cQOM

Detailed program for ITN Workshop in Diavolezza, 01-05. February 2015

Wednesday 04.02.2015

Time	Speaker's name	Title
8:00	Breakfast	
8:30-9:00	Raphael Van Laer (UGent)	Brillouin scattering and optomechanics in silicon photonic wires
9:10-10:00	Dries Van Thourhout, Paul Tiebot, Jesper Hakansson (UGent)	New integrated platforms for optomechanics
10:00-10:30	Coffee break	
10:30-10:50	Paul Seidler (IBM)	Nanophotonics at IBM Research
11:00-11:30	Katharina Schneider (IBM)	Optomechanics with a slotted photonic crystal nanobeam cavity
11:40-12:00	Elad Koren (IBM)	
12:10-12:30	Amir Ghadimi (EPFL)	Localizing the vibrational mode of a nanomechanical beam
12:30	Lunch	
	Free time	
18:30	Dinner	
19:45-20:30	Florian Marquardt (FAU)	Topological phases in optomechanics
20:45-21:15	Stefan Walter (FAU)	Synchronization in the quantum regime
21:20-22:50	Talitha Weiss (FAU)	Quantum synchronization of two optomechanical systems
22:00-22:30	Xuefeng Song (Aalto)	Graphene optomechanics at microwave frequencies

Brillouin scattering and optomechanics in silicon photonic nanowires

Raphaël Van Laer, Bart Kuyken,
Roel Baets and Dries Van Thourhout

04/02/2015

UNIVERSITEIT GENT

imec

PHOTONICS RESEARCH GROUP

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Overview

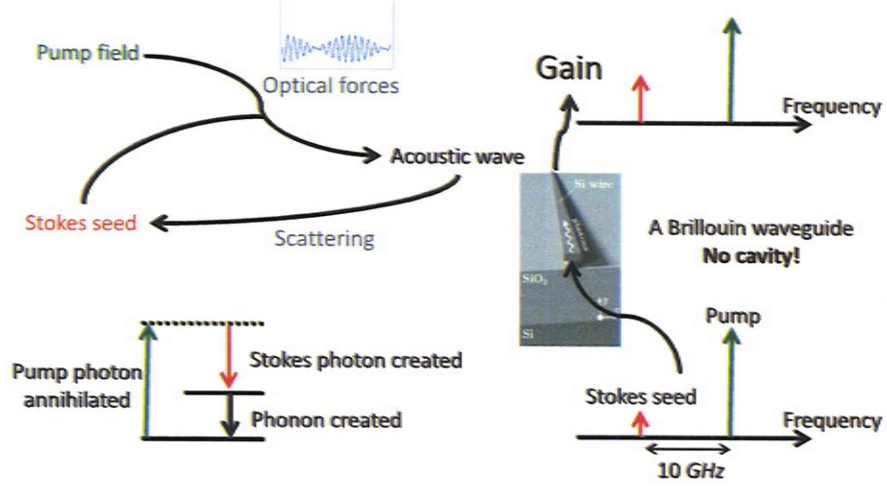
Brillouin scattering in silicon nanowires
Recent experimental demonstration

Brillouin scattering vs. cavity optomechanics
Transition from Brillouin waveguide to dispersive optomechanical cavity

Prospects
From silicon photonics to silicon phononics

Light and sound couple in a feedback loop

"Stimulated Brillouin scattering (SBS)"

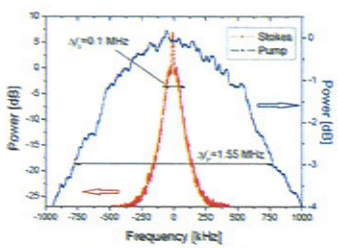


Sound is the gateway to a slow timescale

Tunable delay

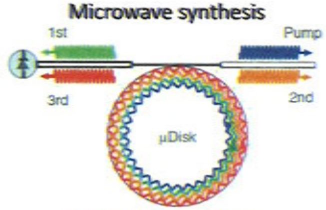
Boyd, Science (2008)

Spectral purification



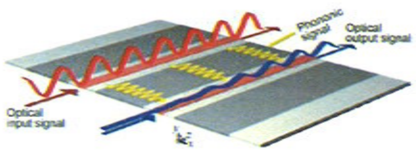
Eggleton, Opt. Lett. (2013)

Microwave synthesis



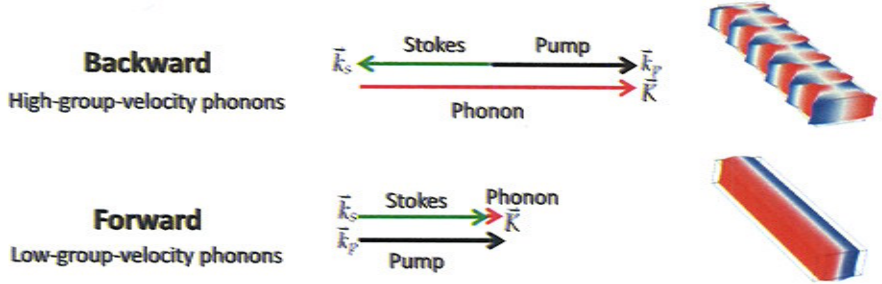
Vahala, Nat. Commun. (2013)

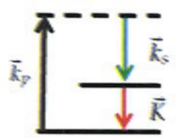
RF filters



Rakich, arXiv (2014)

Distinguish between localized and propagating acoustic phonons

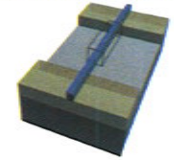


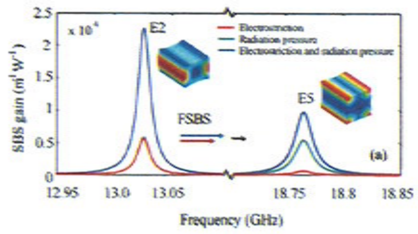


Forward scattering is dominant in silicon wires, unlike in conventional silica fibers

Brillouin scattering was unexplored territory in silicon nanowires

Suspended silicon nanowire





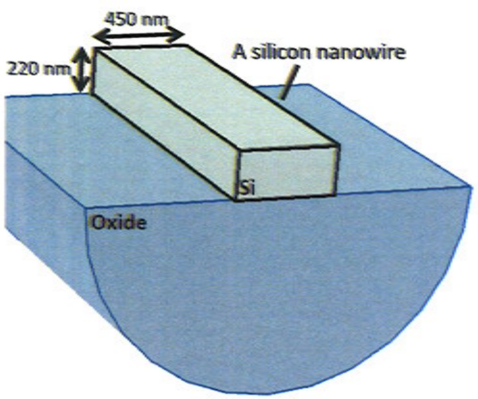
Rakich, Phys. Rev. X (2012)

Strong nonlinearity
Predicted gain up to 10 dB/(mW cm)

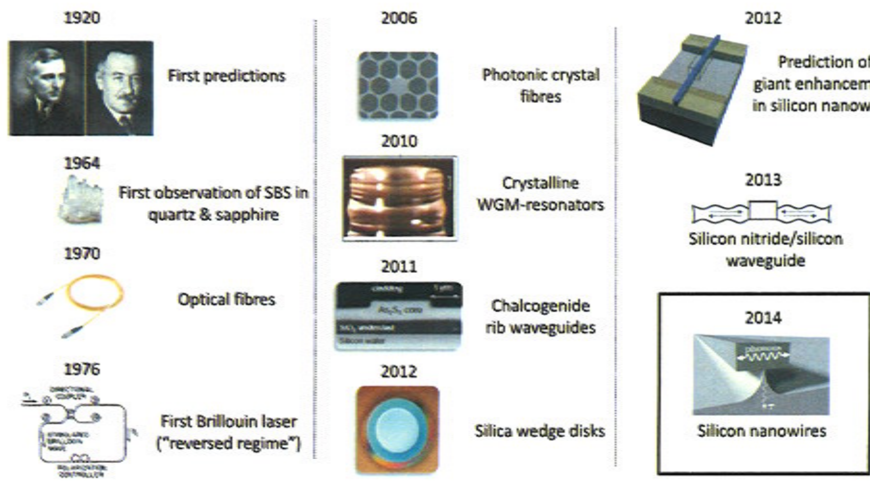
Reasonably fast response
In the microwave domain

Tailorable properties
Phononic resonance depends heavily on waveguide geometry

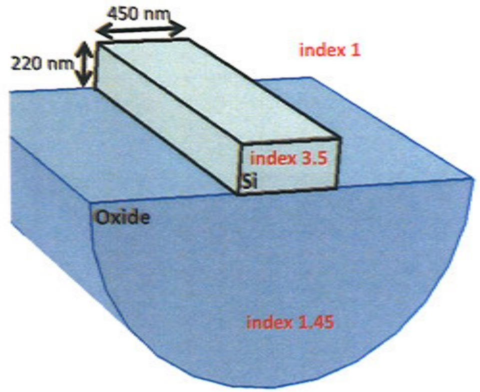
Confining not only light, but also sound



The historical development of SBS

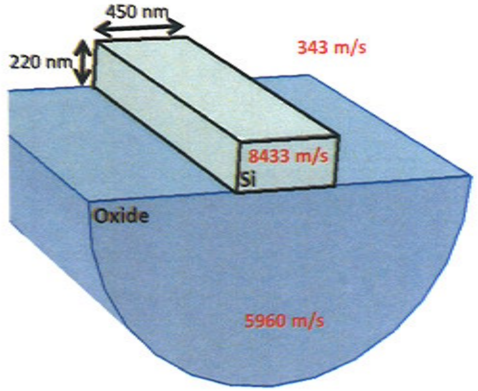


Confining not only light, but also sound



Light confined by TIR
Total Internal Reflection because light moves faster in all surrounding materials

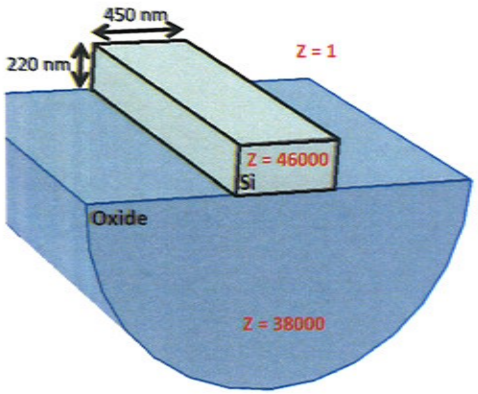
Confining not only light, but also sound



Light confined by TIR
Total Internal Reflection because light moves faster in all surrounding materials

Sound not confined
No TIR because sound moves slower in all surrounding materials

Confining not only light, but also sound

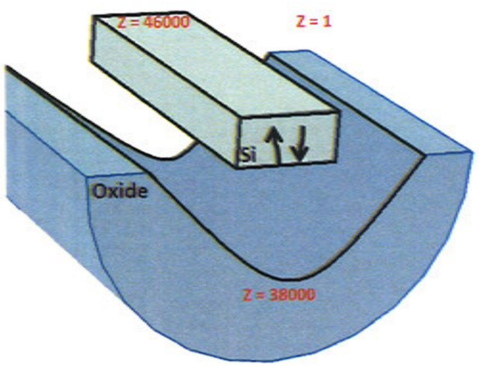


Light confined by TIR
Total Internal Reflection because light moves faster in all surrounding materials

Sound not confined
No TIR because sound moves slower in all surrounding materials

Confine sound by impedance mismatch
Z = mass density x speed

Confining not only light, but also sound



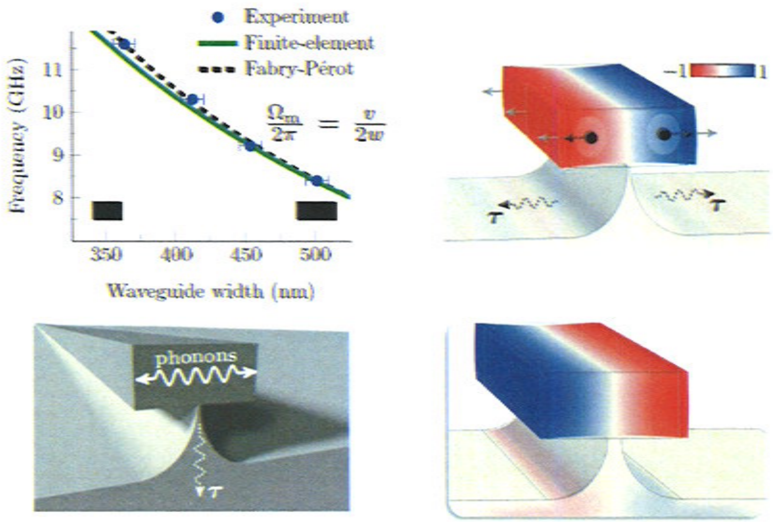
Light confined by TIR
Total Internal Reflection because light moves faster in all surrounding materials

Sound not confined
No TIR because sound moves slower in all surrounding materials

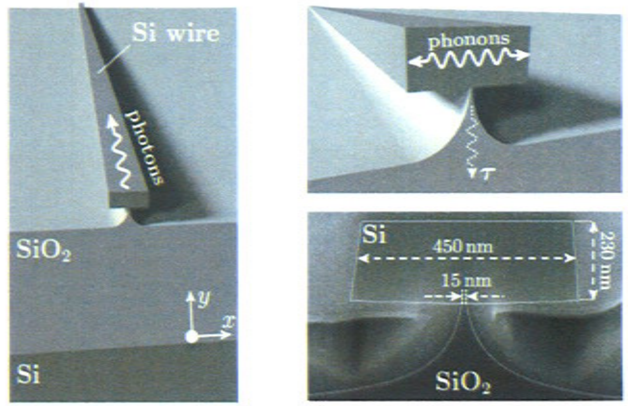
Remove the silicon dioxide

How to make it long?

The wire is a Fabry-Pérot cavity for sound

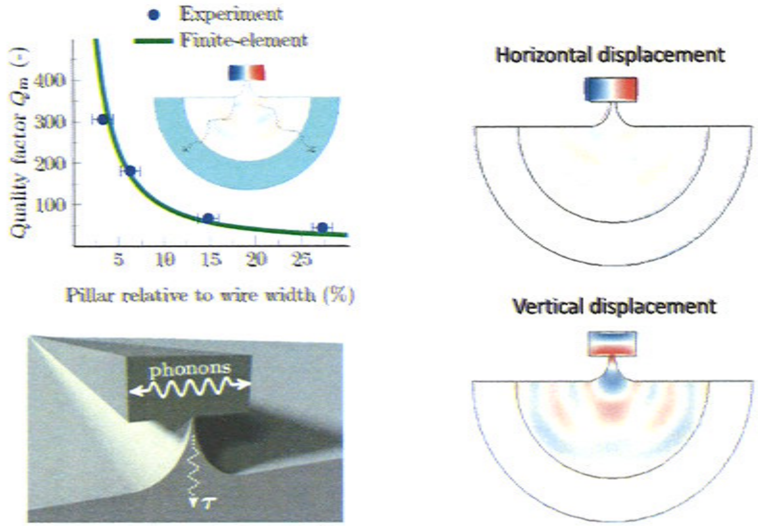


Also make it long: put the **wire on a pillar**

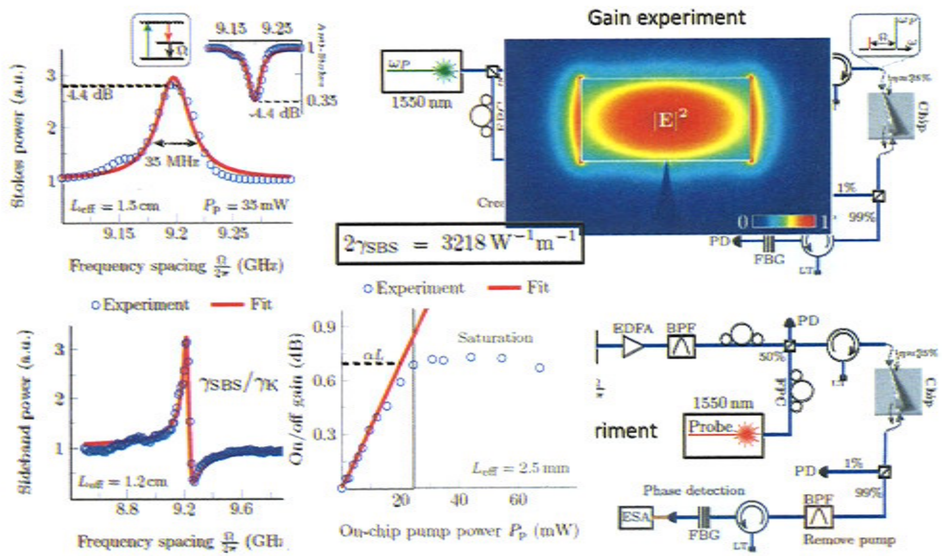


Middle road between minimal phonon leakage and a centimeter-scale interaction length

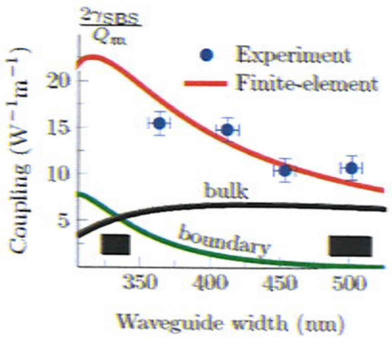
The phonons leak through the pillar

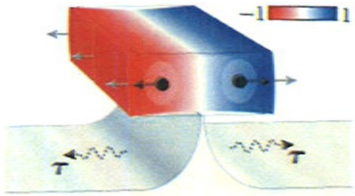


First demonstration of SBS in nanowire



Both electrostriction and radiation pressure drive the acoustic wave





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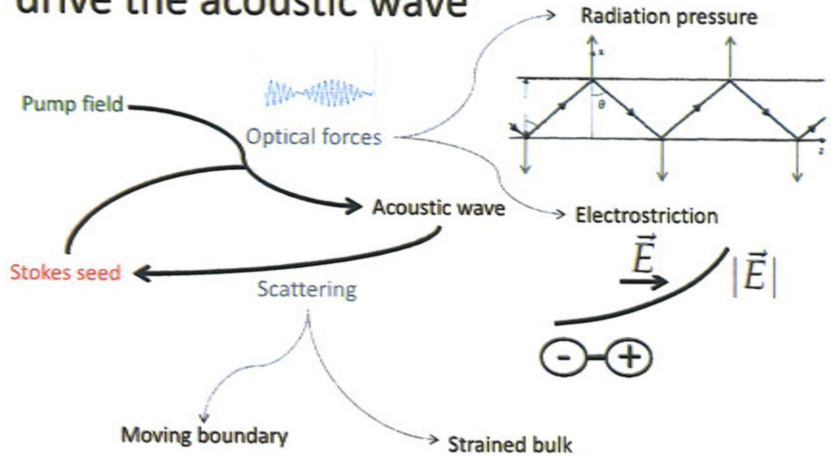
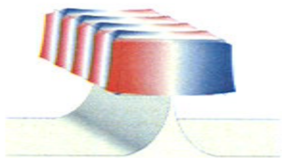


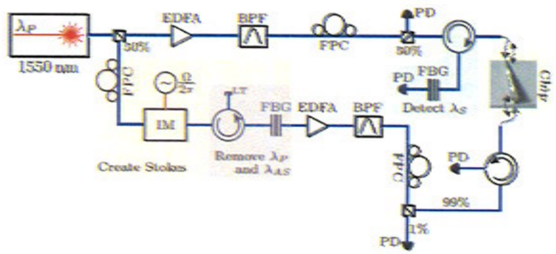
We also observed backward SBS



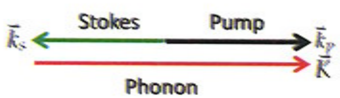
$359\,W^{-1}m^{-1}$

$\frac{2\gamma_{SBS}}{Q_m} = 0.37\,W^{-1}m^{-1}$

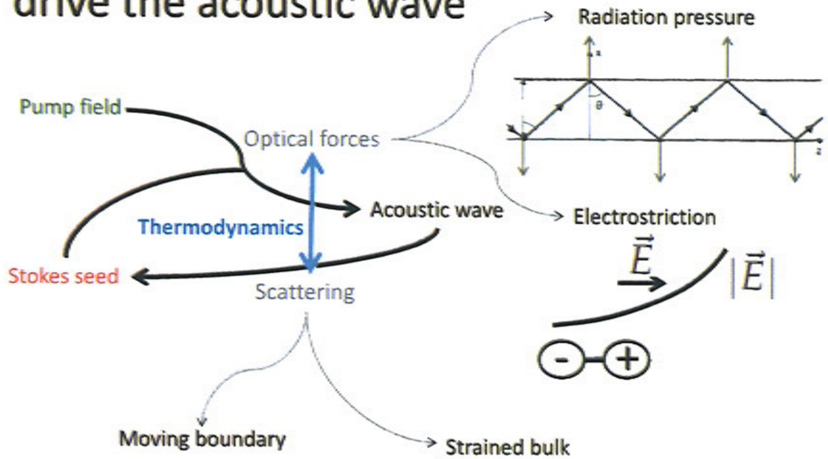
$Q_m = 971$



Much less efficient than forward SBS



Both electrostriction and radiation pressure drive the acoustic wave



Photon-phonon coupling huge in silicon wires

Efficiency ($m^{-1}W^{-1}$)	Coupling ($m^{-1}W^{-1}$)	Loss (dB/cm)	Gain (dB/cm)	Gain (dB/mW)
0.8 @ 10.8 GHz $\xrightarrow{\times 1000/Q}$	1.5 Q = 540	2×10^{-6}	3.5×10^{-2} @ 1 W	3 @ 1 km
1.5 @ 1.8 GHz	12.3 Q = 122	7×10^{-4}	3.2×10^{-2} @ 500 mW	0.3 @ 50 m
304 @ 7.7 GHz	1344 Q = 226	0.2	3.9 @ 300 mW	0.05 @ 5 mm
2328 @ 1.3 GHz	1327 Q = 1750	7	0.8 @ 20 mW	0.02 @ 5 mm
3136 @ 9.2 GHz	10344 Q = 300	2.6	2.3 @ 20 mW	0.1 @ 4 cm

Photon-phonon coupling huge in silicon wires

Efficiency ($m^{-1}W^{-1}$)	Coupling ($m^{-1}W^{-1}$)
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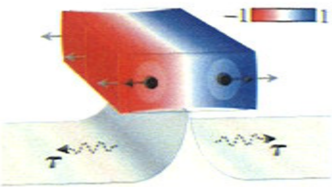
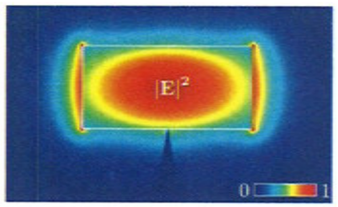
3136 @ 9.2 GHz	10344 Q = 300

There is room for improvement by orders of magnitude



Decrease optical losses

Currently 2.6 dB/cm, lowest 0.7 dB/cm



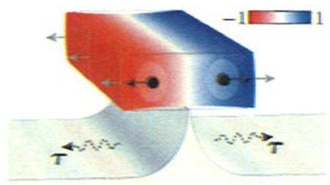
Increase efficiency

Better phononic Q or light-sound overlap

Van Laer et al. *"Interaction between light and highly confined hypersound in a silicon photonic nanowire"* Nature Photon. (to be published)

Photon-phonon coupling huge in silicon wires

Gain (dB)	Loss (dB/cm)	Gain (dB/cm)	Gain (dB/mW)
3000	2×10^{-6}	3.5×10^{-2} @ 1 W	3 @ 1 km
500	7×10^{-4}	3.2×10^{-2} @ 500 mW	0.3 @ 50 m
16	0.2	3.9 @ 300 mW	0.05 @ 5 mm
0.4	7	0.8 @ 20 mW	0.02 @ 5 mm
4.4	2.6	2.3 @ 20 mW	0.1 @ 4 cm



Brillouin scattering
(+Raman scattering)

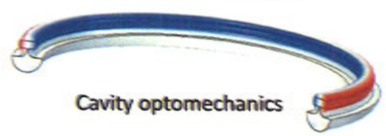
$$\frac{1}{v_s}\frac{\partial a_s}{\partial t} \pm \frac{\partial a_s}{\partial z} = -i\kappa^{mo} a_p b^* - \frac{\alpha_s}{2} a_s$$
$$\frac{1}{v_p}\frac{\partial a_p}{\partial t} + \frac{\partial a_p}{\partial z} = -i\kappa^{mo} a_s b - \frac{\alpha_p}{2} a_p$$
$$\frac{\partial b}{\partial t} + v_m \frac{\partial b}{\partial z} = -i\kappa^{om} a_p a_s^* - \chi_m^{-1} b$$

Transition

Link

$$g_0^2 = v_s v_p \frac{(\hbar\omega_p)\,\Omega_m}{4L}\left(\frac{\mathcal{G}_{SBS}}{Q_m}\right)$$

$$\dot{a}_s = -\chi_s^{-1} a_s - i\kappa_{mo} a_p b^* + \sqrt{\kappa_{cs}}\, s_s$$
$$\dot{a}_p = -\chi_p^{-1} a_p - i\kappa_{mo} a_s b + \sqrt{\kappa_{cp}}\, s_p$$
$$\dot{b} = -\chi_m^{-1} b - i\kappa_{om} a_p a_s^*$$



Cavity optomechanics

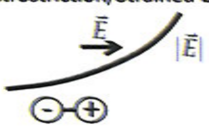
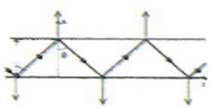
Overview

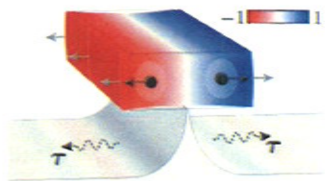
Brillouin scattering in silicon nanowires
Recent experimental demonstration

Brillouin scattering vs. cavity optomechanics
Transition from Brillouin waveguide to dispersive optomechanical cavity

Prospects
From silicon photonics to silicon phononics

Different historical traditions

Brillouin scattering	Cavity optomechanics
High-group-velocity phonons	Low-group-velocity phonons
	
Electrostriction/Strained bulk	Radiation pressure/Moving boundary
	
Optical response modified $\Gamma_m \gg \kappa$	Mechanical response modified $\kappa \gg \Gamma_m$



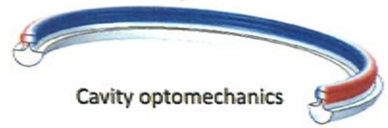
Brillouin scattering

$\mathcal{G}_{SBS}$ (W^{-1}m^{-1})

Link?

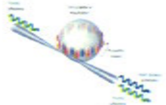
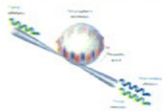
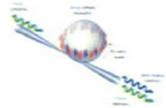
$$g_0^2 = v_s v_p \frac{(\hbar\omega_p)\,\Omega_m}{4L}\left(\frac{\mathcal{G}_{SBS}}{Q_m}\right)$$

g_0 (Hz)



Cavity optomechanics

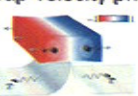
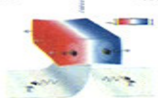
Silica microspheres

Brillouin scattering	Cavity optomechanics
High-group-velocity phonons 	Low-group-velocity phonons
Electrostriction/Strained bulk 	Radiation pressure/Moving boundary
Optical response modified	Mechanical response modified 

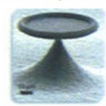
Silica fibers

Brillouin scattering	Cavity optomechanics
High-group-velocity phonons 	Low-group-velocity phonons
Electrostriction/Strained bulk 	Radiation pressure/Moving boundary
Optical response modified 	Mechanical response modified

Silicon nanowires

Brillouin scattering	Cavity optomechanics
High-group-velocity phonons 	Low-group-velocity phonons 
Electrostriction/Strained bulk 	Radiation pressure/Moving boundary
Optical response modified 	Mechanical response modified

Microtoroids

Brillouin scattering	Cavity optomechanics
High-group-velocity phonons	Low-group-velocity phonons 
Electrostriction/Strained bulk	Radiation pressure/Moving boundary 
Optical response modified	Mechanical response modified 

Neglecting phonon propagation

$$\frac{\partial b}{\partial t} + v_{\mathrm{m}} \cancel{\frac{\partial b}{\partial z}} = -i\kappa^{\mathrm{om}} a_{\mathrm{p}} a_{\mathrm{s}}^{\star} - \chi_{\mathrm{m}}^{-1} b$$

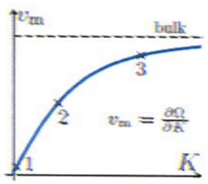
Phonons don't get far

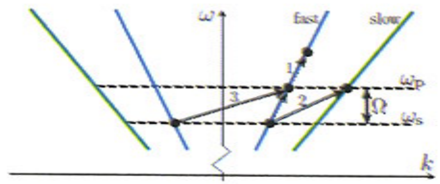
Even high-group-velocity phonons

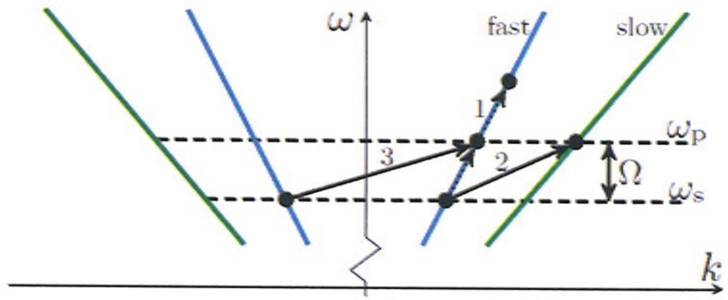
$$\alpha_{\mathrm{m}}^{-1} = \frac{v_{\mathrm{m}}}{\Gamma_{\mathrm{m}}} \approx 10\,\mu\mathrm{m}$$

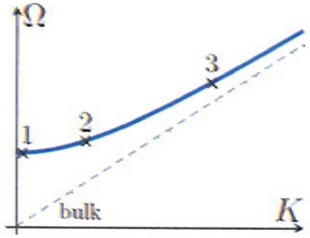
Otherwise reduced SBS

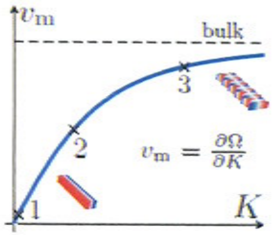
Wolff, arXiv (2014)











In steady-state: Brillouin gain

$$b = -i\kappa^{\mathrm{om}} \chi_{\mathrm{m}} a_{\mathrm{p}} a_{\mathrm{s}}^{\star}$$

$$\pm \frac{\partial a_{\mathrm{s}}}{\partial z} = \frac{\mathcal{G}_{\mathrm{SBS}} P_{\mathrm{p}} - \alpha_{\mathrm{s}}}{2} a_{\mathrm{s}}$$

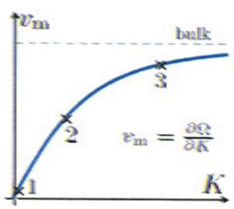
$$\boxed{\mathcal{G}_{\mathrm{SBS}} = \frac{4}{\Gamma_{\mathrm{m}}} \kappa^{\mathrm{mo}} \kappa^{\mathrm{om}}}$$

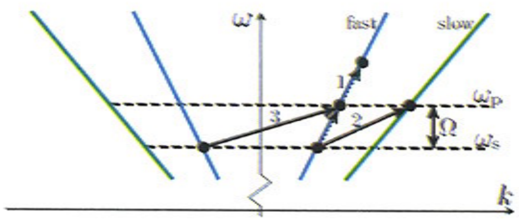
Acoustic slave wave

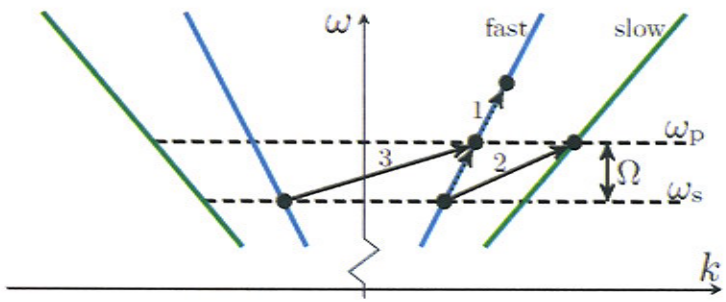
Fully determined by beat note

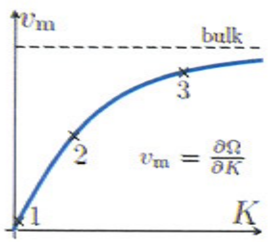
Gain on Stokes wave

Exponential build-up









$$\frac{1}{v_{\mathrm{s}}}\frac{\partial a_{\mathrm{s}}}{\partial t} \pm \frac{\partial a_{\mathrm{s}}}{\partial z} = -i\kappa^{\mathrm{mo}} a_{\mathrm{p}} b^{\star} - \frac{\alpha_{\mathrm{s}}}{2} a_{\mathrm{s}}$$

$$\frac{1}{v_{\mathrm{p}}}\frac{\partial a_{\mathrm{p}}}{\partial t} + \frac{\partial a_{\mathrm{p}}}{\partial z} = -i\kappa^{\mathrm{mo}} a_{\mathrm{s}} b - \frac{\alpha_{\mathrm{p}}}{2} a_{\mathrm{p}}$$

$$\frac{\partial b}{\partial t} + v_{\mathrm{m}}\frac{\partial b}{\partial z} = -i\kappa^{\mathrm{om}} a_{\mathrm{p}} a_{\mathrm{s}}^{\star} - \chi_{\mathrm{m}}^{-1} b$$

$$\chi_{\mathrm{m}}^{-1} = \frac{\Gamma_{\mathrm{m}}}{2} + i\Delta_{\mathrm{m}}$$

Transition from waveguide to cavity

$$\frac{1}{v_g}\frac{\partial a}{\partial t}+\frac{\partial a}{\partial z}=\zeta-\frac{\alpha}{2}a$$

Mean fields

Average over roundtrip

$$\overline{a}(t) \;=\; \frac{1}{L}\int_0^L a(z,t)\mathrm{d}z$$

Lugiato, Phys. Rev. A (1978)

Boundary condition

The fields feed back into themselves

$$a(L,t)-a(0,t)\approx\left(\frac{\alpha'+\mu}{2}+i\delta\right)\overline{a}(t)-\sqrt{\mu}\,s(t)$$

$$\frac{1}{v_g}\dot{\overline{a}}(t)+\frac{1}{L}\{a(L,t)-a(0,t)\}=\overline{\zeta}(t)-\frac{\alpha}{2}\overline{a}(t) \qquad \frac{1}{L}\int_0^L\frac{\partial a}{\partial t}\mathrm{d}z=\dot{\overline{a}}(t)$$

$$\dot{\overline{a}}=-\left(\frac{\kappa}{2}+i\Delta\right)\overline{a}+v_g\sqrt{T}\,\overline{\zeta}+\sqrt{\kappa_c}s$$

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$$a(0,t)=\sqrt{1-\alpha'}\sqrt{1-\mu}\,e^{-i\delta}a(L,t)+\sqrt{\mu}\,s(t)$$

$$\dot{\overline{a}}=-\left(\frac{\kappa}{2}+i\Delta\right)\overline{a}+v_g\sqrt{T}\,\overline{\zeta}+\sqrt{\kappa_c}s$$

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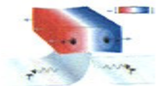
High-finesse limit

Mean-field approximation

$$\dot{\overline{a}}=-\left(\frac{\kappa}{2}+i\Delta\right)\overline{a}+v_g\sqrt{T}\,\overline{\zeta}+\sqrt{\kappa_c}s$$

$$\kappa_c=\frac{\mu}{T} \quad \kappa_i=\frac{\alpha'+\alpha L}{T} \quad \Delta=\frac{\delta}{T}=\omega-\omega_c \quad T=\frac{L}{v_g}$$

Transition from waveguide to cavity



$$\frac{1}{v_g}\frac{\partial a}{\partial t}+\frac{\partial a}{\partial z}=\zeta-\frac{\alpha}{2}a$$

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Mean-field approximation

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Link to the usual Hamiltonian

$$\dot{a}_s = -\chi_s^{-1} a_s - i\kappa_{mo} a_p b^* + \sqrt{\kappa_{cs}} s_s$$
$$\dot{a}_p = -\chi_p^{-1} a_p - i\kappa_{mo} a_s b + \sqrt{\kappa_{cp}} s_p$$
$$\dot{b} = -\chi_m^{-1} b - i\kappa_{om} a_p a_s^*$$

Undepleted pump

$$\dot{a}_s = -\chi_s^{-1} a_s - i\kappa_{mo} a_p b^* + \sqrt{\kappa_{cs}} s_s$$
$$\dot{b} = -\chi_m^{-1} b - i\kappa_{om} a_p a_s^*$$

$$a_s \to a_s^* \qquad b \to b^*$$

$$\hat{\mathcal{H}}_{\mathrm{int}}^{(\mathrm{lin})} = -\hbar g \left(\delta\hat{a} + \delta\hat{a}^\dagger\right)\left(\hat{b} + \hat{b}^\dagger\right)$$

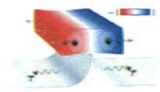
$$\delta\dot{\hat{a}}^\dagger = -\left(\frac{\kappa}{2} + i\Delta\right)\delta\hat{a}^\dagger - ig\left(\hat{b} + \hat{b}^\dagger\right) + \sqrt{\kappa_c}\,\delta\hat{a}_{\mathrm{in}}^\dagger$$
$$\dot{\hat{b}}^\dagger = -\left(\frac{\Gamma_m}{2} - i\Omega_m\right)\hat{b}^\dagger - ig\left(\delta\hat{a} + \delta\hat{a}^\dagger\right)$$

$$\delta\hat{a} \to \hat{a}_s e^{i\Omega t} \qquad \hat{b} \to \hat{b} e^{-i\Omega t}$$

Rotating-wave approximation

$$\dot{\hat{a}}_s^\dagger = -\chi_s^{-1}\hat{a}_s^\dagger - ig\hat{b} + \sqrt{\kappa_c}\,\hat{s}_s^\dagger$$
$$\dot{\hat{b}}^\dagger = -\chi_m^{-1}\hat{b}^\dagger - ig\hat{a}_s$$

Transition from waveguide to cavity



$$\frac{1}{v_g}\frac{\partial a}{\partial t} + \frac{\partial a}{\partial z} = \zeta - \frac{\alpha}{2}a$$

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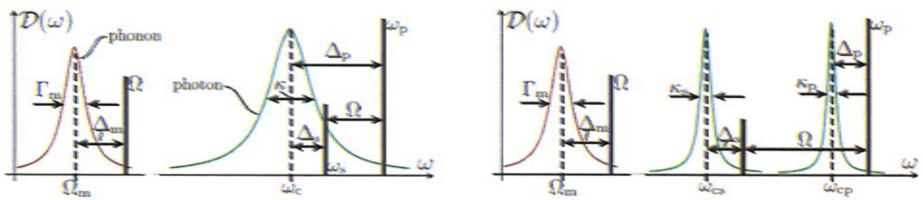
High-finesse limit

Mean-field approximation

$$\dot{\overline{a}} = -\left(\frac{\kappa}{2} + i\Delta\right)\overline{a} + v_g\sqrt{T}\,\overline{\zeta} + \sqrt{\kappa_c}\,s$$
$$\zeta(z,t) \propto f(z,t)g(z,t) \qquad \overline{fg} = \overline{f}\,\overline{g}$$

Lasing vs. sasing



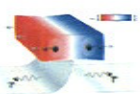
$$\dot{a}_s = -\chi_s^{-1} a_s - i\kappa_{mo} a_p b^*$$
$$\dot{b} = -\chi_m^{-1} b - i\kappa_{om} a_p a_s^*$$

$$\left(\frac{\mathrm{d}}{\mathrm{d}t} + \chi_m^{-*}\right)\left(\frac{\mathrm{d}}{\mathrm{d}t} + \chi_s^{-1}\right) a_s = g^2 a_s \qquad g = \sqrt{\kappa_{mo}\kappa_{om}}\,|a_p|$$

$$a_s \propto e^{\gamma t}$$

$$\gamma_\pm = \frac{1}{2}\left\{-\left(\chi_s^{-1} + \chi_m^{-*}\right) \pm \sqrt{\left(\chi_s^{-1} - \chi_m^{-*}\right)^2 + 4g^2}\right\}$$

Transition from waveguide to cavity



$$\frac{1}{v_s}\frac{\partial a_s}{\partial t} \pm \frac{\partial a_s}{\partial z} = -i\kappa^{mo} a_p b^* - \frac{\alpha_s}{2}a_s$$
$$\frac{1}{v_p}\frac{\partial a_p}{\partial t} + \frac{\partial a_p}{\partial z} = -i\kappa^{mo} a_s b - \frac{\alpha_p}{2}a_p$$

$$\frac{1}{v_g}\frac{\partial a}{\partial t} + \frac{\partial a}{\partial z} = \zeta - \frac{\alpha}{2}a$$

$$\dot{\overline{a}} = -\left(\frac{\kappa}{2} + i\Delta\right)\overline{a} + v_g\sqrt{T}\,\overline{\zeta} + \sqrt{\kappa_c}\,s$$
$$\zeta(z,t) \propto f(z,t)g(z,t) \qquad \overline{fg} = \overline{f}\,\overline{g}$$

$$\frac{\partial b}{\partial t} = -i\kappa^{om} a_p a_s^* - \chi_m^{-1} b$$

$$\dot{\overline{b}} = -i\kappa_{om}\overline{a}_p\overline{a}_s^* - \chi_m^{-1}\overline{b}$$

$$\boxed{\begin{aligned}\dot{a}_s &= -\chi_s^{-1} a_s - i\kappa_{mo} a_p b^* + \sqrt{\kappa_{cs}} s_s\\ \dot{a}_p &= -\chi_p^{-1} a_p - i\kappa_{mo} a_s b + \sqrt{\kappa_{cp}} s_p\\ \dot{b} &= -\chi_m^{-1} b - i\kappa_{om} a_p a_s^*\end{aligned}}$$

$$\kappa_{om} = \frac{\kappa^{om}}{\sqrt{T_s T_p}} \qquad \kappa_{mo} = \kappa^{mo}\sqrt{v_s v_p}$$

Overview

Brillouin scattering in silicon nanowires
Recent experimental demonstration

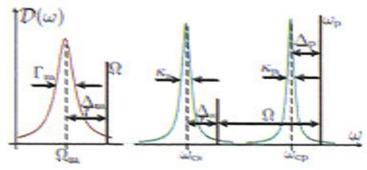
Brillouin scattering vs. cavity optomechanics
Transition from Brillouin waveguide to dispersive optomechanical cavity

Prospects
From silicon photonics to silicon phononics

Lasing vs. sasing

$$\gamma_\pm = \frac{1}{2}\left\{-\left(\chi_s^{-1}+\chi_m^{-*}\right) \pm \sqrt{\left(\chi_s^{-1}-\chi_m^{-*}\right)^2+4g^2}\right\}$$

Weak coupling $4g \ll |\kappa_s - \Gamma_m|$



$$\gamma_+ = -\chi_m^{-*} + \frac{g^2}{\chi_s^{-1}-\chi_m^{-*}}$$
$$\gamma_- = -\chi_s^{-1} - \frac{g^2}{\chi_s^{-1}-\chi_m^{-*}}$$

$\kappa_s \gg \Gamma_m$

Optical response barely modified

$\chi_s^{-1} + g^2\chi_s \approx \chi_s^{-1}$

Mechanical response can be strongly modified: "sasing"

$\chi_m^{-1} + \Sigma_m \quad \Sigma_m = -g^2\chi_s^*$

$\Gamma_m \gg \kappa_s$

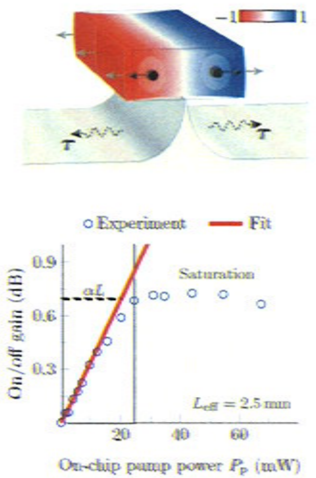
Mechanical response barely modified

$\chi_m^{-1} + g^2\chi_m \approx \chi_m^{-1}$

Optical response can be strongly modified: "lasing"

$\chi_s^{-1} + \Sigma_s \quad \Sigma_s = -g^2\chi_m^*$

We are closer to sasing than lasing



Close to transparency
Currently 2.6 dB/cm loss, 2.3 dB/cm gain

$\mathcal{C} \le 0.9$

$\frac{g_0}{2\pi} = 500\,\mathrm{kHz}$

Lasing harder than sasing
Need better optical Qs

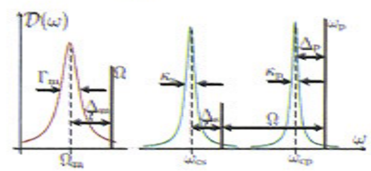
$\Gamma_m \ll \kappa_s$

Cooperativity is the roundtrip gain/loss ratio

$$\mathcal{C} = \frac{4g^2}{\kappa_s\Gamma_m} \qquad \mathcal{C} = \frac{4g_0^2\overline{n}_{cav}}{\kappa_s\Gamma_m}$$

$$\kappa_{mo} = \kappa^{mo}\sqrt{v_s v_p}$$
$$\kappa_{om} = \frac{\kappa^{om}}{\sqrt{T_s T_p}}$$
$$g^2 = \kappa_{mo}\kappa_{om}|a_p|^2$$
$$\mathcal{G}_{SBS} = \frac{4}{\Gamma_m}\kappa^{mo}\kappa^{om}$$

$$g_0^2 = v_s v_p \frac{(\hbar\omega_p)\,\Omega_m}{4L}\left(\frac{\mathcal{G}_{SBS}}{Q_m}\right)$$



$$\boxed{\mathcal{C} = \frac{\mathcal{G}_{SBS}P_p}{\frac{\kappa_s}{v_s}} = \frac{\mathcal{G}_{SBS}P_p L}{\kappa_s T_s}}$$

Also holds for sasing!

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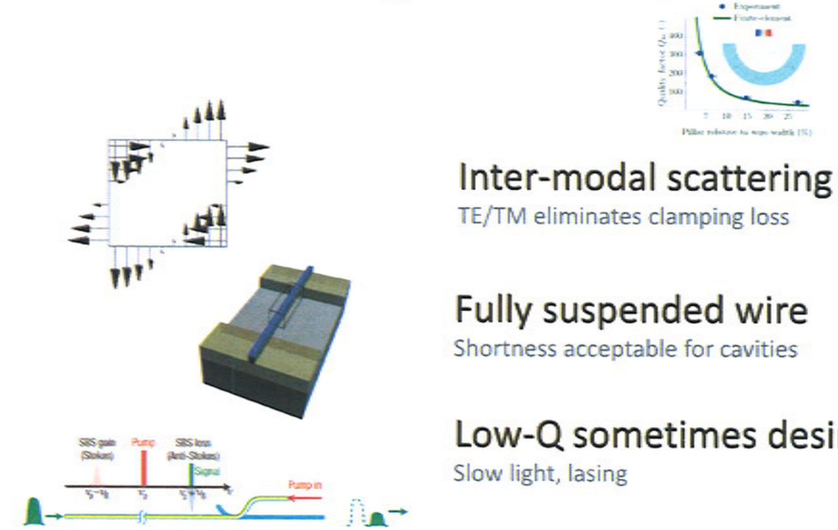
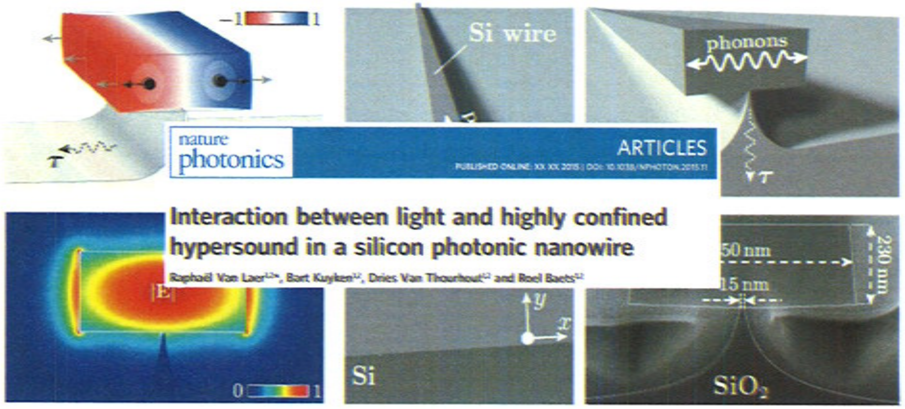
Increasing the acoustic Q



Inter-modal scattering
TE/TM eliminates clamping loss

Fully suspended wire
Shortness acceptable for cavities

Low-Q sometimes desirable
Slow light, lasing



$$g_0^2 = v_s v_p \frac{(\hbar\omega_p)\,\Omega_m}{4L}\left(\frac{\mathcal{G}_{SBS}}{Q_m}\right) \qquad C = \frac{\mathcal{G}_{SBS} P_p}{\frac{\kappa_s}{v_s}}$$

Raphaël Van Laer, Bart Kuyken, Roel Baets and Dries Van Thourhout

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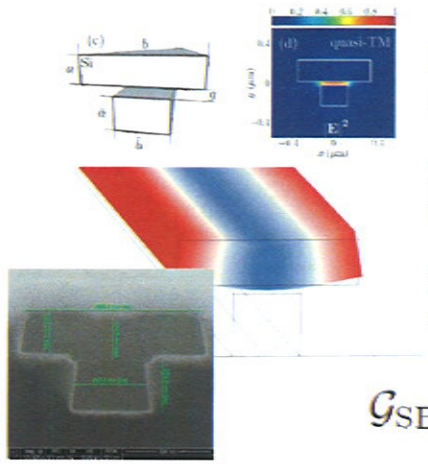
Increase the coupling strength in 5-nm-gap silicon slots



Giant light-sound overlap
Less TPA, probably higher losses

Kerr-like optomechanics
Transition from Kerr-like to Brillouin-like

Broadband operation
Up to resonance frequency

$\mathcal{G}_{SBS}$ x 10 – 100 in best case