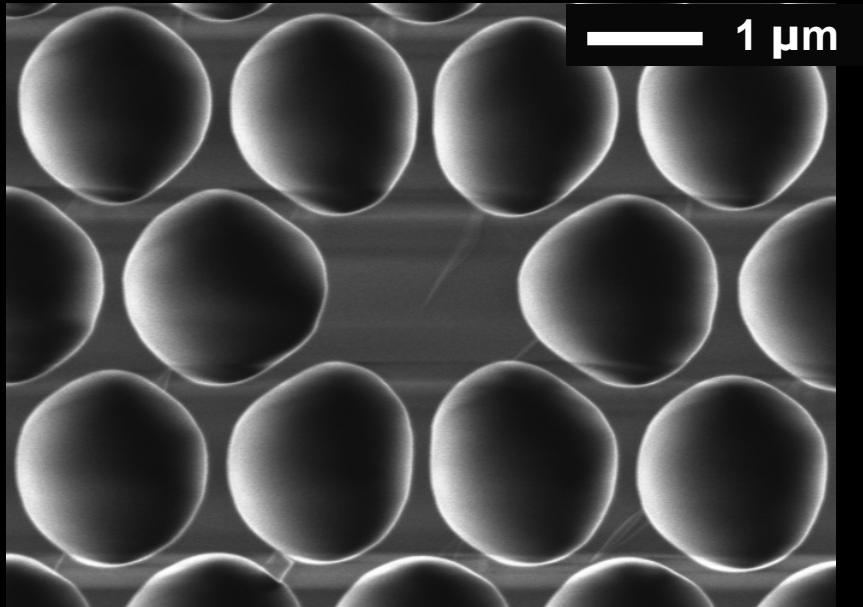
two different PCFs



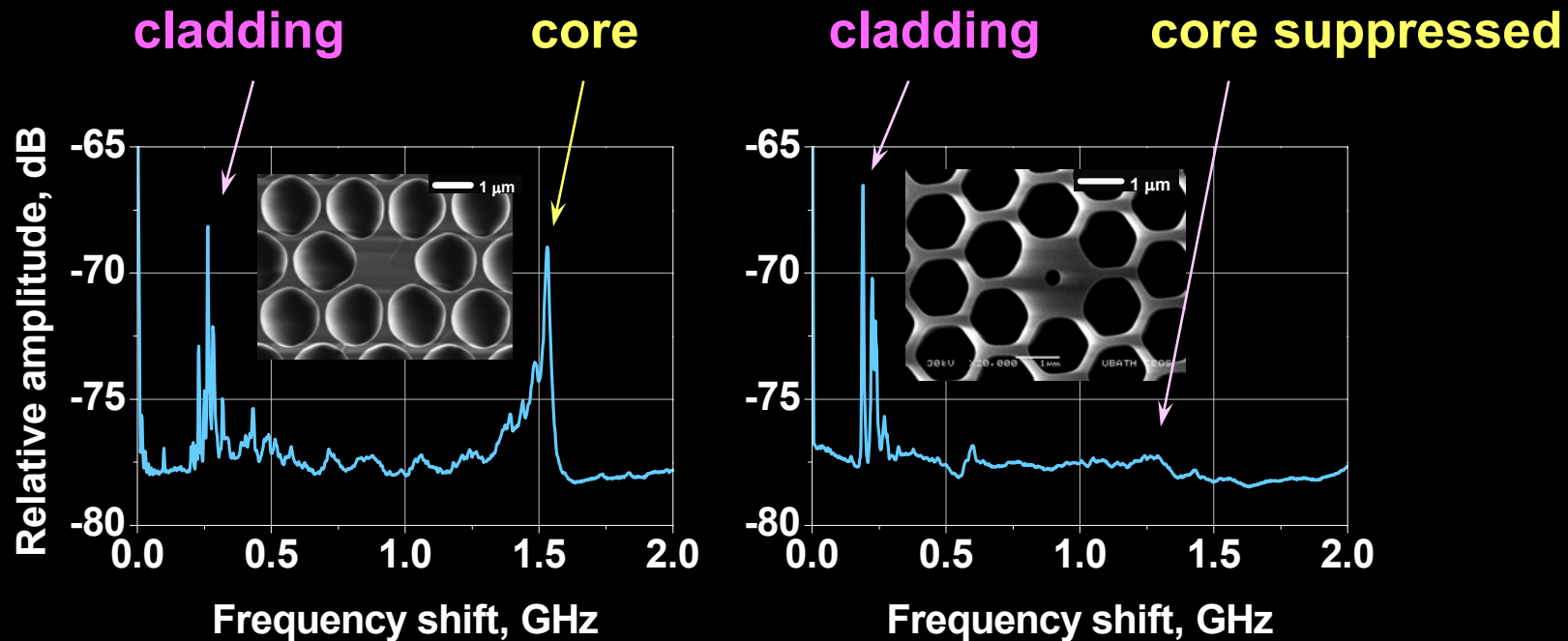


# Effect of small hole in core

acoustic phonon control

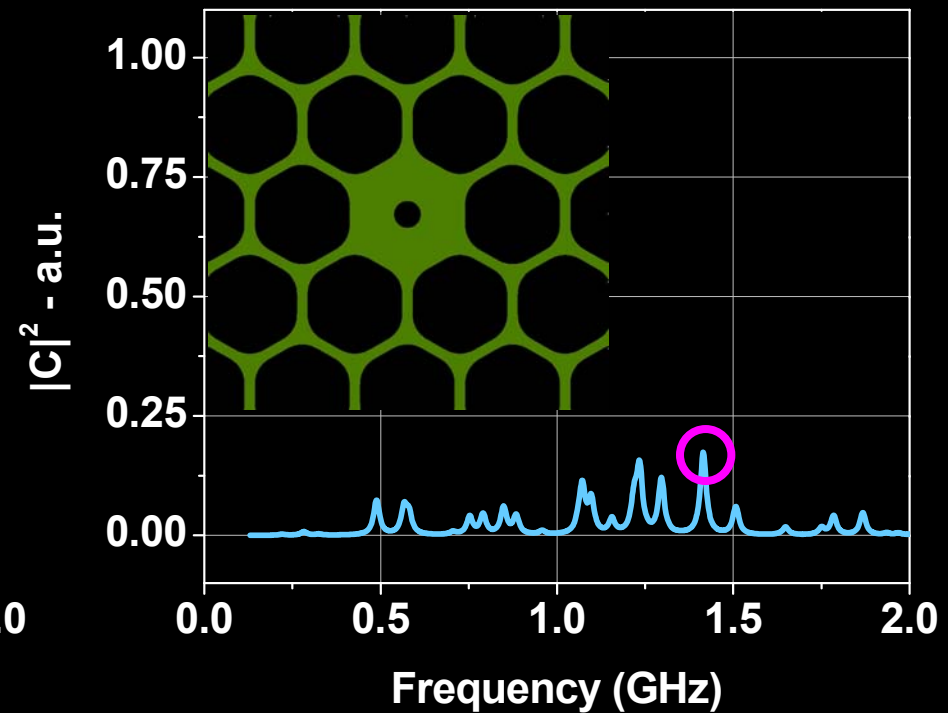
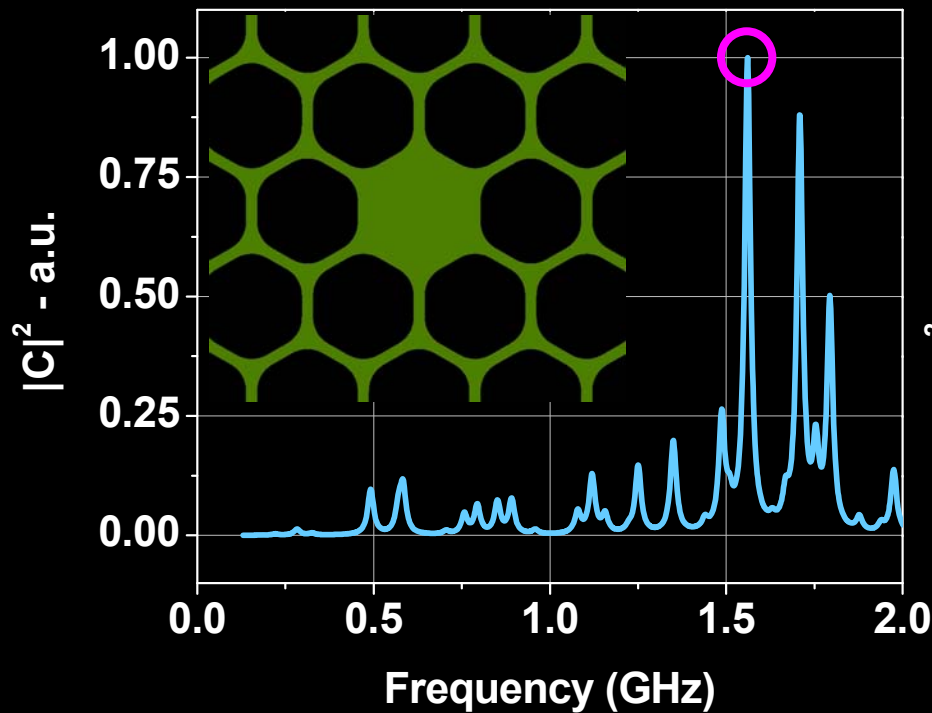


# Spontaneous scattering



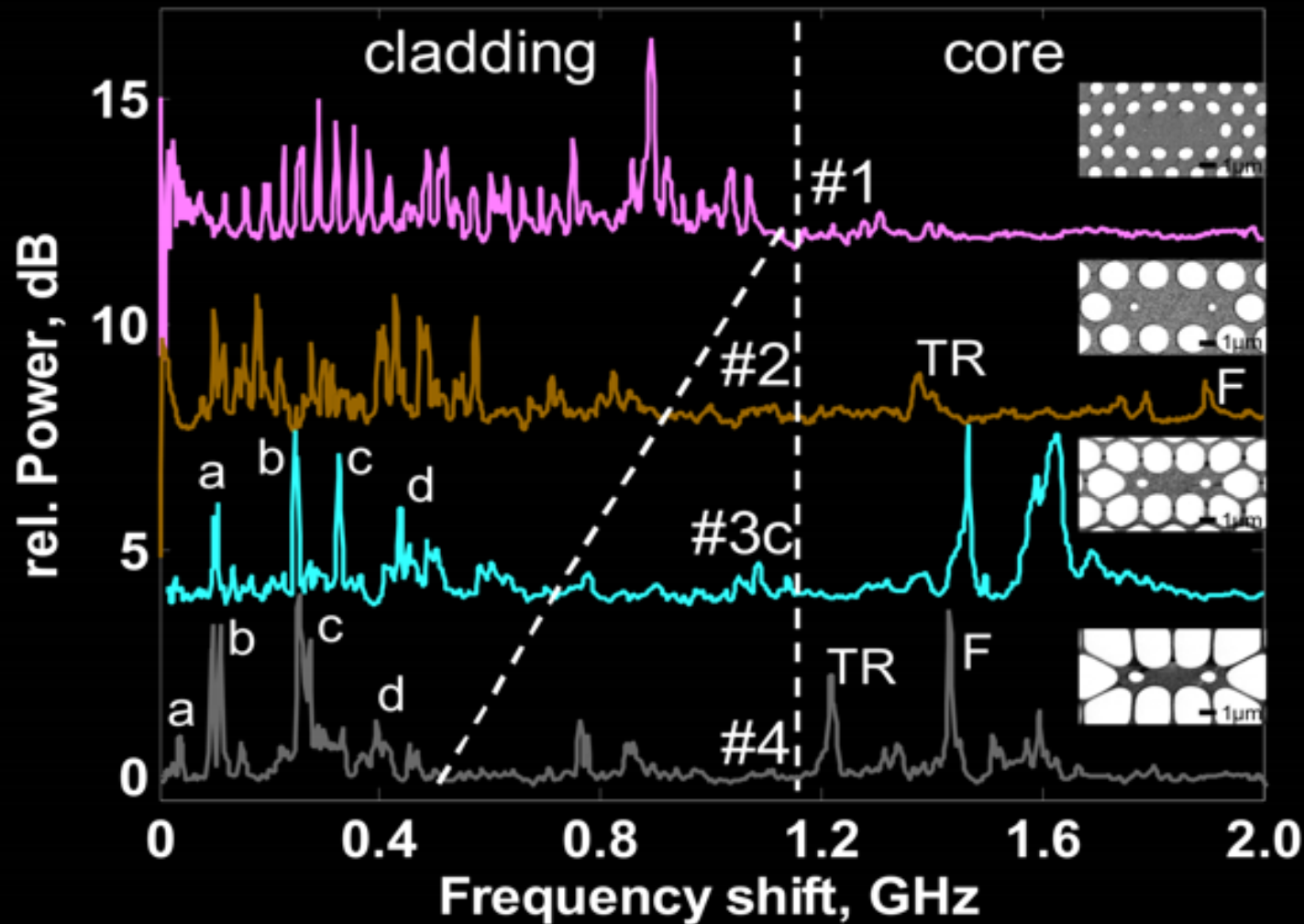
# PCF modes

- **Finite element simulations of sound-light interaction**
- **Main scattering peaks are due to TR-like modes**



# Scattering spectra for different PCFs

Brenn, CLEO-Europe 2007



# Acoustics on the nano-scale

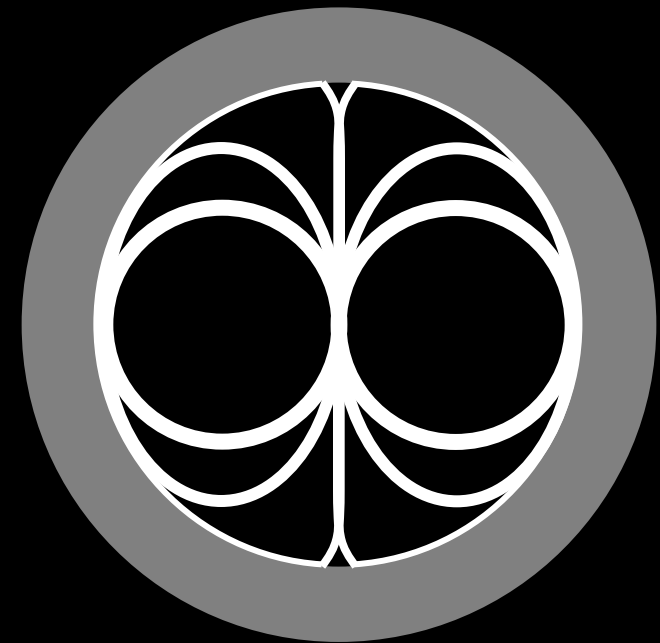
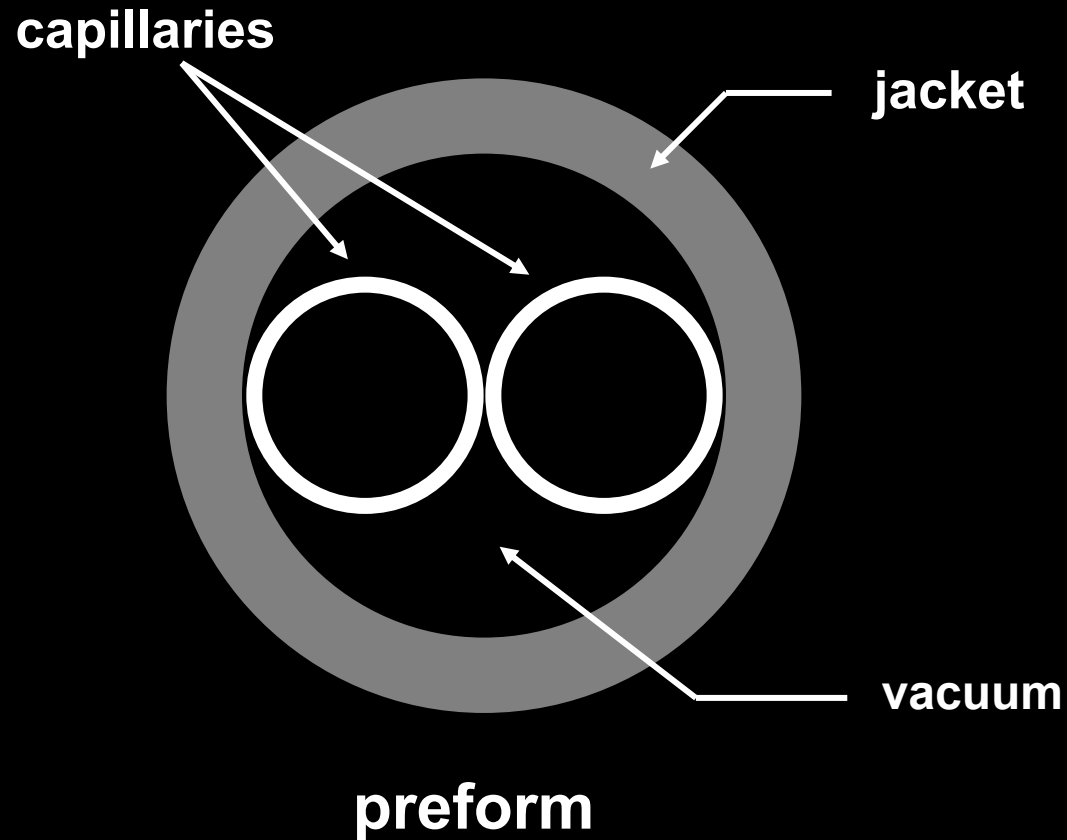
## Opportunities:

- **Coherent control of acoustic resonances**
- **Stimulated Raman-like scattering**
- **Artificial Raman-active molecules**
- **Enhanced acoustooptic effects**

# Glass Nanowebs

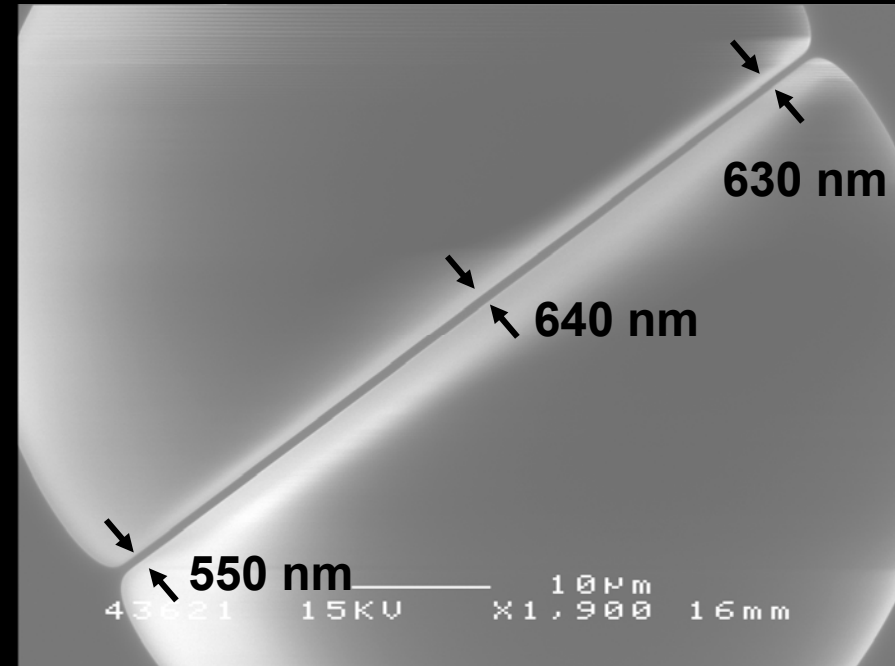
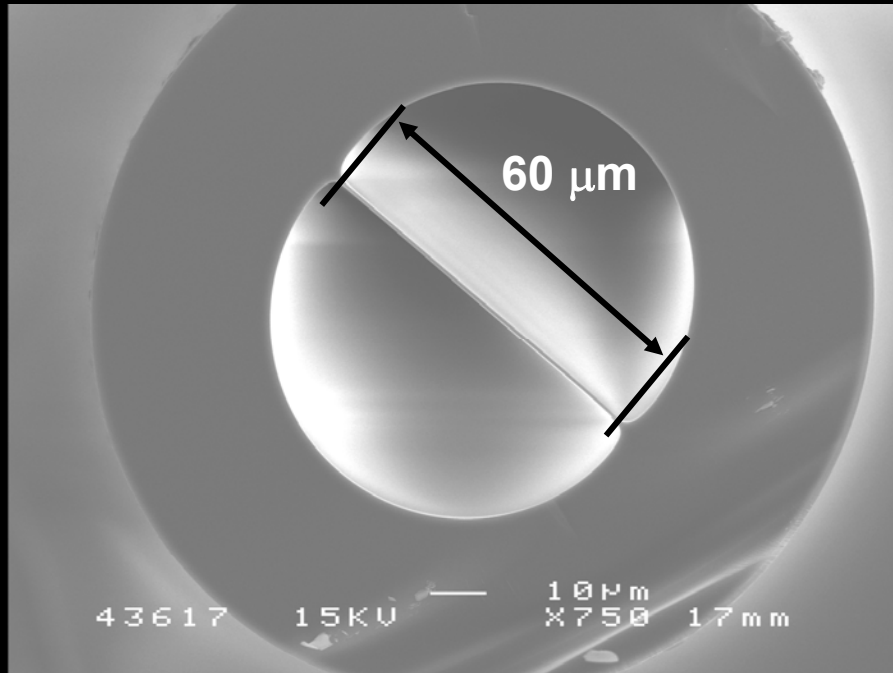
# Fabrication

Joly et al: Opt. Lett. v30 p2469 (2005)



# Linear properties

Joly et al: Opt. Lett. v30 p2469 (2005)

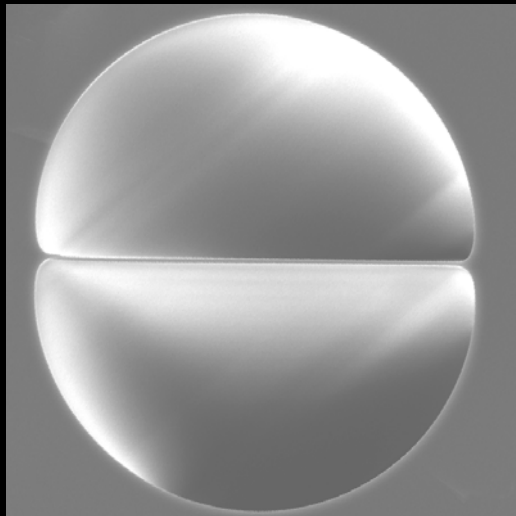
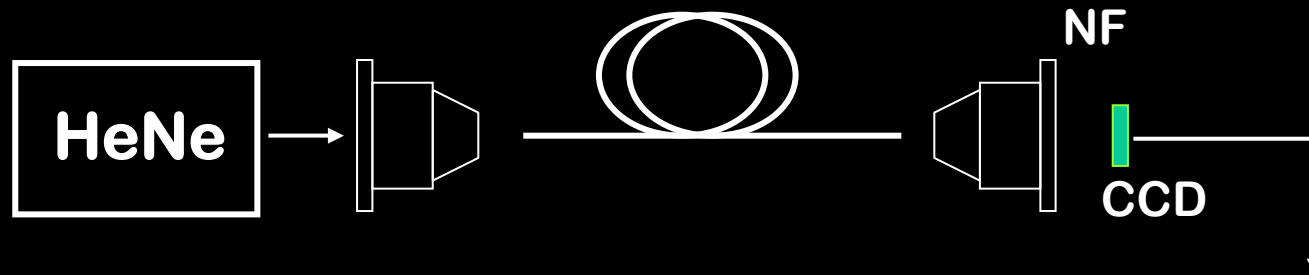


**aspect ratio 100:1**



# Linear properties

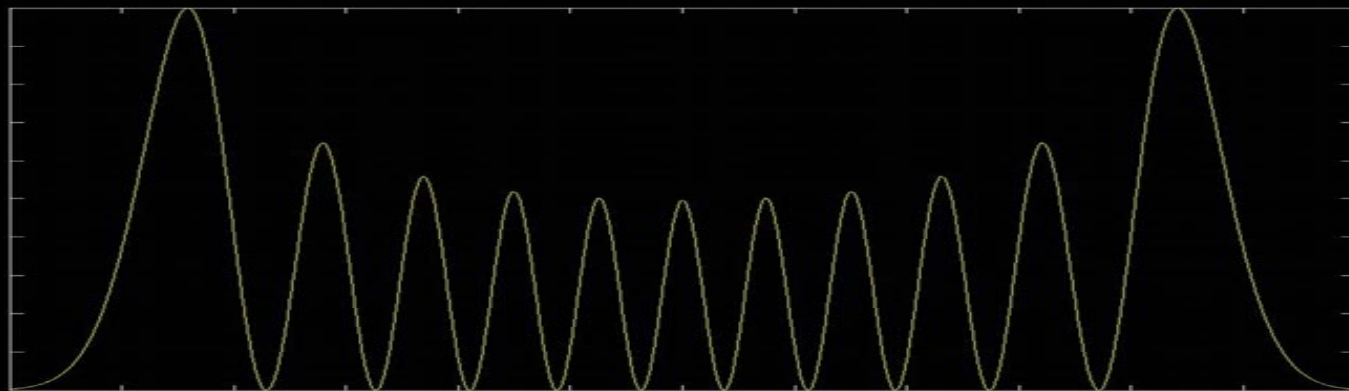
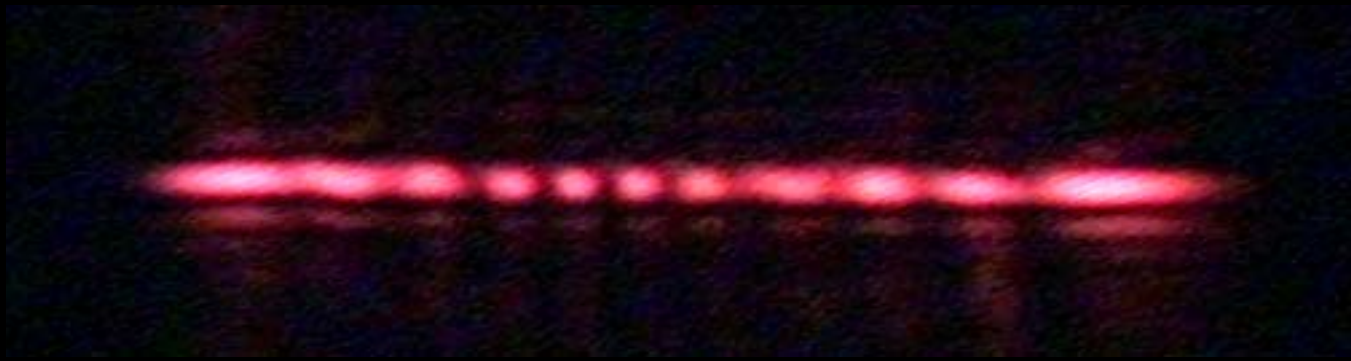
Joly et al: Opt. Lett. v30 p2469 (2005)

 $m = 0$  $m = 2$ higher  
order

# Highest order excited mode

Joly et al: Opt. Lett. v30 p2469 (2005)

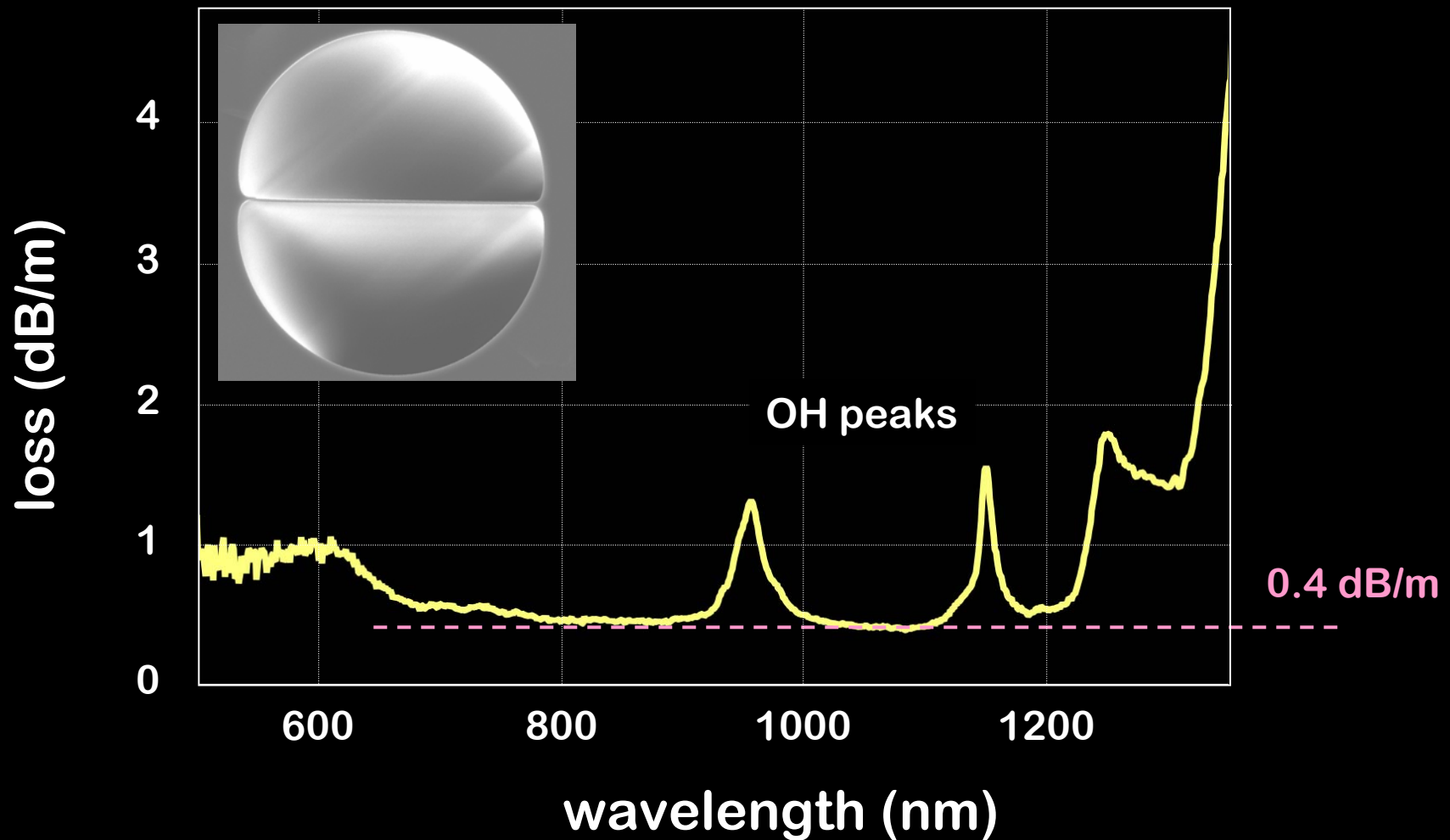
$m = 10$



**Hermite-Gaussian distribution**

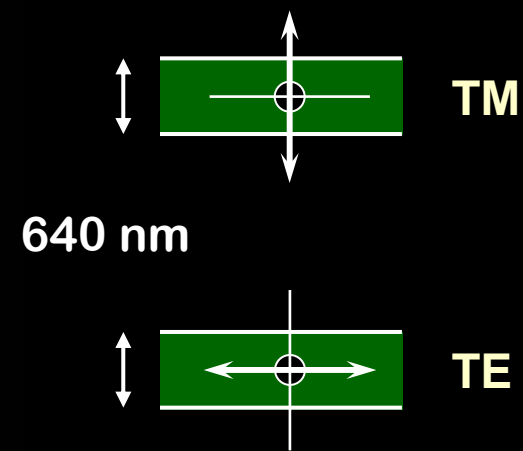
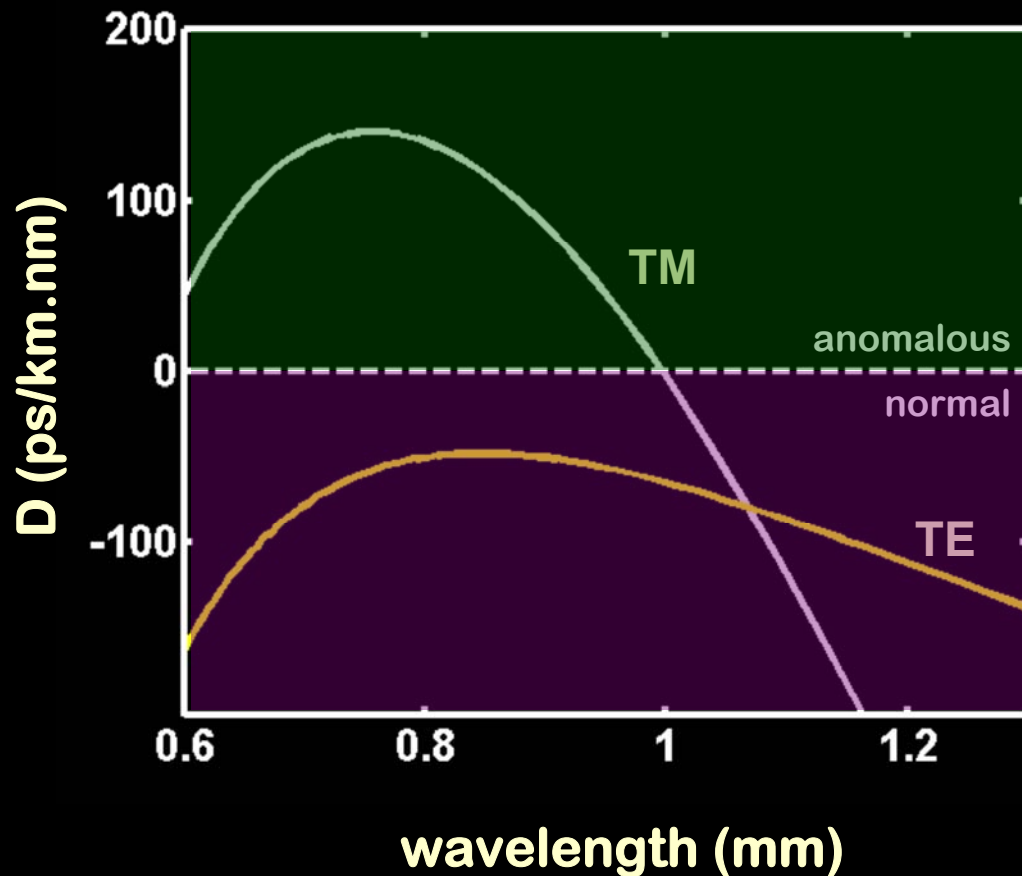
# Waveguide loss

Joly et al: Opt. Lett. v30 p2469 (2005)



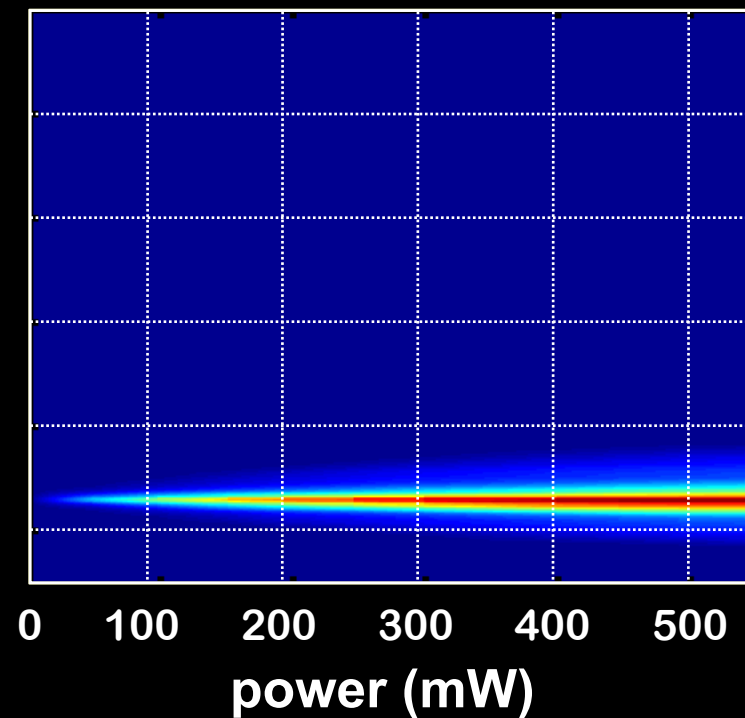
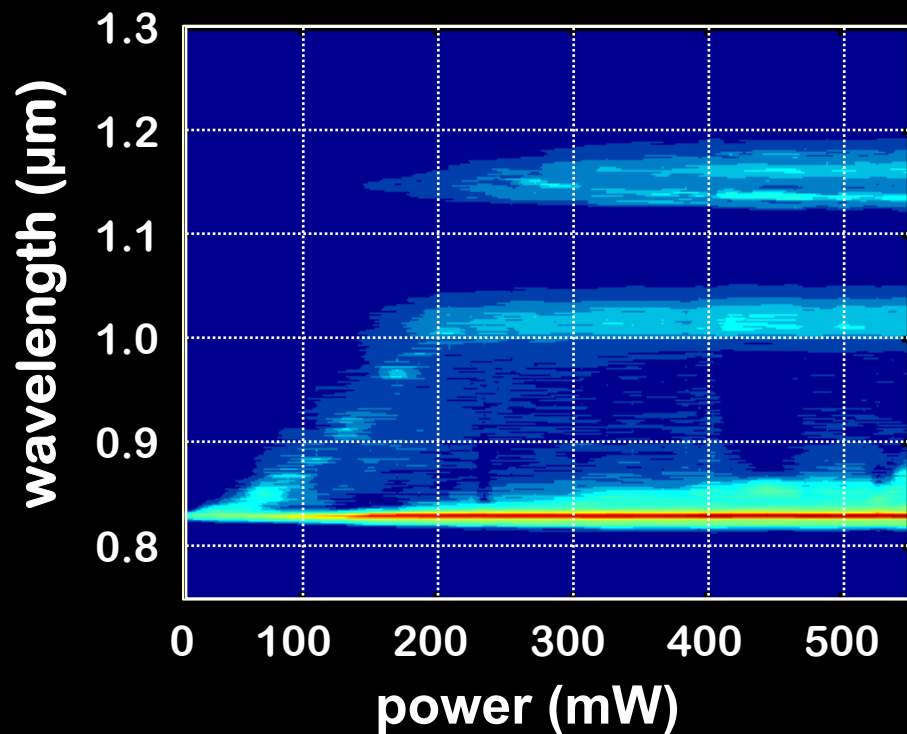
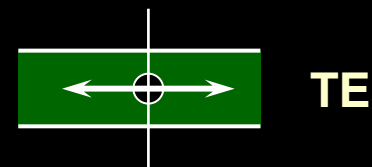
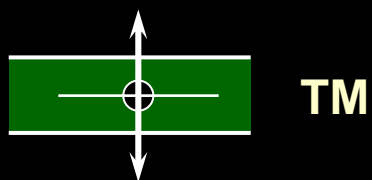
# Group velocity dispersion

Joly et al: Opt. Lett. v30 p2469 (2005)



# Excitation with 110 fs pulses

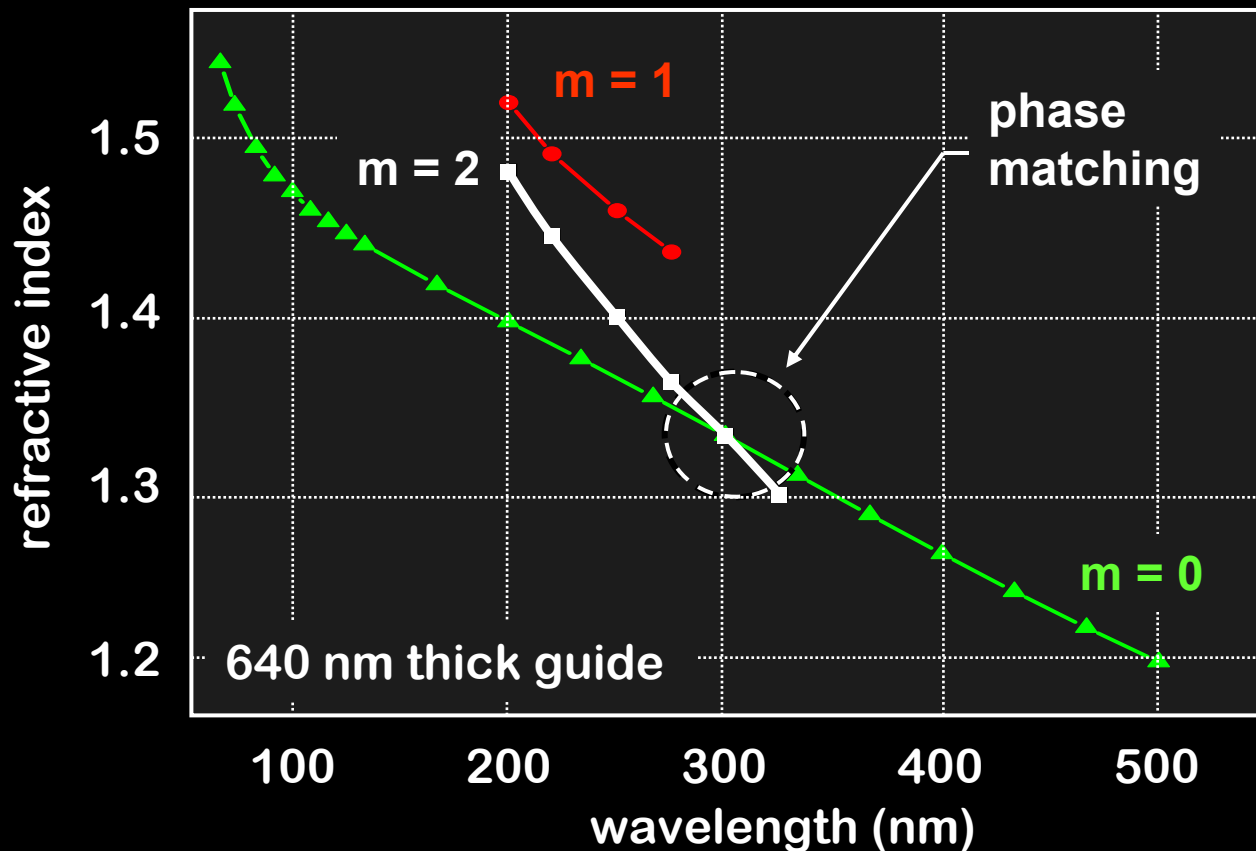
Joly et al: Opt. Lett. v30 p2469 (2005)



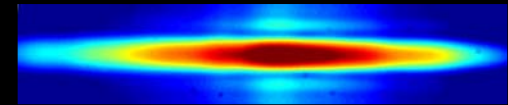
# UV-generation via third harmonic

Joly et al: Opt. Lett. v30 p2469 (2005)

$$3\beta_{\omega} = \beta_{3\omega} \Rightarrow n_{\omega} = n_{3\omega}$$



924 nm



$m = 0$  (near-field)

308 nm



$m = 2$  (far-field)