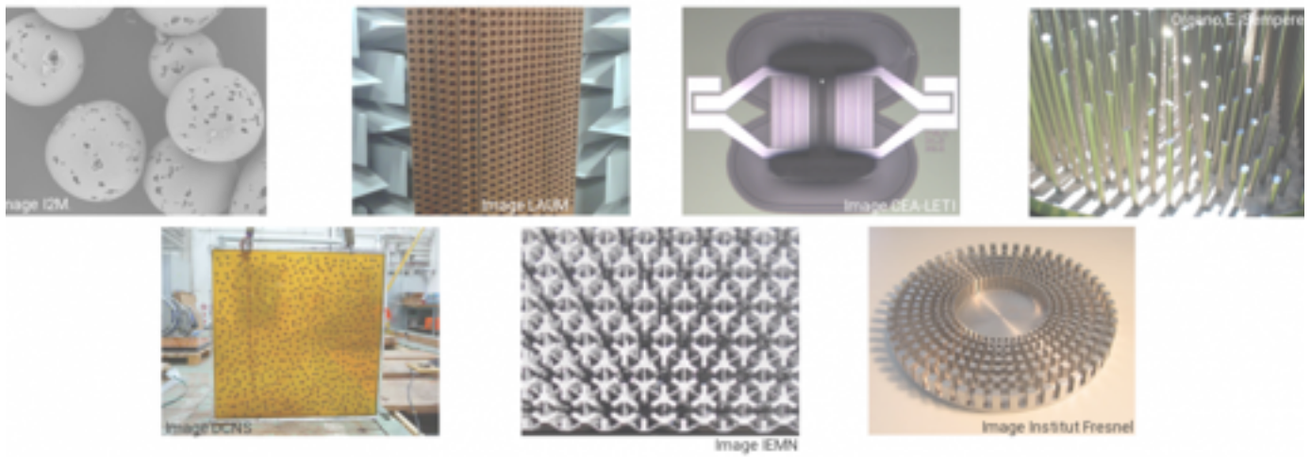
État de l'art et problématiques liées aux META pour l'audible,



Réunion de lancement du GdR META -- Vendredi 22 janvier 2016

Vicent Romero-García,

Laboratoire d'Acoustique de l'Université du Maine (LAUM)

Nicolas Côte.

Institut Supérieur d'Électronique et du Numérique (ISEN)

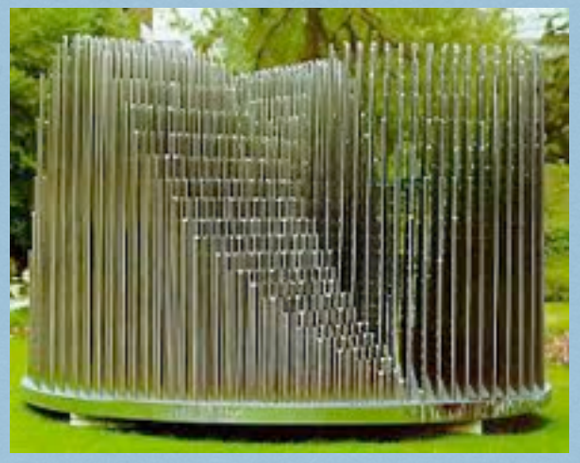
www.cnrs.fr

Outline

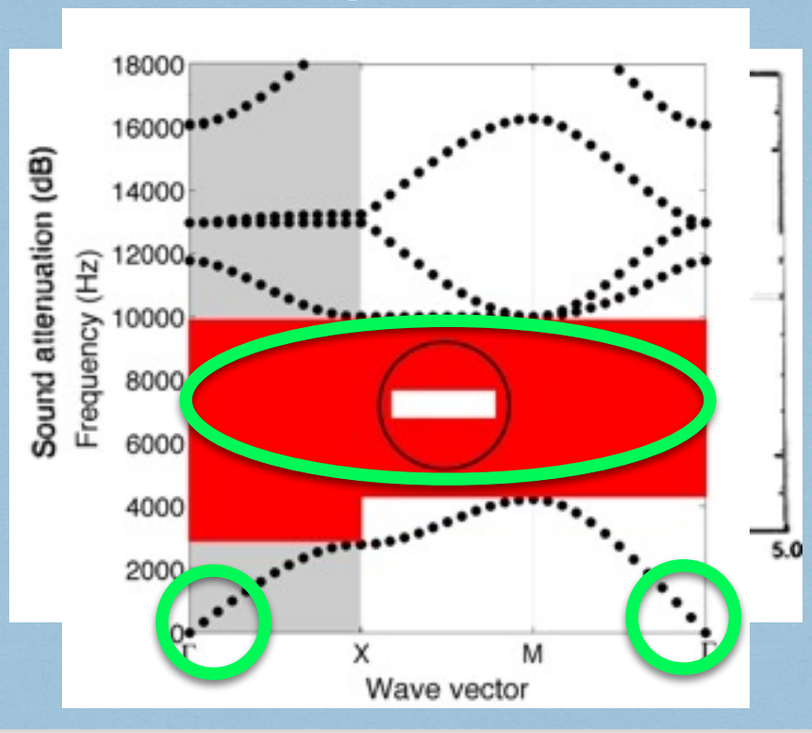
- Phononic Crystals and Metamaterials: Introduction and state of the art
- Interaction with the Society
- Metamaterials and Phononic Crystals against the traffic noise
- Metamaterials against the neighborhood noise
- Goals of the GT3
- Discussion

Phononic (Sonic) crystals

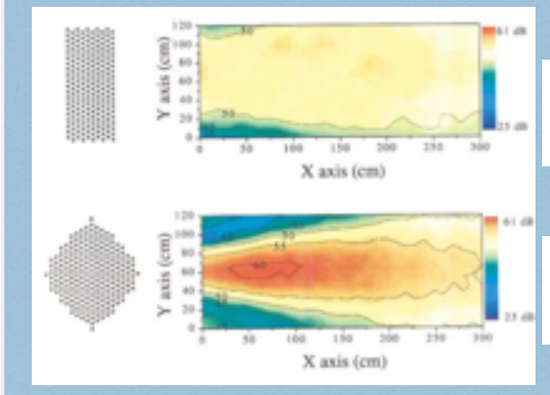
Sound filtering



Nature
378, 241, (1995)



Refraction



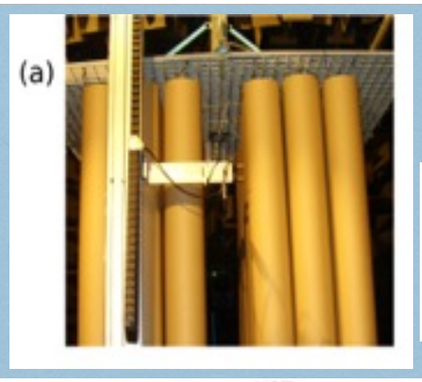
$$\bar{\rho}_{\text{eff}} = (1+f)/(1-f),$$

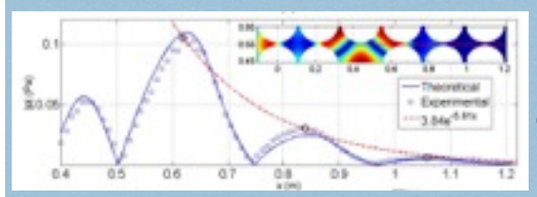
$$\bar{c}_{\text{eff}} = 1/\sqrt{1+f}. \qquad (10)$$

Phys. Rev. Lett.
88, 023902, (2002)

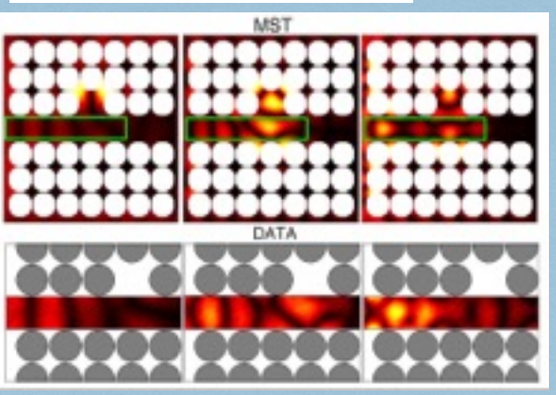
Phys. Rev. Lett.
96, 204302, (2006)

Localization and Guiding

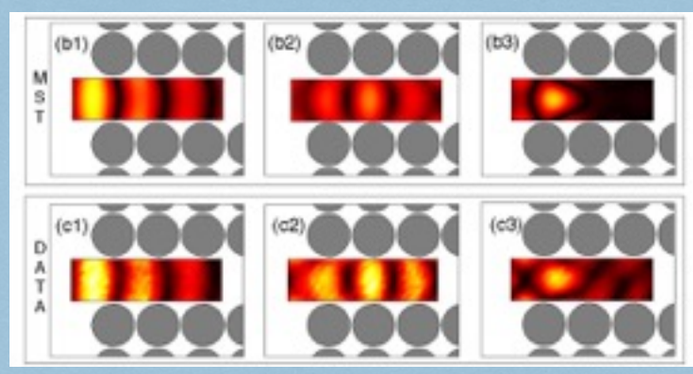




Appl. Phys. Lett.
96, 124102 (2010)

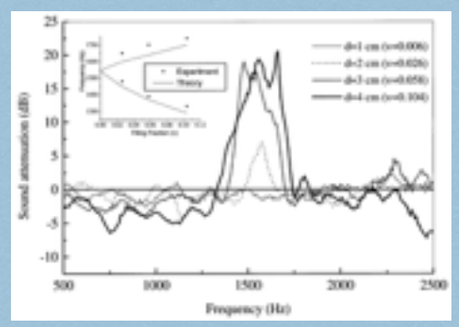


New J. Phys
14, 023049, (2012)

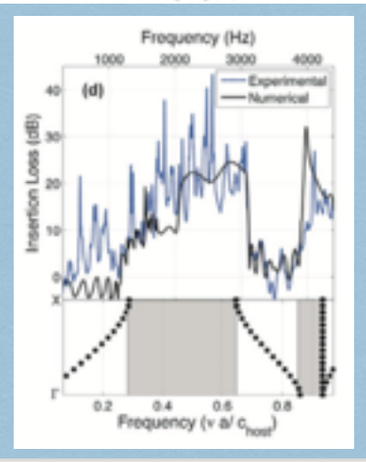


Phys. Rev. B
84, 212302 (2011)

Low transmission of sound



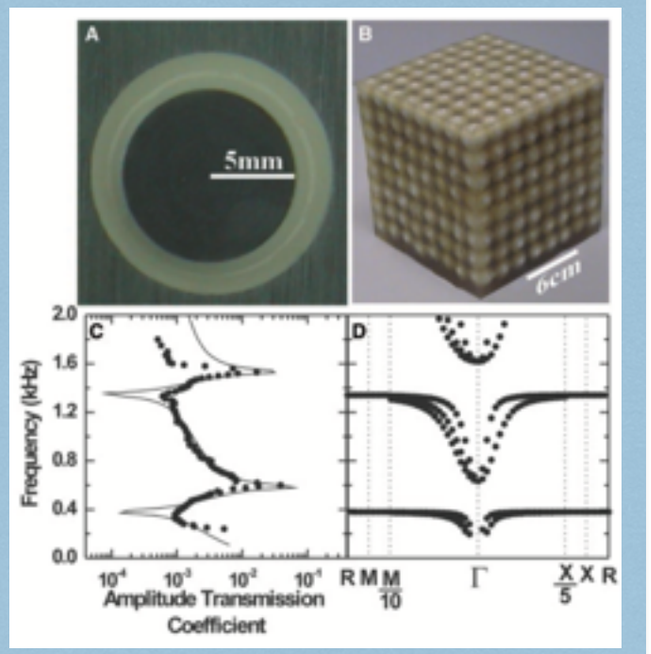
Phys. Rev. Lett.
80, 5325, (1998)



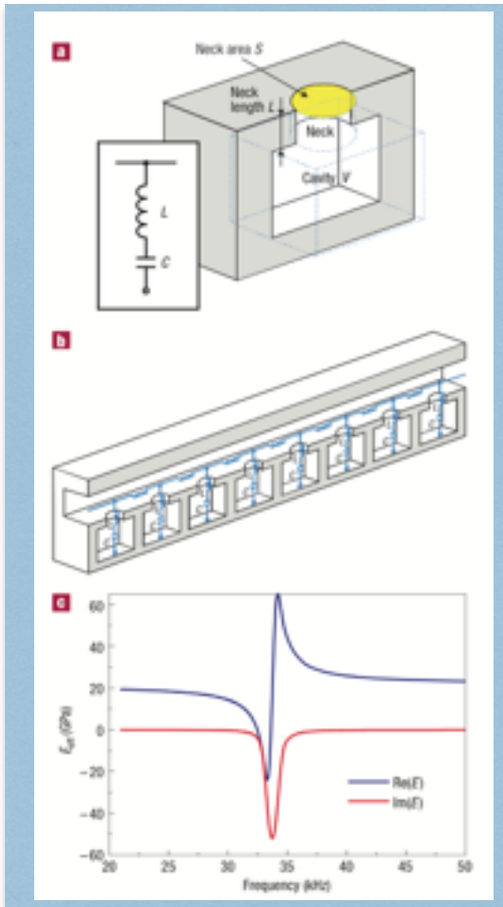
J. Phys. D: Appl. Phys.
46, 305108, (2013)

Metamaterials: Definition?? and highlights

- **Artificial**, i.e. man-made, heterogeneous devices that display ***new responses*** precluded by physical constraints from occurring in the constituent materials.



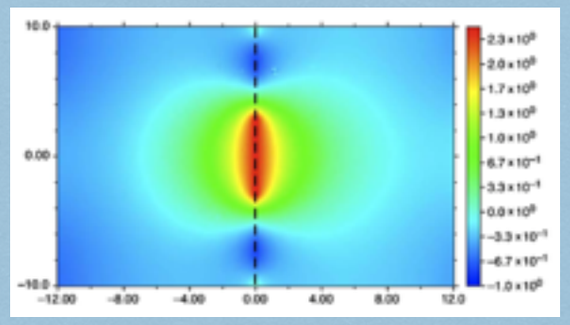
Z. Liu, et al.
Science
289, 1734 (2000);

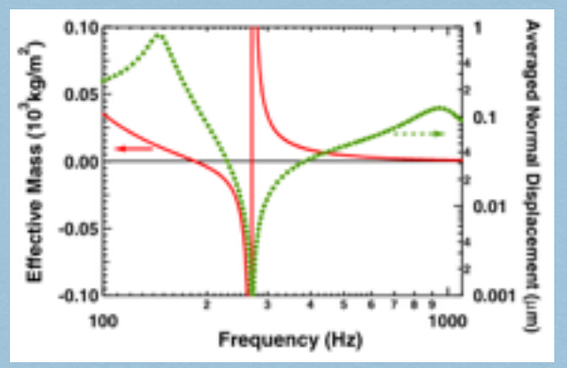


N. Fang et al.
Nature Materials
5, 452 (2006)

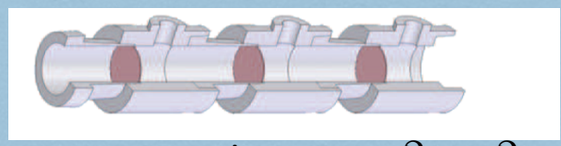
Sugimoto, N. and Horioka, T.
J. Acoust. Soc. Am. 97,
1446–1459, 1995

C.E. Bradley
Technical Report, 1991



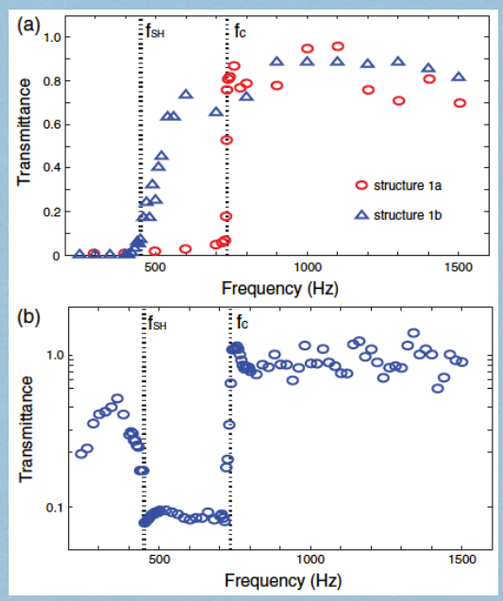


Z. Yang et al.
Phys. Rev. Lett.
101, 204301,(2008)



$$\rho_{eff} = \rho'(1 - \omega_0^2/\omega^2)$$

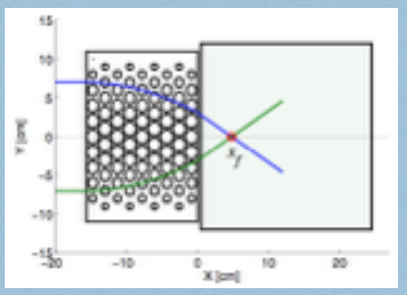
$$B_{eff} = B'(1 - \omega_{SH}^2/\omega^2)^{-1}$$

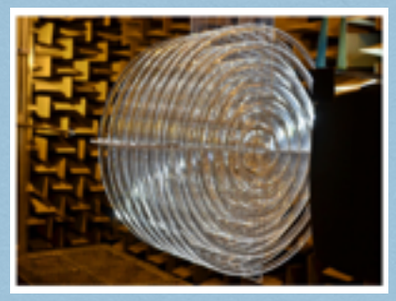


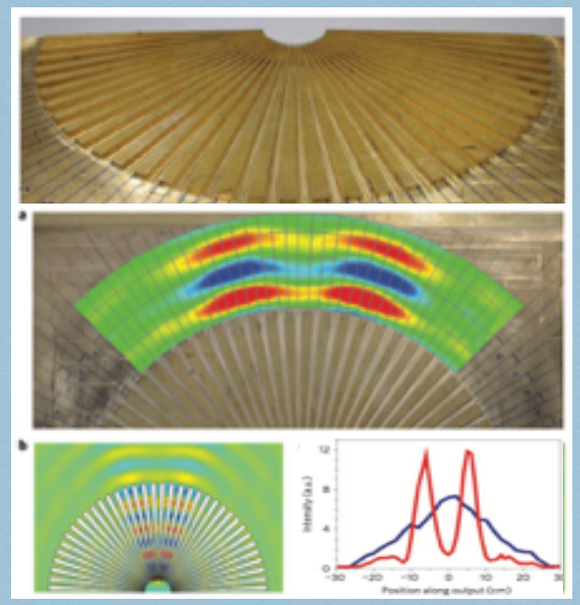
S. Lee et al.
Phys. Rev. Lett.
104, 054301, (2010)

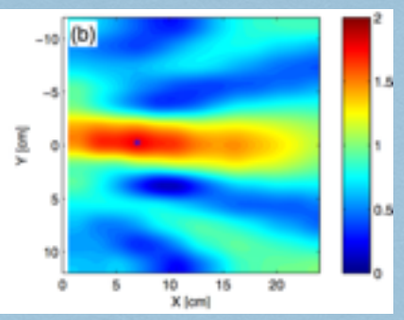
What can we do?

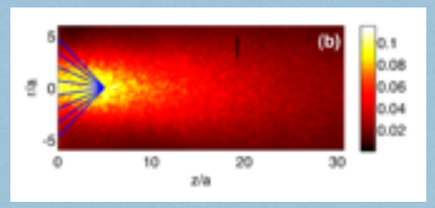
Focusing sound









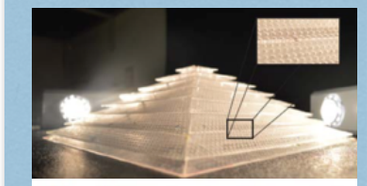


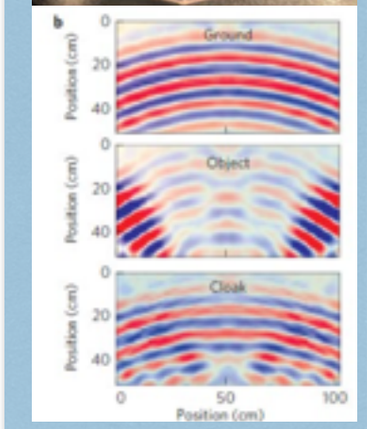
Appl. Phys. Lett.
97, 104103, (2010)

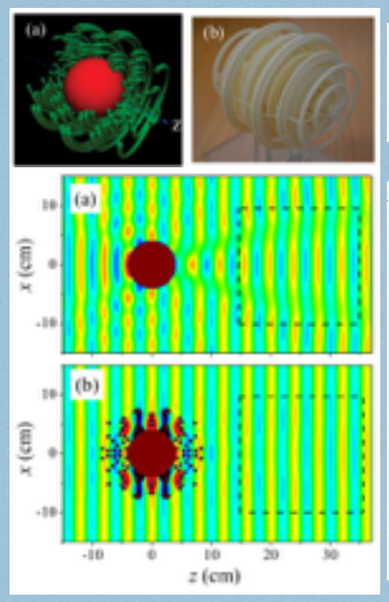
Appl. Phys. Lett.
103, 264106 (2013)

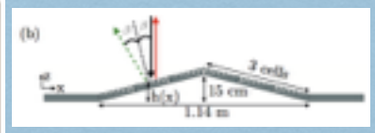
Nat. Mat.
8, 931 (2009)

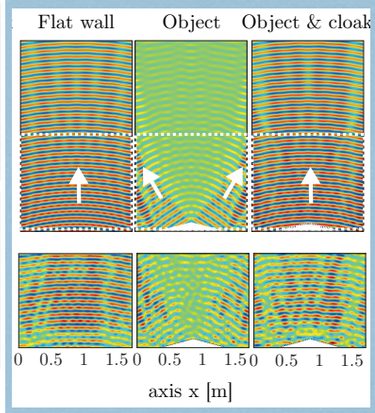
Cloaking









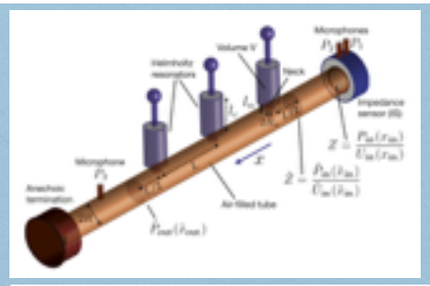


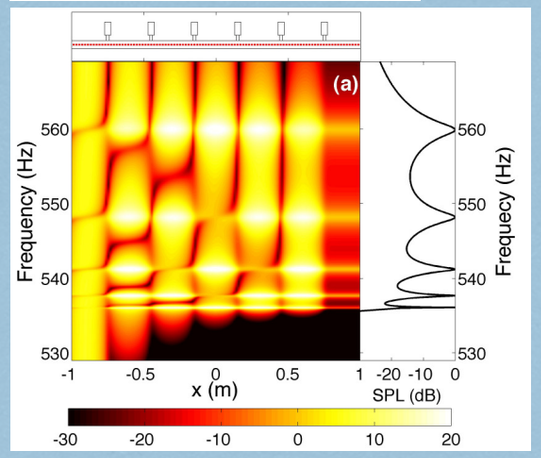
PRL, 106, 253901 (2011)
Nat. mat., 3901 (2014)

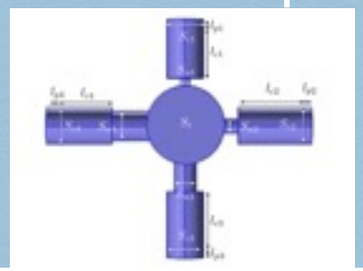
Phys. Rev. Lett.,
110, 124301 (2013)

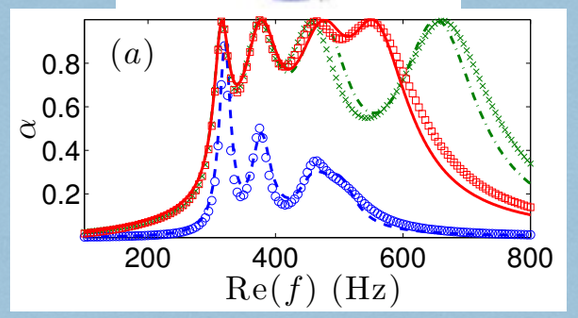
Submitted APL (2016)

Filtering/Absorption





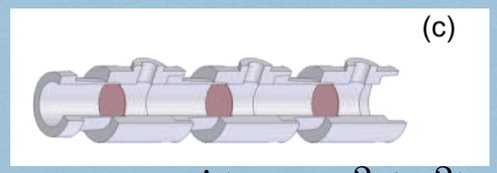




New J. Phys.
15, 093017, (2014)

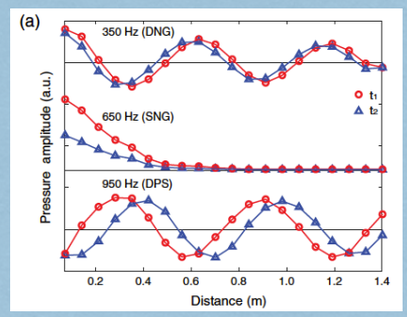
Submitted to JASA (2016)

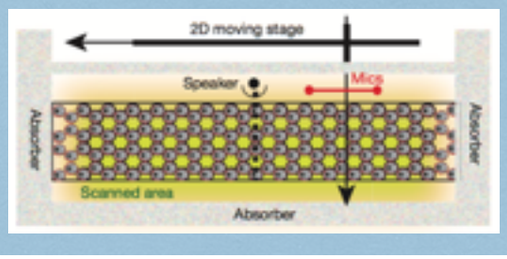
Anomalous propagation

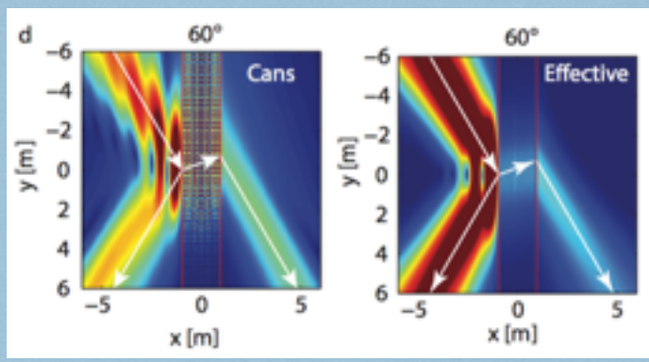


$$\rho_{eff} = \rho'(1 - \omega_0^2/\omega^2)$$

$$B_{eff} = B'(1 - \omega_{SH}^2/\omega^2)^{-1}$$







Phys. Rev. Lett.
104, 054301, (2010)

Nature
525, 14678, (2015)

Interaction with the Society

The INSEE* and the TNS-SOFRES** in 2014,

82% of French people
are concerned by
sound nuisances from

Traffic

Acoustic Barriers

- Acoustic drawbacks: shadow geometric region
- Structural drawbacks: high resistivity of air
- Environmental Impact

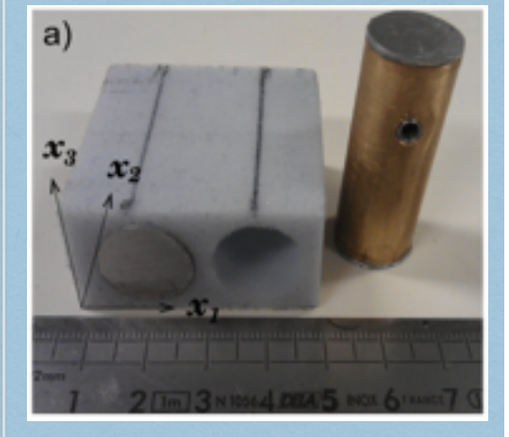
Phononic crystal + Metamaterials + Absorption

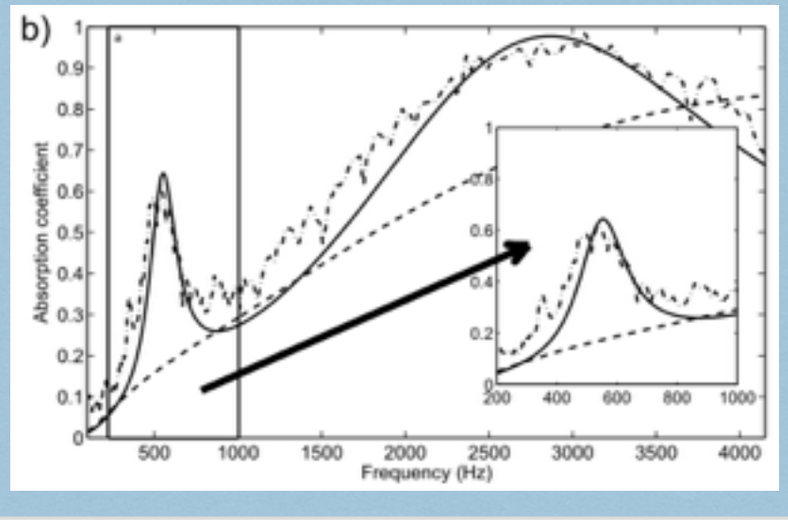
Neighborhood

Multilayer systems

- Acoustic drawbacks: small efficiency at low frequencies

Metamaterials + Absorption



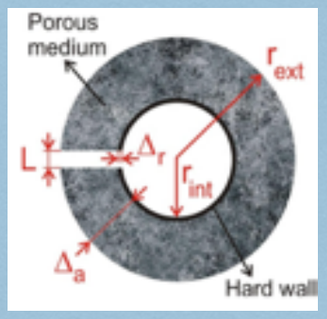


* Institut national de la statistique et des études économiques

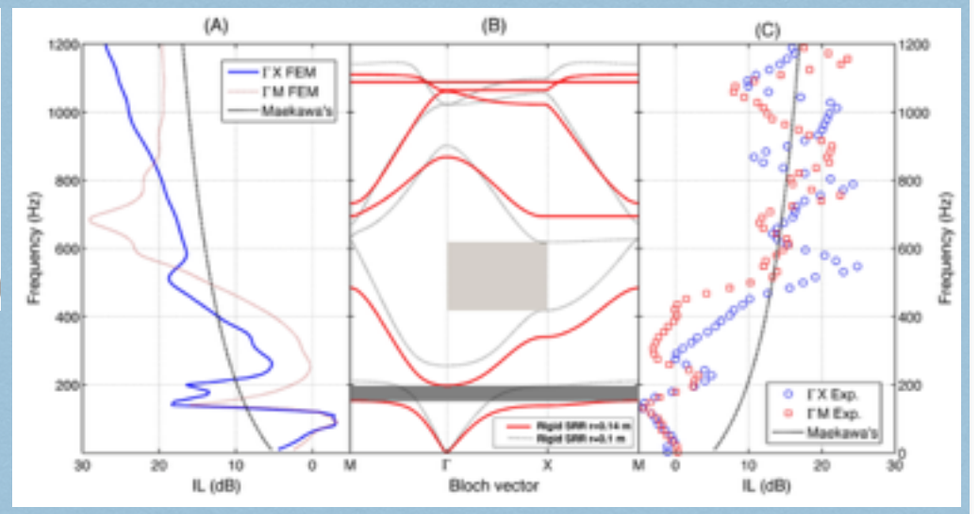
** Marketing Studies and Opinion

Acoustic barriers based on metamaterials and phononic (sonic) crystals

Resonance+Periodicity+Absorption

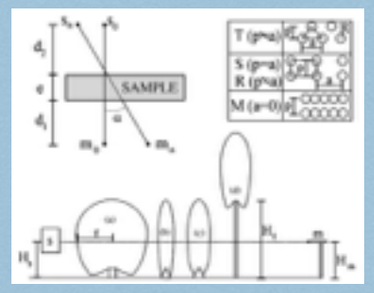


J. Appl. Phys. 110, 014904 (2011)



Environmental Engineering and Management Journal 14 (2015), 12, 2759-2769

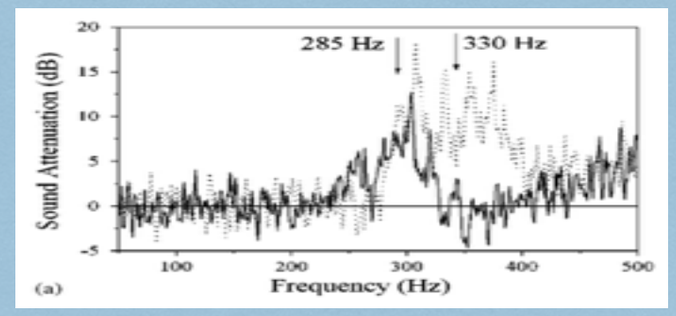
J. Acous. Soc. Am., Vol. 129, pp. 1173-1183 (2011).

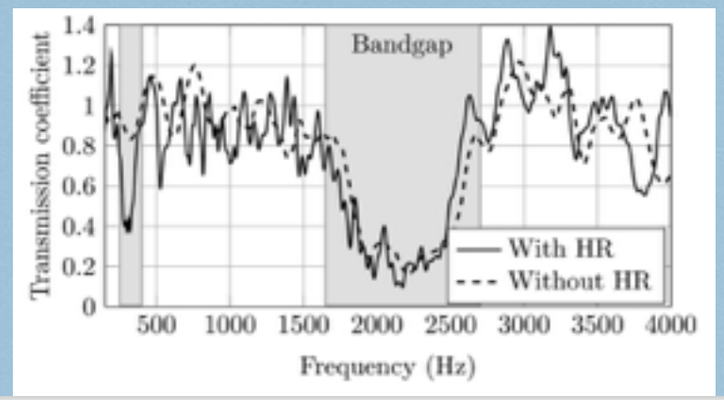


J. Sound Vib. 291 (2006) 100–106

J. Acoust. Soc. Am., 133 : 247-254, (2013).

Natural materials





Perceptive effects

A noise barrier made of a phononic crystal can introduce
audible effects

Sound examples

Timbre modification (street noise):

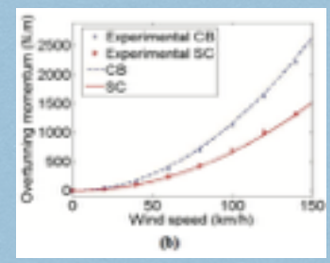
Free-field / PC / Free-standing

Effect of band gap:

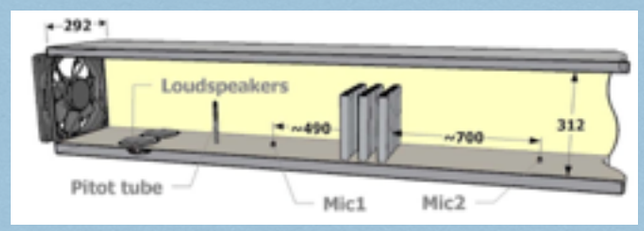
Free-field / PC

Internoise 2014
Photonics 2015

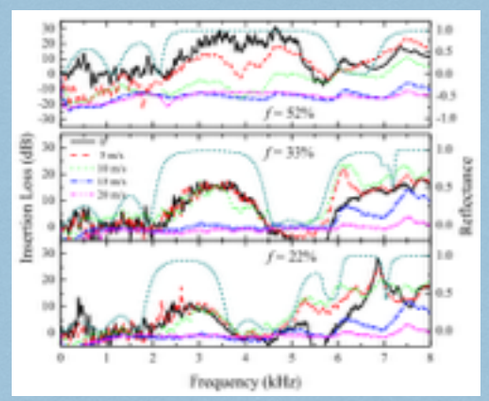
Reduction of air flow resistivity



Environmental Engineering and Management Journal 14 (2015), 12, 2759-2769

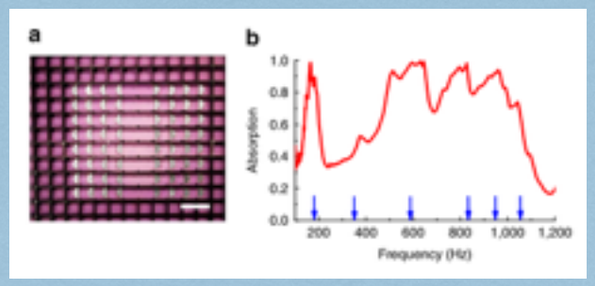


Appl. Phys. Lett. 94, 134104 2009

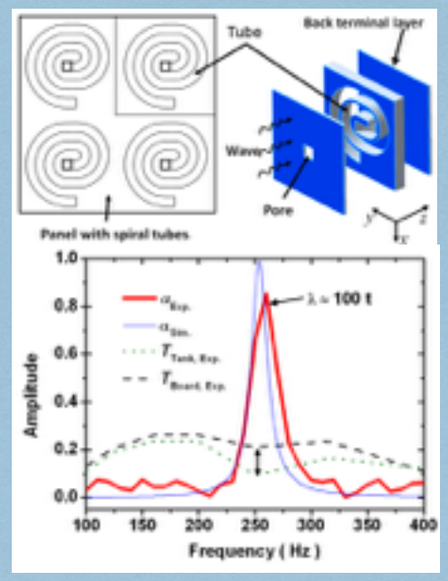


Thin (deep-subwavelength) absorbers based on metamaterials

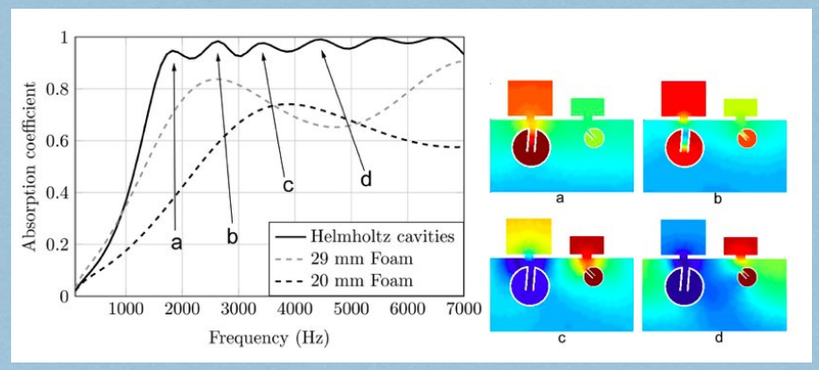
Mixing absorption and resonances



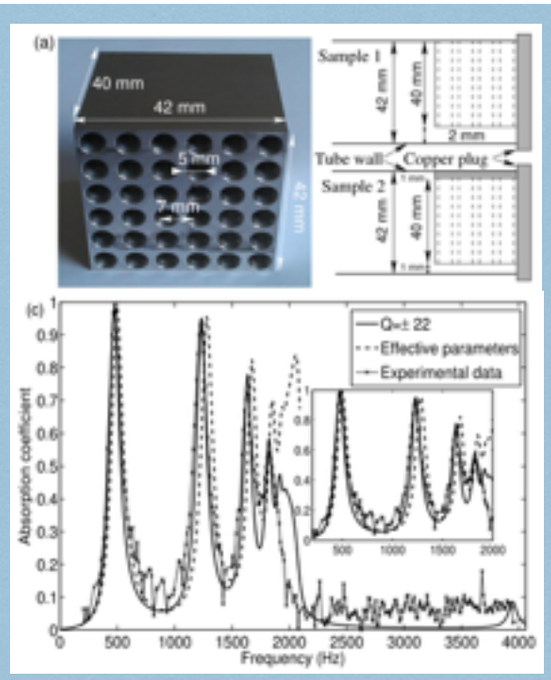
Nat. Commun.
3:756
doi: 10.1038/ncomms1758, (2012)



Appl. Phys. Lett.
105, 12901 (2014)

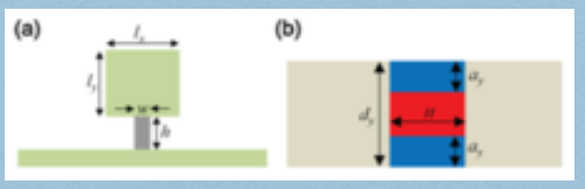


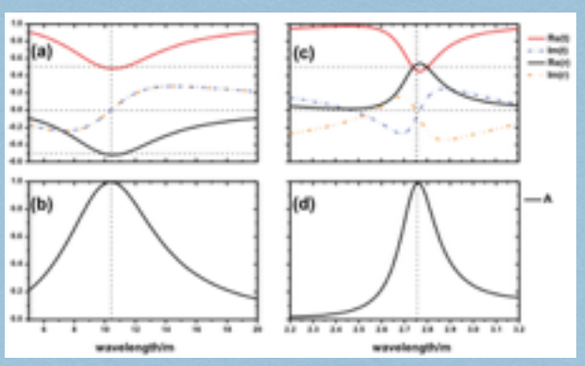
J. Acoust. Soc. Am., 134 : 4670-4680, 2013.
J. Acoust. Soc. Am., 136 : 1139-1148, 2014.
Scientific Reports, 4 : 4674, 2014.
J. Acoust. Soc. Am., 137 : 273-280, 2015.
Applied Acoustics, 102: 49-54, 2016



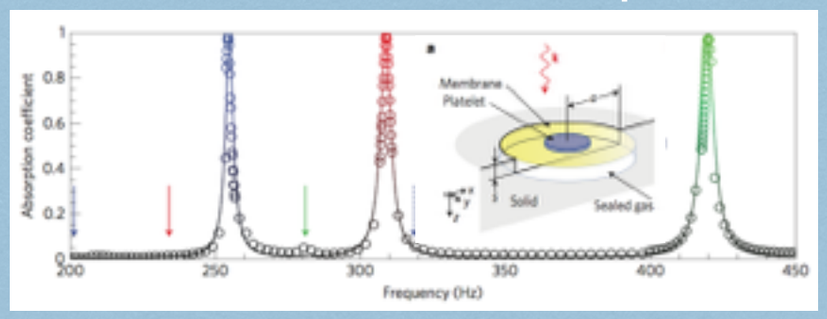
J. Appl. Phys. 117, 124903 (2015)
New J. Phys. 15, 093017, (2014)

Perfect and broadband absorption

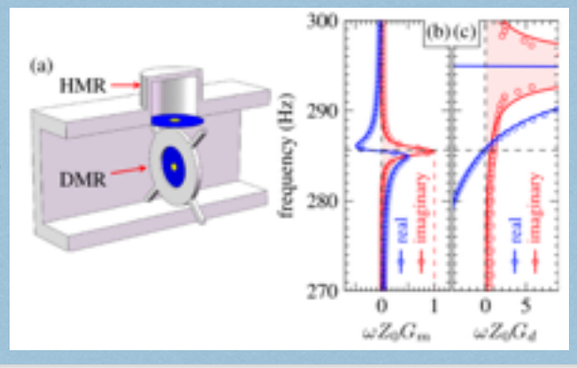




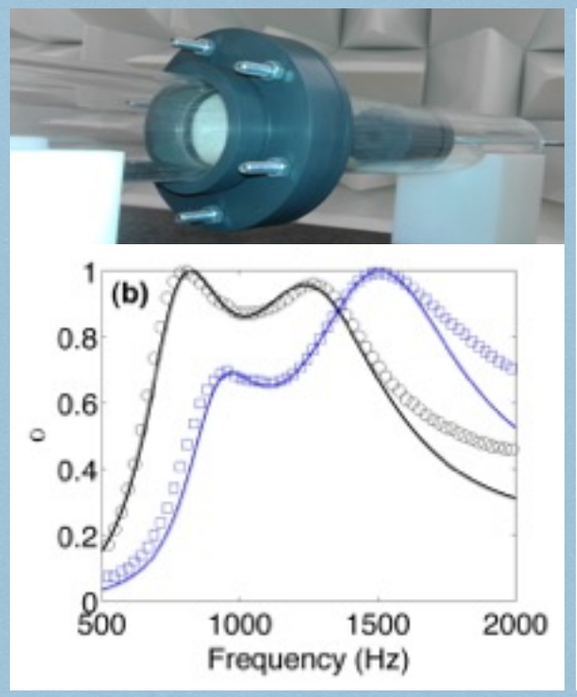
Appl. Phys. Lett.
104, 121902 (2014)



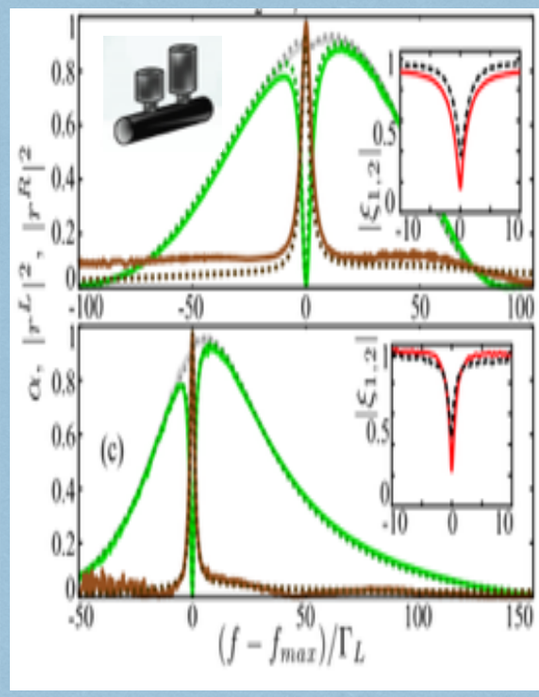
Nat. Mat., 3994, DOI:10.3994, (2014)



Appl. Phys. Lett.
107, 104104
(2015)



Scientific Reports,
5, 19519,(2016)



Appl. Phys. Lett.
107, 244102 (2015)

Goals of the GT3

- **French framework** to work, motivate collaborations and flow of information concerning the topic of this GT3.
- Motivate **discussions to share the skills and knowledge of scientists working on acoustic metamaterials and phononic crystals and their industrial partners** around the possible industrial applications. Particularly on the topic of: **traffic noise and neighborhood noise**.
- **European and International visibility** of the work on Acoustic Metamaterials and Phononic Crystals developed in the French community.

CFA 2016 - VISHNO

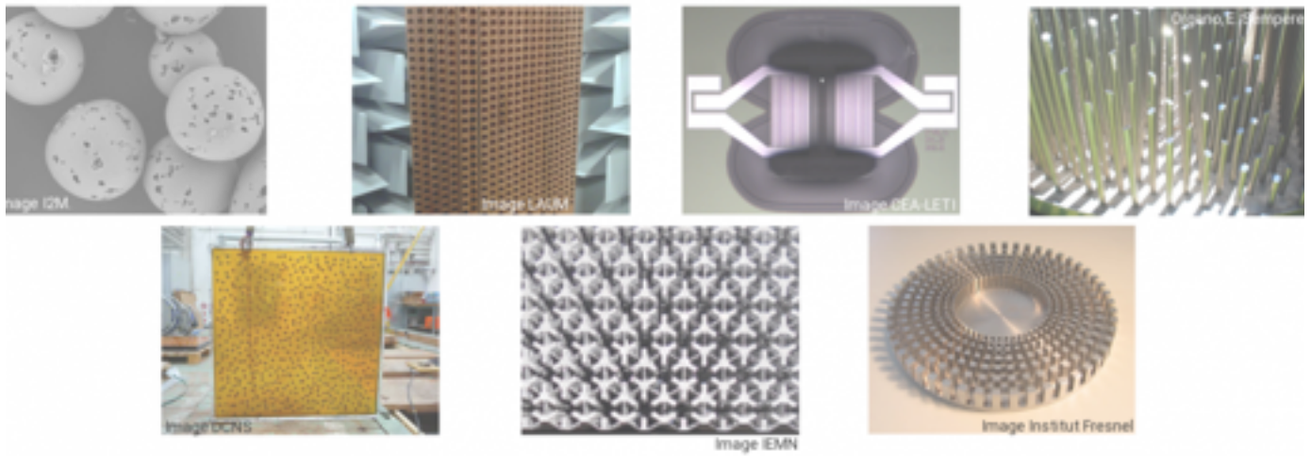
"Acoustic Metamaterials and Phononic Crystal in the audible regime"
Deadline: 6th March

vicente.romero@univ-lemans.fr
Jean-Philippe.Groby@univ-lemans.fr

État de l'art et problématiques liées aux META pour l'audible,

MERCI POUR VOTRE ATTENTION

DISCUSSION / QUESTIONS



Réunion de lancement du GdR META -- Vendredi 22 janvier 2016

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