E-NEWSLETTER

December 2021 issue

THE SOCIETY OF ACOUSTICS SINGAPORE

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Registration No: 0331/1989
Year of Registration: 1989

President: Dr Gan Woon Siong
Secretary: Michel Rosmolen
Treasurer: Asso.Prof Alfred Tan Cheng Hock

CONTENTS

I.CONFERENCE NEWS

. The 28[7h] International Congress on Sound and Vibration(ICSV28) will be held in Singapore from 24 to 28 July 2022 and will be a hybrid conference.

Woon Siong Gan will be organising three structured sessions on:

1. Nonlinear acoustics and vibration
2. Acoustic metamaterials & phononic crystals: fundamentals and applications

3. Sound propagation in curvilinear spacetime

Please visit www.icsv28.org for more informations.

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II.ANNONCEMENTS

The Society of Acoustics(Singapore) will be sending out invoices to members with outstanding membership subscriptions. Members are encouraged to make payment in support of the Society.

The E-Newsletters will be made available to industrial contacts in an effort to promote the activities of the Society.

The Society is also exploring the possibility of organising zoom seminars/workshops and other professional events in collaboration with acoustic societies of the ASEAN countries.

Membership Certificates will soon be made available to all members who had made full payments of membership dues

The Society aims to increase membership by inviting all persons, including those from the institution of higher learning and other related societies such as the Institute of Architects, Singapore and the members of the mechanical engineering division of the Institution of Engineers, Singapore who are qualified in the various field of Acoustics to join our Society.

We are especially keen to invite students to join our society and we are establishing the Youth Chapter soon.

III.INTERNATIONAL ACOUSTICS NEWS

The International Liaison Committee(ILC) is under the Acoustical Society of America(ASA). The Society of Acoustics(Singapore) is a member of the ILC. There is a Southeast Asia Chapter of the ASA and is under the umbrella of ILC. The ILC organised a committee meeting recently and the following is the Minutes of the committee meeting.

ASA Administrative Committee Report

Committee: International Liaison Chair Brigitte Schulte-Fortkamp

The Committee International Liaison convened on November 16th

from 10am to 11am EST. It was

attended by 7 members from Hongkong (1) India (1), USA (2), Singapore(1), Germany (2). 6 members

were excused. It is obvious that the Committee should meet earlier that all members can attend.

Next time the Committee should start the meeting latest at 9 am EST.

Topics discussed:

It was decided to publish a report of the session “Excellence in Acoustics around the world” in POMA.

The report will be written by Andy Chung, Maurice Yeung and Brigitte Schulte-Fortkamp. The draft will be sent to all presenters for review. The plan is to finalize the report within the next two months.

A further decision was to write an Article about the committee's aim and work to enhance the

respective awareness. This article will be organized by Adrian K.C. Lee as soon as the POMA report is

finalized.

A report about the Acoustics Masters Lecture Series and the Royster student scholarship award

2021/2022 was prepared by Andy Chung and Maurice Yeung, and presented by Maurice.

The special session on "Excellence in Acoustics around the World Part II"is planned for the Chicago

Spring Meeting 2023. The session should go under "Interdisciplinary"

The next meeting of the International Liaison Committee is planned for Denver and should be

scheduled as a virtual meeting; nevertheless the committee plans to meet in person at the Spring

meeting in addition if possible.

Report written by

Brigitte Schulte-Fortkamp

Submitted to the committee:

November 17- 2021

IV.MEMBERSHIP SUBSCRIPTION

Fellow	S$70
Member	S$50
Associate	S$30
Student	S$15
Corporate	S$200

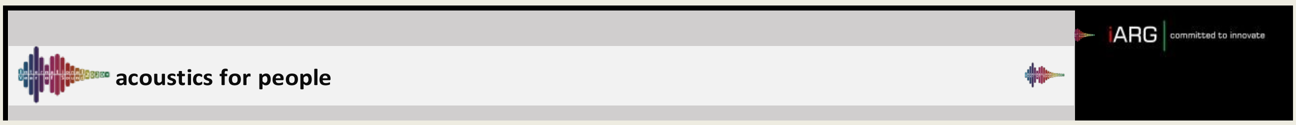
FEE BASED ON ANNUAL RATE

FOR MORE INFORMATION PLEASE CONTACT: Dr. Woon Siong Gan at email: wsgan5@gmail.com

Membership application forms can be downloaded from the society website: www.acousticssingapore.com. Please complete and email to wsgan5@gmail.com

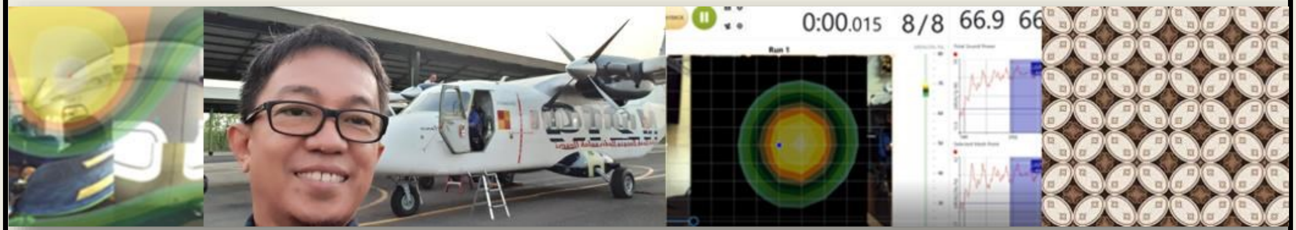
V.ARTICLES

The following is a powerpoint presentation of one of the speakers Dr Iwan Yahya at the zoom joint seminar between the Society of Acoustics(Singapore) and the Association of Acoustics and Vibration Indonesia (AAVI) held on 7 December 2021.



Acoustic Metamaterials and Metasurfaces:

the physics principles, inspirations idea and its applications



AAVI

Iwan Yahya – AAVI, Indonesia
The Iwany Acoustics Research Lab. [iARG] Physics Dept.
Sebelas Maret University iyahya@mipa.uns.ac.id

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universitas sebelas maret

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Universitas Sebelas Maret (UNS) is a state university with thirteen schools and faculties, including sciences, medical, engineering, law, agriculture and culture to serve undergraduate and graduate courses. We have around 40.000 student body and 1900 faculty members. Our green campus located in Surakarta (SOLO city). A small city with the population around 578.500. Regarded as culture city with two royal family. Very famous fine batik and culinary festivals.

universitas sebelas maret
Jl. Ir. Sutami 36 A, Kentingan, Surakarta
https://uns.ac.id

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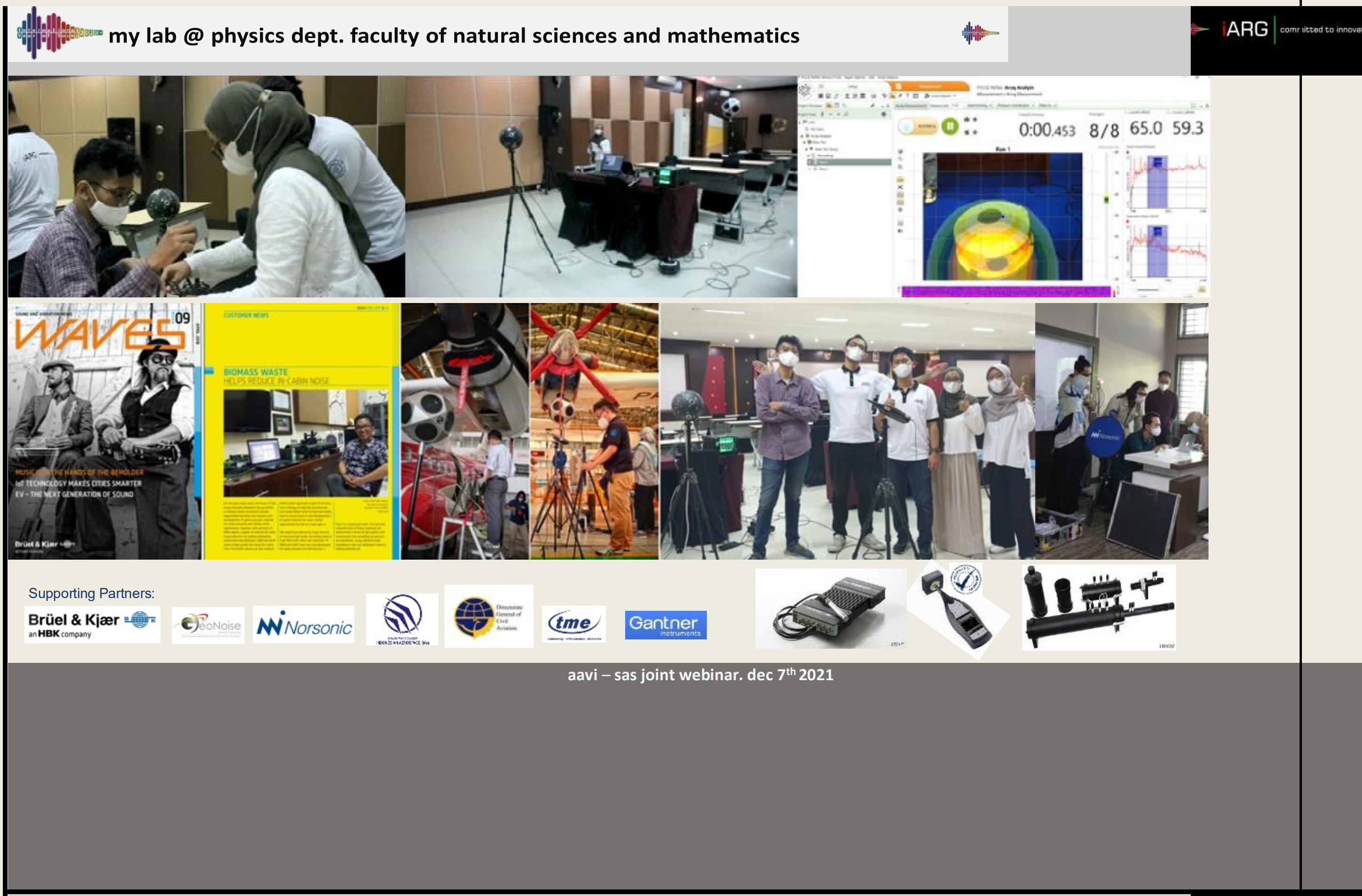
my lab @ physics dept. faculty of natural sciences and mathematics
iARG
0:00.453 8/8 65.0 59.3
WAVES
BIOMASS WASTE HELPS REDUCE IN-CABIN NOISE
Supporting Partners:
Brüel & Kjær
an HBK company
Norsonic
tme
Gantner instruments
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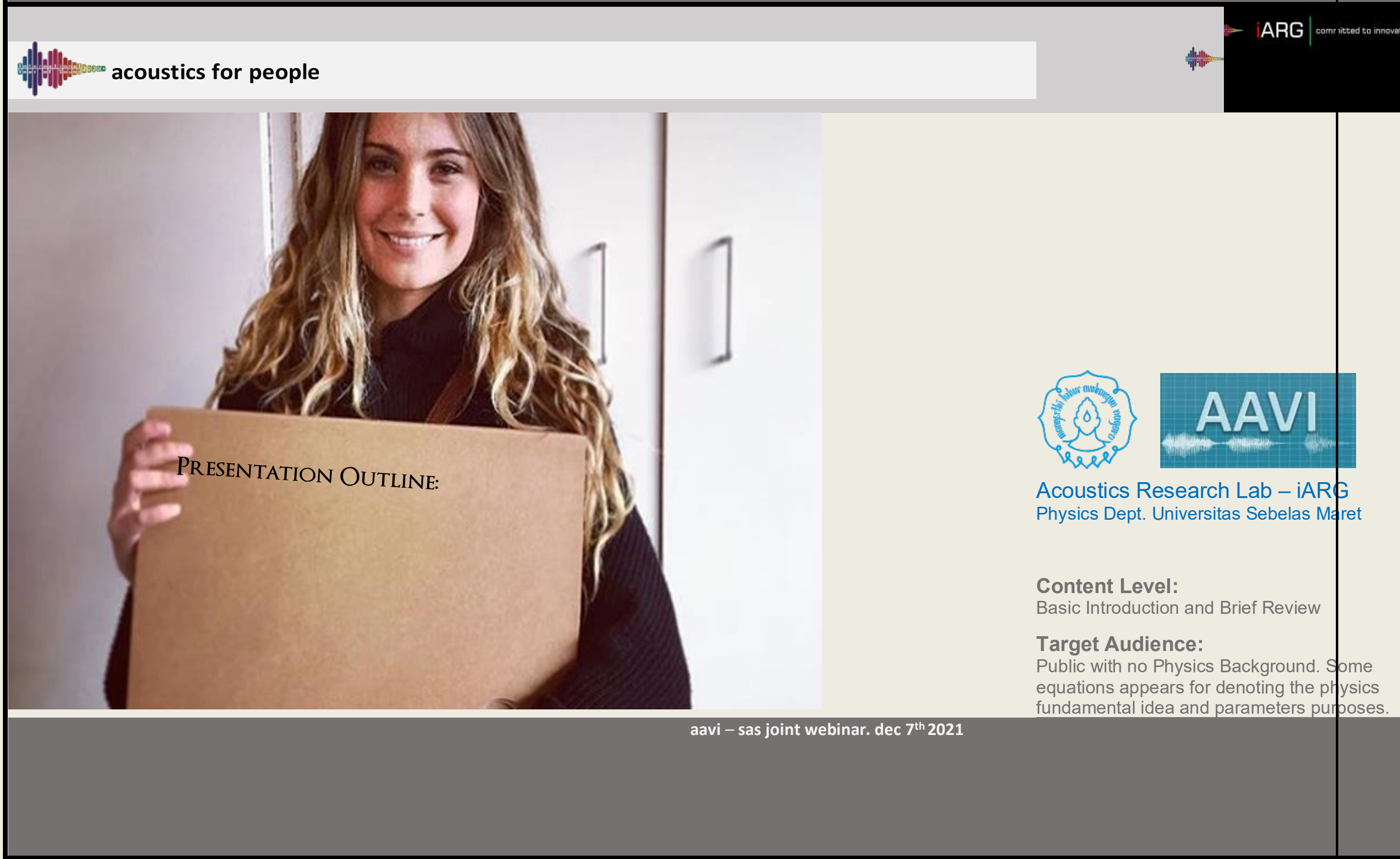
acoustics for people
iARG
Presentation Outline:
AAVI
Acoustics Research Lab – iARG
Physics Dept. Universitas Sebelas Maret
Content Level:
Basic Introduction and Brief Review
Target Audience:
Public with no Physics Background. Some equations appears for denoting the physics fundamental idea and parameters purposes.
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idea inspiration

introduction

noise and sound propagation

- ★ The Unusual Phenomena
- ★ Metamaterial Definition
- ★ The Pioneers in the Field

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acoustics for people

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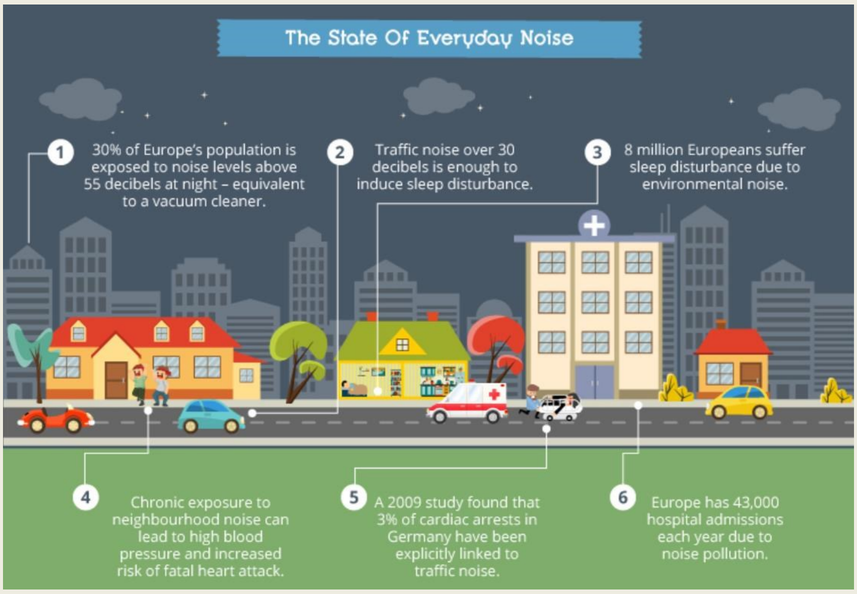

https://resonics.co.uk/metamaterials-soundproofing-the-future/

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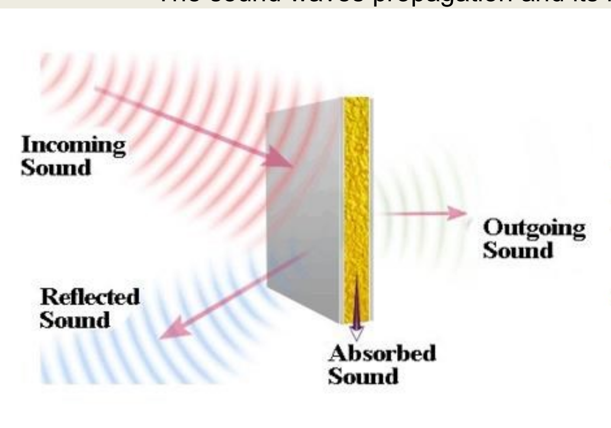
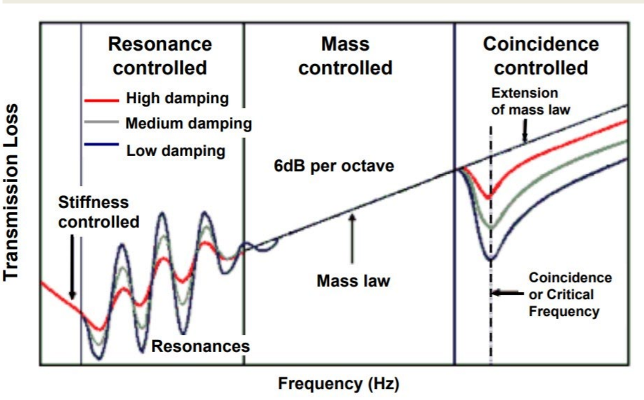
introduction: sound propagation

The sound waves propagation and its interaction with (conventional) materials





What if we can replace any material molecules with an artificial and tailored unit cell structure in the order of much less than the wavelength?

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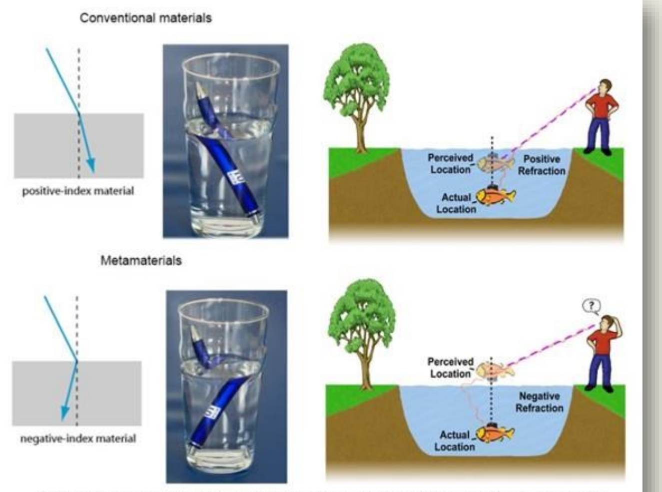
metamaterials



https://medium.com/@materialexpress.org/meta-material-cloaking-the-wizard-cloak-from-harry-potter-7b611c28ff0f

Martin Beech. The Physics of invisibility. Springer. 2012

the exotic and unusual properties of metamaterials

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the definitions

metamaterials*: etymology

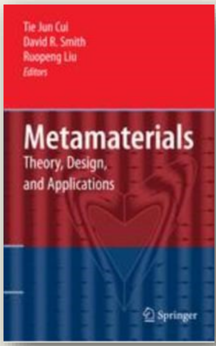
Metamaterials is a compound word composed of two terms “meta” and “materials”.
Meta literary means “beyond” then metamaterials means “beyond-materials.”

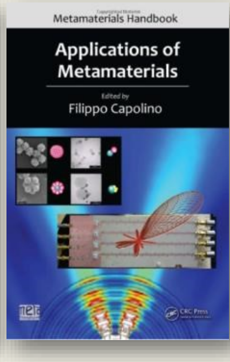
definition

Referred to composite artificial materials which are engineered to produce unusual effective material properties or exhibit exotic behaviors which are not readily available in nature. This anomalous behaviors are not due their microscopic but effective material properties resulting from arrangement, geometrical shapes and dimensions of the engineered composite.

classification

Metamaterials can be grouped using different criteria such as:
Geometry: can be1D, 2D or 3D structures
Physics: can be studied in electromagnetics, acoustics, thermodynamics, mechanics, optics or other realms.
Effective material properties: can be categorized based on their negative, positive, extreme or near-zero effective material properties.





*Seyyed Hussein Seyyed Esfahlani: Electromagnetic inspired Acoustic Metamaterials: Studying the Applications of Sound-Metastructures Interactions based on Different Wave Phenomena. PhD. Thesis. Ecole Polytechnique Federale de Lausanne. 2017

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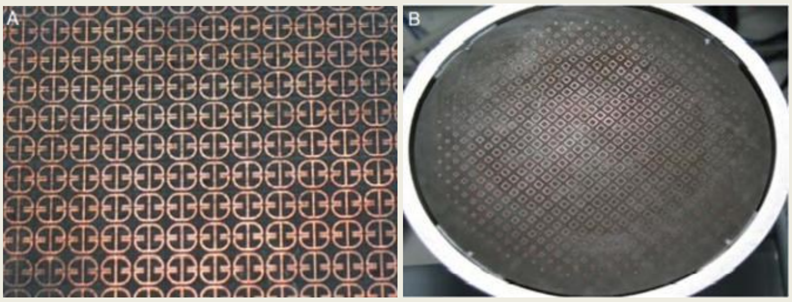
actual definition

metamaterials*:

A metamaterial is a microscopic composite of periodic or non-periodic structure, whose function is due to both cellular architecture and the chemical composition.

If the material is regarded as an effective medium, there is an additional requirement the cellular size is smaller than or equal to the sub-wavelength.



A periodic structure equivalent to inhomogeneous (gradient) medium

A non periodic structure equivalent to an homogeneous medium

*Tiu Jun Cui, David R. Smith., and Ruopeng Liu. Metamaterials Theory, Design and Applications. Springer. 2010

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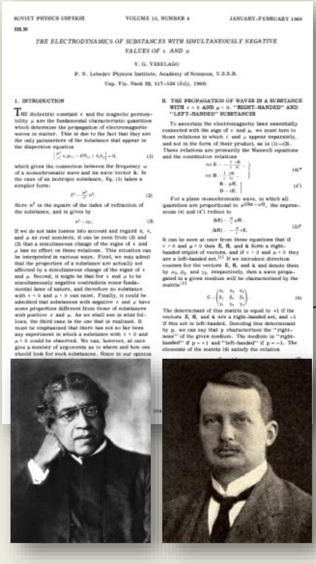
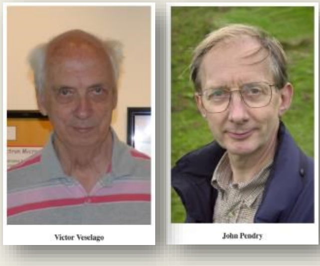
the pioneers

early historical background electromagnetic metamaterials



First actual development
1948: Winston E. Kock [Bell System Technical Journal, 27(1):58-82. 1948]

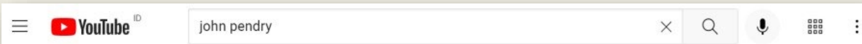
First theoretical description of negative index materials
1968: Victor G. Veselago [Soviet Physics Uspekhi, 10(4): 509, 1968]
Hypothetic materials could transmit waves with phase velocity anti-parallel to the direction of Poynting vector which is contrary to wave propagation in conventional materials. This study is considered as one of the pillars of metamaterial field.



Chiral properties of material
1898: Jagadish Chandra Bose
1914: Karl Ferdinand Lindman

Ma et al.
Meta chirality: Fundamental, Construction and Applications. Nanomaterials 2017,7, 116; doi:10.3390/nano7050116

Fully realize of the Left-Handed (LH) metamaterial.
John B. Pendry (British Professor) propose the LH metamaterial (as oppose to Right-Handed, RH, materials) which allows an electromagnetic waves to convey energy with group and phase velocities in opposite directions.
1996, 1998: metallic wires aligned along the direction of waves could provide negative permittivity (□□□).
1999: demonstrated a split ring with its axis palced along the direction of wave propagation could exhibit negative permeability (□□□).
2000: Proved that such a negative index materials makes a perfect lens..



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inspiration idea

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the brief physics

material properties

★ Metamaterials

★ Acoustic Metamaterials and Metesurfaces

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materials properties

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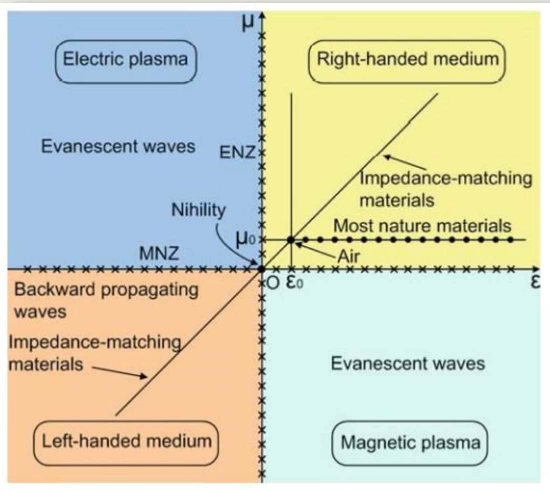

metamaterials properties: □-□Domain

Material properties characterized by an electric permittivity (□) and magnetic permeability (□).

Free space or air are regarded as the thinnest material in nature whose permittivity ε_0 and permeability is μ_0. The relative value are defined as $\varepsilon_r = \varepsilon/\varepsilon_0$ and $\mu_r = \mu/\mu_0$ respectively, which define another important parameter, the refractive index, as $n = \sqrt{\varepsilon_r \mu_r}$

Metamaterials brings the possibilities to realize all material properties by designing different cellular architectures and using different substrate materials.

First Quadrant [□,□□0]: Right =handed material (RHM), Second quadrant [□□0,□□0] denotes electric plasma which support evanescent waves. Third quadrant [□,□□0] is wellknown as left-handed material (LHM). Forth quadrant [□□0,□□0] represent magnetic plasma which support evanescent waves.

Tiu Jun Cui, David R. Smith., and Ruopeng Liu. Metamaterials Theory, Design and Applications. Springer. 2010

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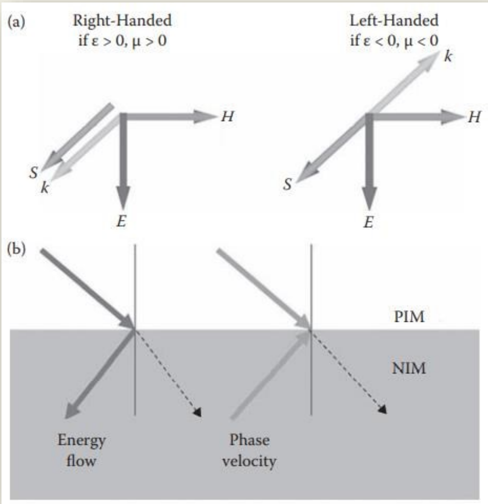
metamaterial properties

metamaterials properties: □-□Domain [2]



Naginov and Podolskiy., Tutorials in Metamaterials. CRC Press. 2012

According to Maxwell Equations,

$$\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$$
$$\nabla \times \mathbf{H} = +\partial \mathbf{D}/\partial t$$
$$\nabla \cdot \mathbf{D} = \rho$$
$$\nabla \cdot \mathbf{B} = 0$$

It is suggest that for RHM, the electric field ***E***, the magnetic field ***H*** support propagating waves and form right handed system with the wave vector *k*, and the refractive index is positive (positive index material, PIM).

$$k \times E = \frac{\omega}{c}\mu H$$
$$k \times H = -\frac{\omega}{c}\varepsilon E.$$

The Poynting vector defined as,

$$S = \frac{c}{4\pi} E \times H$$

is parallel to the *k*-vector.

Contrary to the RHM, for the LHM the electric field, the magnetic field and wave vector form a left-handed system. The refractive index value is negative (NIM), and the Poynting vector is anti-parallel to the *k*-vector.

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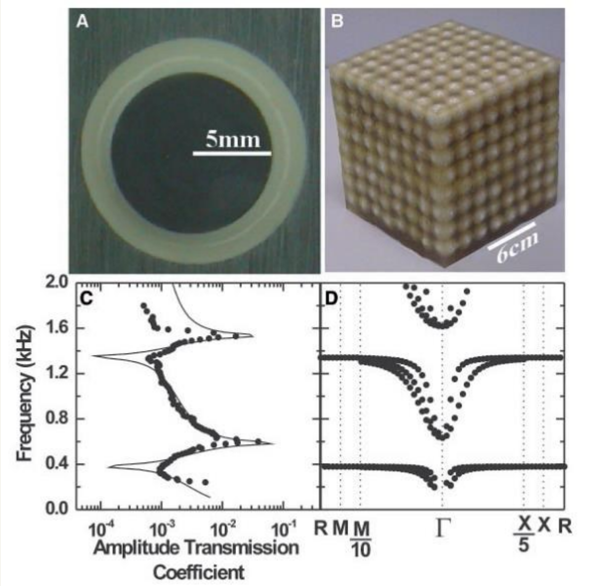
acoustic metamaterials



Inspired by the work in electromagnetic waves, in 2000, Liu et al. proposed the first realization of acoustic metamaterials, which consist of a matrix of silicone rubber-coated lead spheres. The first resonance frequency is around 400 Hz and the size of the structure is two orders of magnitude smaller than the corresponding wavelength, thus bringing the long existed concept of phononic crystals into the acoustic metamaterials realm.

The strong dispersion in the dynamic mass density, either extremely large or negative, breaks the mass-density law of sound transmission. This revolutionized the way we treat and manipulate acoustic waves.

Locally Resonant Sonic Materials
Zhengyou Liu *et al.*
Science **289**, 1734 (2000);
DOI: 10.1126/science.289.5485.1734

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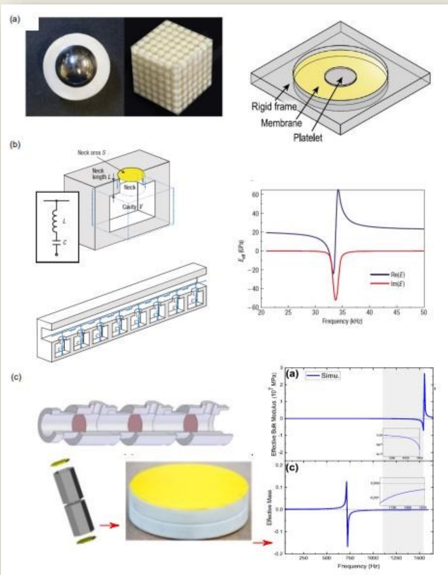
acoustic metamaterials



The acoustic metamaterials, which exhibit exotic constitutive parameters in the effective medium sense, can therefore control the acoustic waves in an unusual manner unprecedented. By taking the effective medium theory, the size of the unit cells of the acoustic metamaterials generally needs to be sufficiently smaller compared to the operating wavelength (typically about ten times smaller).

Examples of resonant acoustic metamaterials:
(a). Negative mass density ($\rho < 0$) schematic illustrations of sonic crystals and a decorated membrane-type metasurface;
(b). Negative effective bulk modulus ($E < 0$): the Helmholtz resonator unit cell, consisting of a rectangular cavity and a cylindrical neck, filled with water;
(c). Double negativity ($\rho < 0, E < 0$): the composite structure consisting of interspaced membranes and side holes.

Crystals 2020, 10, 686; doi:10.3390/cryst10080686

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the major theories

acoustic wave equation

Acoustic waves is a mechanical waves and are therefore characterized by three interrelated quantities: acoustic pressure P, particle velocity u, and change of density ρ.

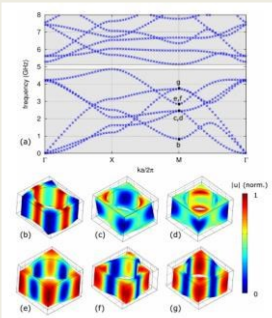
The particle motion equation (Newton's second law), describes the relationship between P and u; the continuity equation (the law of mass conservation), describes the relationship between u and ρ; whereas the equation of state describes the relationship between P and ρ.

$$\rho \frac{du}{dt} = -\frac{\partial P}{\partial x}$$

$$\frac{\partial^2 P}{\partial x^2} = \frac{1}{c_0^2}\frac{\partial^2 P}{\partial t^2}$$

Liao et al. Adv. Mater. Technol. 2021, 6, 2000787
DOI: 10.1002/admt.202000787

major theories
about acoustic metamaterials



Vincent Laude et al. 9 May 2011 / Vol. 19, No. 10 / OPTICS EXPRESS

crystal lattice and energy band gap theor

Phononic crystals is a periodic structur composed unit of acousti metamaterials arranged in space tha similar to crystal structure in solid stat physics. Because of the periodi structures, the energy band is define with regard to the special dispersio relation when elastic waves propagat in a phonon crystal. The dispersio relation curves for a certain frequenc range are called ban structures. Within the frequency rang of the bandgap, the propagation c acoustic waves is inhibited; b comparison, in other frequency ranges the acoustic waves can propagat without loss.

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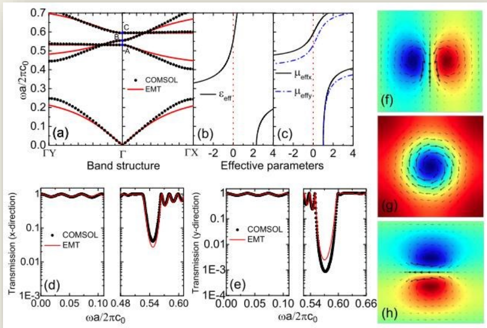
the major theories

effective medium theory

In classical theory, the behaviors of transmitted and reflected acoustic waves in a uniform medium can be solved analytically using rigorous mathematical equations. On the other hand, acoustic characteristics can be difficult to analyze when the medium is nonuniform. It can be solved once the heterogeneous medium is treated as a homogeneous medium under certain approximation conditions. In this way, an effective medium theory can be developed. Regarding an entire material composed of different structures and materials as a uniform material through the approximation method to gain the approximate value of a characteristic (such as effective sound velocity and mass density) of the studied material is considered valid when the desired precision is satisfied, which is the core concept of the theory.



Xiujuan Zhang & Ying Wu (2015), SCIENTIFIC REPORTS | 5 : 7892 | Adv. Mater. Technol. 2021, 6, 2000787 DOI: 10.1038/srep07892

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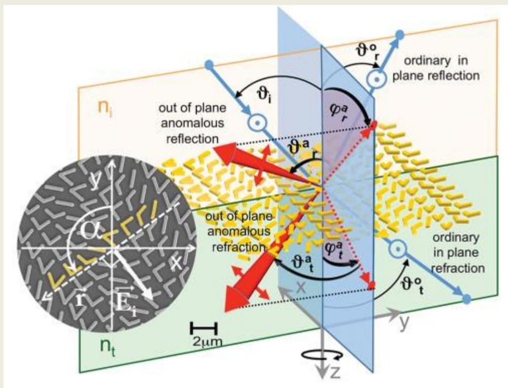
the major theories

general Snell's law

The angle of refraction is related to the acoustic properties of the two media when the incident angle is fixed. However, this physical law is established on the condition that the phase of the acoustic waves increases gradually along the travel path. By contrast to natural materials, AMs can manipulate the wave front and phase of acoustic waves; therefore, the propagation of acoustic waves does not abide by traditional Snell's law.



A general Snell's law, which was quite different from traditional Snell's law, was first proposed by Yu et al. in the field of electromagnetism. Subsequently, the generalized Snell's law was extended by Li et al. to the field of acoustics. The direction of reflection or refraction can be changed by designed AMs that occupy a phase mutation covering the range 0–2π, and abnormal acoustic refraction or reflection and other interesting phenomena may occur.

Li et al. SCIENTIFICREPORTS| 3 : 2546 | DOI: 10.1038/srep025462 N. Yu, P. Genevet, M. Kats, F. Aieta, J. Tetienne, F. Capasso, Z. Gaburro, Science 2011, 334, 333 F Aieta., N. Yu, P. Genevet, M. Kats, J. Tetienne, F. Capasso, Z. Gaburro, Nano Letters. dx.doi.org/10.1021/nl300204s

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acoustic metamaterials: electromagnetic analogy

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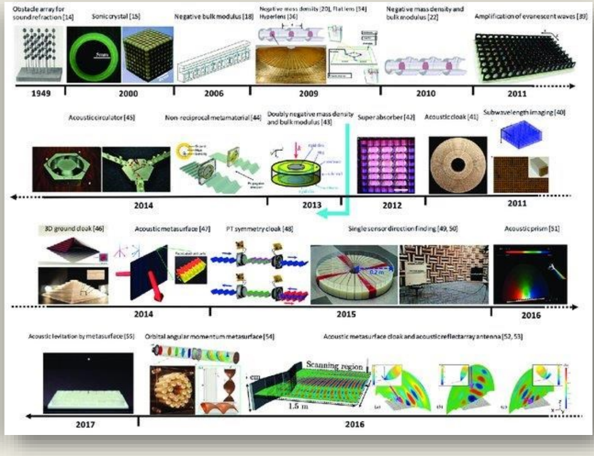
time-laps of the evolution of acoustic metamaterials*

Acoustics	Electromagnetism (TMz)	Analogy
$\frac{\partial P}{\partial x} = -i\omega\rho_x u_x$ $\frac{\partial P}{\partial y} = -i\omega\rho_y u_y$ $\frac{\partial u_x}{\partial x} + \frac{\partial u_y}{\partial y} = -i\omega\beta P$	$\frac{\partial E_z}{\partial x} = -i\omega\mu_y H_y$ $\frac{\partial E_z}{\partial y} = i\omega\mu_x H_x$ $\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} = -i\omega\varepsilon_z E_z$	
Acoustic pressure P	Electric field E_z	$-E_z \leftrightarrow P$
Particle velocity u_x u_y	Magnetic field H_x, H_y	$H_y \leftrightarrow -u_x$ $H_x \leftrightarrow u_y$
Dynamic density ρ_x ρ_y	Permeability μ_x μ_y	$\rho_x \leftrightarrow \mu_y$ $\rho_y \leftrightarrow \mu_x$
Dynamic compressibility β	Permittivity ε_z	$\varepsilon_z \leftrightarrow \beta$



*Seyyed Hussein Seyyed Esfahlani: Electromagnetic inspired Acoustic Metamaterials: Studying the Applications of Sound-Metastructures Interactions based on Different Wave Phenomena. PhD. Thesis. Ecole Polytechnique Federale de Lausanne. 2017

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acoustic metasurfaces

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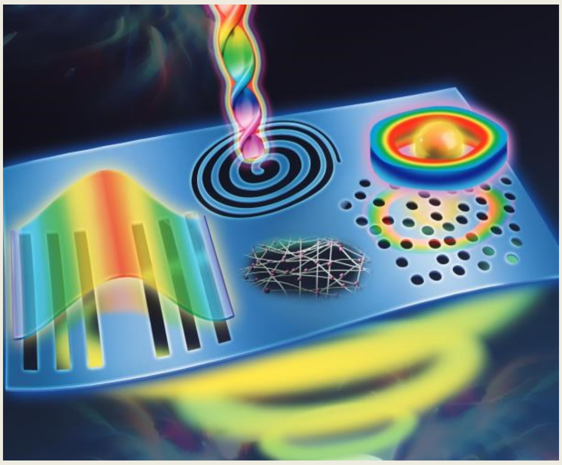
acoustic metasurfaces: frequency selective surface



Acoustic metasurfaces, as a sub-category of acoustic metamaterials. The key feature of metasurfaces is that compared the bulk structures that are commonly associated with acoustic metamaterials, they usually have a sub-wavelength thickness, which greatly reduce the geometric complication.

The acoustic metasurface concept is based on arrays of subwavelength units (regarded as acoustic meta atom), including (but not limited to) Helmholtz resonators , membranes and coiling-up space structures. These units can be used to realize and showcase fascinating wavefront engineering features, including self-bending beams, a twisted wavefront (for example, acoustic vortices), non-diffraction beams, diffuse reflection, asymmetric transmission, beam focusing, artificial Mie resonances and near-perfect absorption.

Advanced Functional Materials, Vol 28. No 36. September 5. 2018

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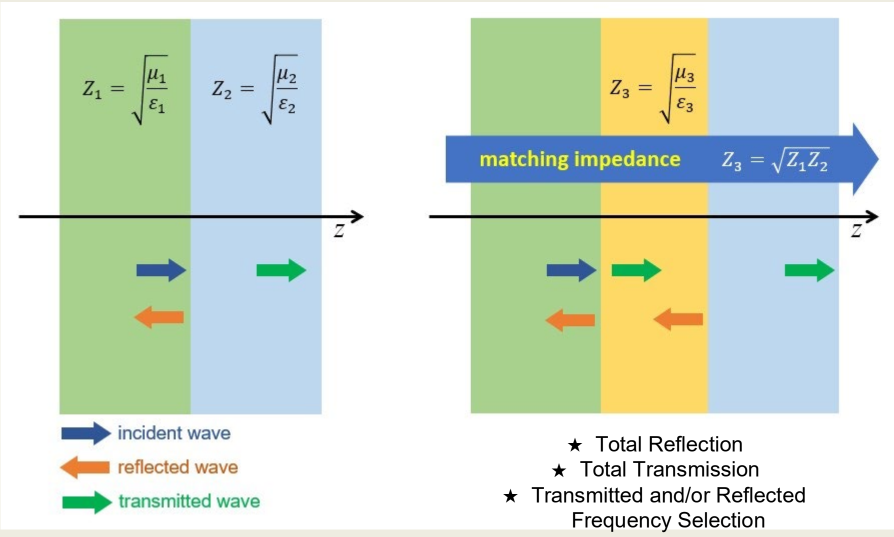
idea of matching impedance

wave propagation in layered medium: an approach for frequency selection purposes



★ Total Reflection
★ Total Transmission
★ Transmitted and/or Reflected Frequency Selection

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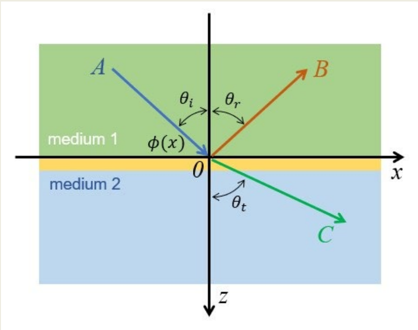
what if we can tailored the insertion layer?

Dimension & Structure
- Sub-wavelength in thickness
- Could be homogeneous or gradient materials
- Could be LH (NIM), RH (PIM), resonant or non resonant architecture.



Type
- Reflective [coiled up space]
- Transmission type [Helmholtz resonator]
- Resonant and anti-resonant [membrane]
- Secondary local grating

If the interface is located in the plane of z=0, it is able to create a phase discontinuity, denoted as $\phi(x)$, for the incident wave as it is reflected or passes through the interface. For 1D cases, we can derive the relationship between the angles of incidence and reflection from Fermat's principle: the acoustic path length (defined as the physical length multiplied by the refractive index of the medium) of a ray of an acoustic wave from point A to point B after being reflected off the interface (or to point C after being refracted into a different medium) is a minimum.

From wave theory, the difference in the length of the acoustic path is equivalent to the variation of the propagation phase. Hence, Fermat's principle can also be understood by considering that the trajectory taken by the acoustic wave between two points, for example, A and B (or C), should be the path of least phase change.

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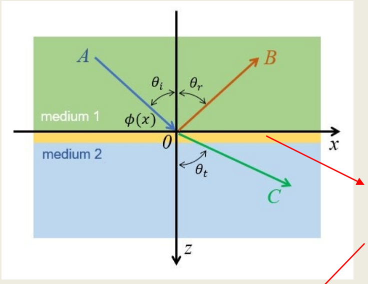
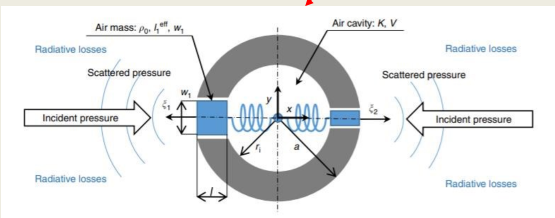
the way on tailoring the insertion layer



regarded as an array of acoustic meta-atom



acoustic metasurface: frequency selective surface

For the reflection case, it can be derived that when we desire a ray of an acoustic wave to leave point A located at (xA, zA), impinge on point O located at (x, 0) with an angle of incidence θi and then bounce back to point B located at (xB, zB), the total phase variation along this path taken by the acoustic wave should be*:

$$\Psi_r(x) = \phi(x) + k_1\sqrt{(x-x_A)^2 + z_A^2} + k_1\sqrt{(x_B-x)^2 + z_B^2}$$

Φ(x) is a nonlinear then the reflection

Furthermore, if designed to be function of x, angles of and refraction depend on the position along the interface, which can be easily understood in the context of geometrical acoustics. This theory suggests the possibility of producing arbitrary manipulation over the reflected and transmitted acoustic beams by controlling the nonlinear function such that the local acoustic response at each point behaves differently.

*Assouar B, Liang B, Wu Y, Li Y, Cheng J-C, et al. (2018) Acoustic metasurfaces. Nature Reviews Materials. Available: http:// dx.doi.org/10.1038/s41578-018-0061-4.

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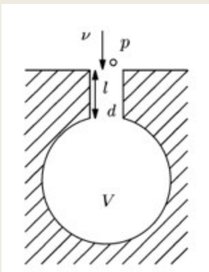
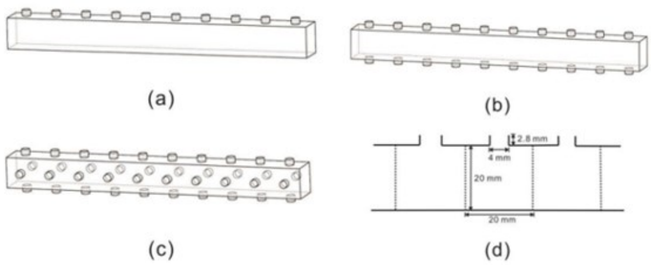
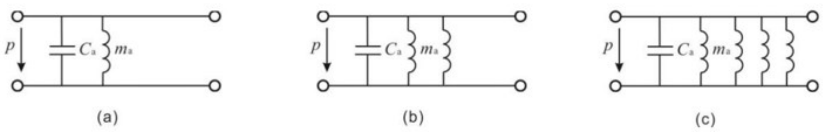
design of the structure





Schematics of single branch and multiple branch opening metamaterials. (a) Single branch. (b) Double branch. (c) Quadruple branch. Ten unit cells are included in each structure. (d) The side view and dimensions of three unit cells with single branch openings. [Chen Shen, 2016]



acoustic circuit and the design principle: example

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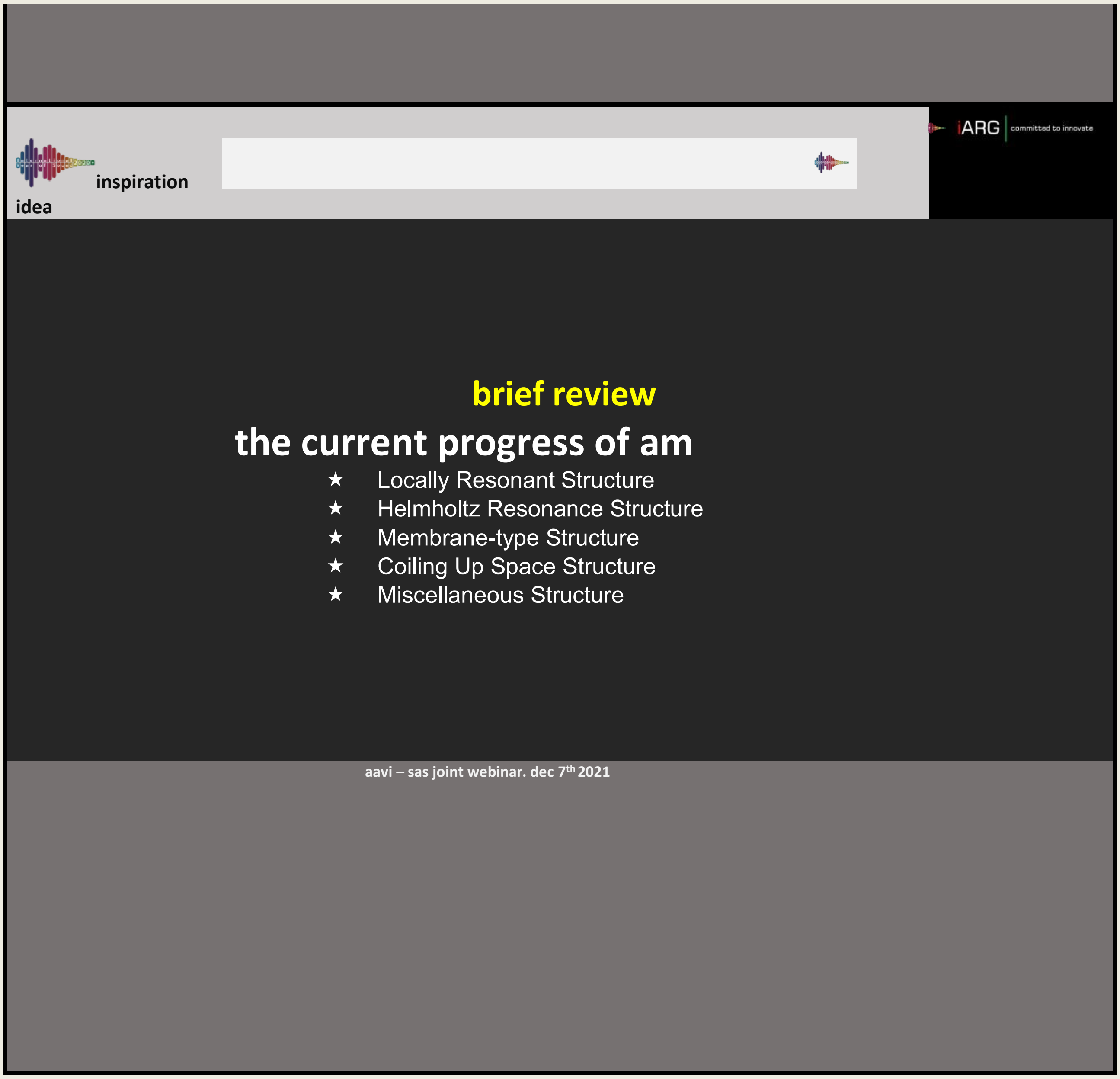
inspiration
idea
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brief review
the current progress of am
★ Locally Resonant Structure
★ Helmholtz Resonance Structure
★ Membrane-type Structure
★ Coiling Up Space Structure
★ Miscellaneous Structure
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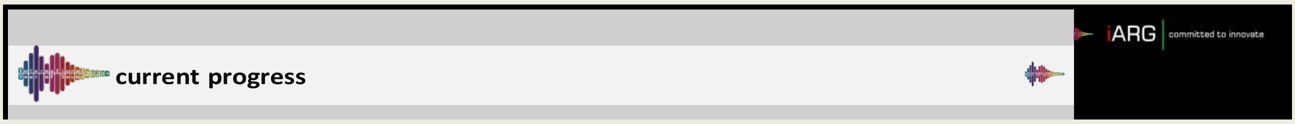
current progress
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REVIEW

ACOUSTICS

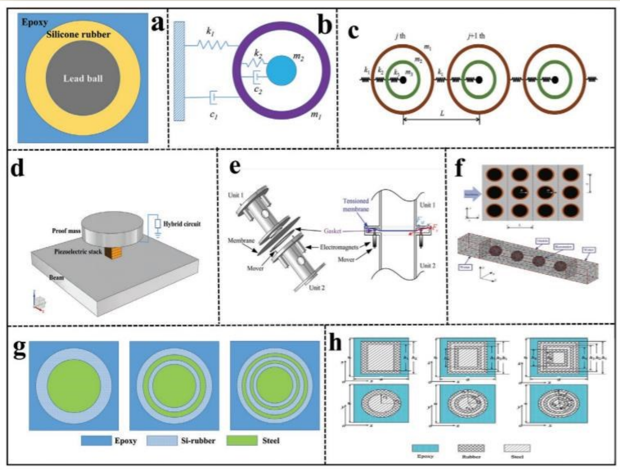
Acoustic metamaterials: From local resonances to broad horizons

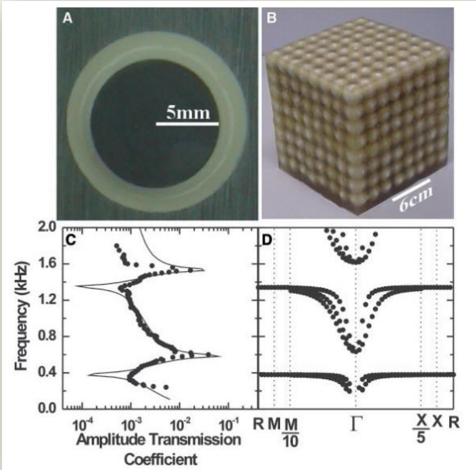
Guancong Ma* and Ping Sheng*

10.1126/sciadv.1501595

Within a time span of 15 years, acoustic metamaterials have emerged from academic curiosity to become an active field driven by scientific discoveries and diverse application potentials. This review traces the development of acoustic metamaterials from the initial findings of mass density and bulk modulus frequency dispersions in locally resonant structures to the diverse functionalities afforded by the perspective of negative constitutive parameter values, and their implications for acoustic wave behaviors. We survey the more recent developments, which include compact phase manipulation structures, superabsorption, and actively controllable metamaterials as well as the new directions on acoustic wave transport in moving fluid, elastic, and mechanical metamaterials, graphene-inspired metamaterials, and structures whose characteristics are best delineated by non-Hermitian Hamiltonians. Many of the novel acoustic metamaterial structures have transcended the original definition of metamaterials as arising from the collective manifestations of constituent resonating units, but they continue to extend wave manipulation functionalities beyond those found in nature.

Ma and Sheng Sci. Adv. 2016;2:e1501595 26 February 2016





Liao et al. Adv. Mater. Technol. 2021, 6, 2000787

DOI: 10.1002/admt.202000787

Locally Resonant Sonic Materials
Zhengyou Liu *et al.*
Science **289**, 1734 (2000);
DOI: 10.1126/science.289.5485.1734

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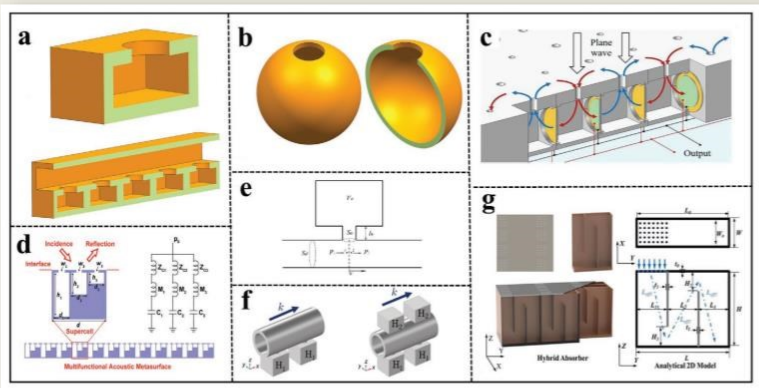
helmholtz resonant structure



Helmholtz resonance structures. a) 1D Helmholtz resonant cavity.
b) Helmholtz resonant cavity with open hollow sphere model.
c) Contiguous coupled Helmholtz resonator array. Reproduced with permission.
d) Helmholtz resonator array of three adjacent Helmholtz resonators with different cavities.
e) Helmholtz resonators periodically arranged on one side of pipe. Reproduced with permission.
f) Cube Helmholtz cavities with different volumes arranged on one or both sides of pipe.
g) Hybrid resonance structure combining Helmholtz resonator and coiling-up space structure.

Liao et al. Adv. Mater. Technol. 2021, 6, 2000787

DOI: 10.1002/admt.202000787

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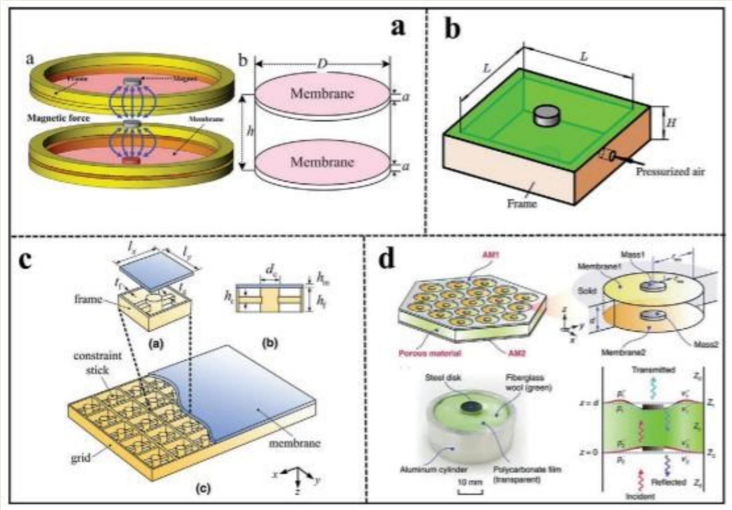
membrane type structure



Membrane-type AMs with ma block attached.
a) Two-layer actively controlled AMs with membrane-typ structure.
b) Static pressurization membranetype AMs.
c) Constrained membrane-typ AMs.
d) Layered membrane-type AMs filled with porous materials.

Liao et al. Adv. Mater. Technol. 2021, 6, 2000787

DOI: 10.1002/admt.202000787

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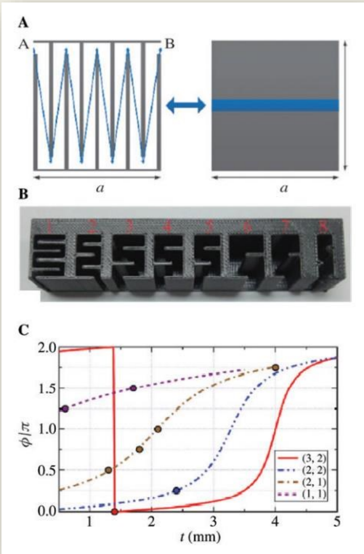
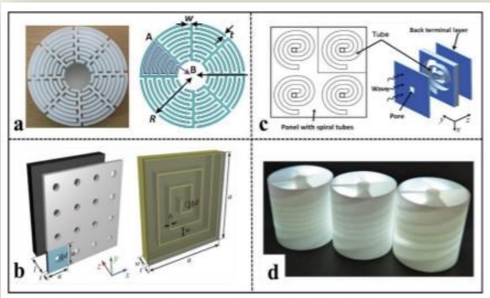
coiling upspacestructure





The idea of slow sound

Reflective Metasurface Structure.

Acoustic metasurfaces based on coiling-up space structures with subwavelength dimensions force acoustic waves to propagate along a coiled path, which is substantially longer than the physical dimensions of the structure. This longer path length allows the modulation of reflected waves and for the reflected phase shift to be tailored within the full 0_ 2π range. However, the zigzag structure must be designed to avoid excessive thermoviscous losses and for optimal impedance matching.

Liao et al. Adv. Mater. Technol. 2021, 6, 2000787

DOI: 10.1002/admt.202000787

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miscellaneous structures

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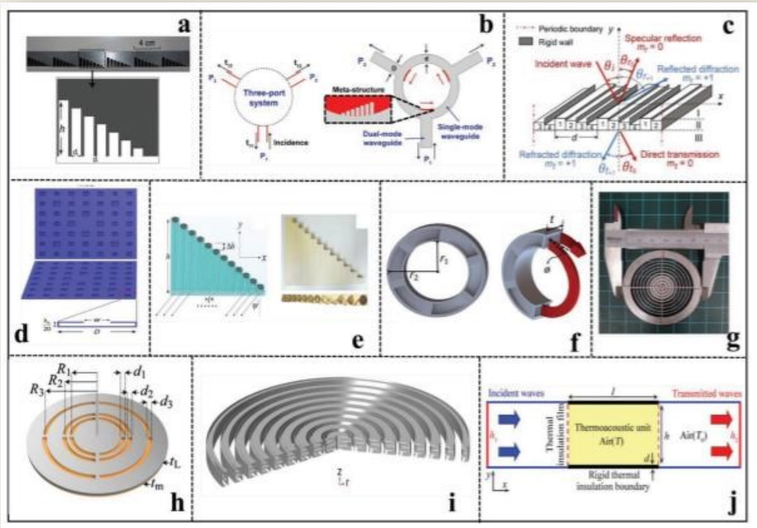
other structures of acoustic metamaterials reported in literatures



Liao et al. Adv. Mater. Technol. 2021, 6, 2000787
DOI: 10.1002/admt.202000787

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inspiration idea

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challenges and opportunity

applications

- To Create a Quieter World

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cloaking invisibility and super lens

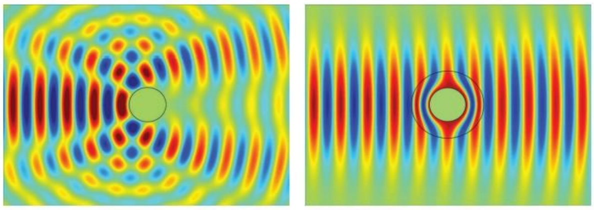
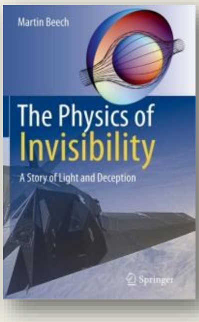
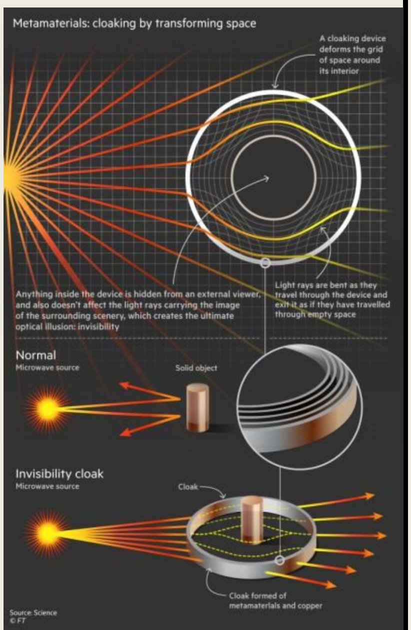
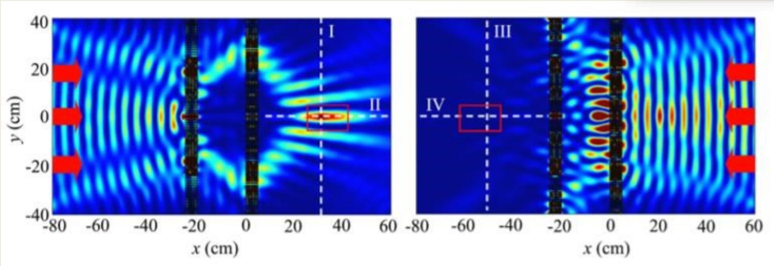


Figure 1. Controlling acoustic wave scattering from an object. Left: The scattering of a wave incident from the left from a rigid object is obvious: the reflection is quasi-specular, the shadow is deep, and a portion of wave power is spread in all directions. Right: Surrounding the same object with an ideal cloaking shell shows the absence of both reflection and shadow, while power is transmitted around the metamaterial object with virtually no losses.







J.-P. XIA et al. PHYS. REV. APPLIED 10, 014016 (2018)

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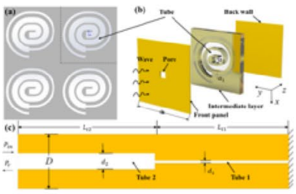
absorption and noise reduction

Quarter Wavelength Resonance	Helmholtz Resonance	Hybrid Resonance	Fano, Split Ring and Combined Structure

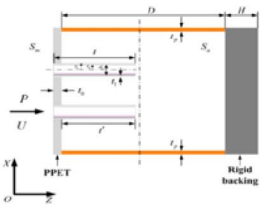
Quarter Wavelength Resonance



A low-frequency sound absorbing material with subwavelength thickness
Changru Chen, Zhibo Du, Gengkai Hu, and Jun Yang
Appl. Phys. Lett. 110, 221903 (2017); doi: 10.1063/1.4984095

J. Appl. Phys. 127, 064902 (2020); doi: 10.1063/1.5119408

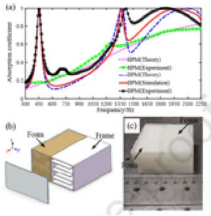
Helmholtz Resonance



Materials 2020, 13, 1091; doi:10.3390/ma13051091

A microstructure material design for low frequency sound absorption
Thomas Duponta,*, Philippe Leclaire, Raymond Panneton, Olga Umnova
Applied Acoustics 136 (2018) 86-93

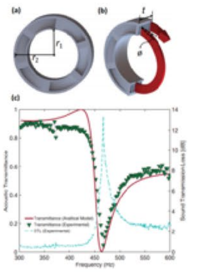
Hybrid Resonance



Zhao, H., Wang, Y., Yu, D., Yang, H., Zhong, J., Wu, F., Wen, J., A double porosity material for low frequency sound absorption, Composite Structures (2020), doi: https://doi.org/10.1016/j.compstruct.2020.111978

H. Zhao et al./Applied Acoustics 142 (2018) 11–17

Fano, Split Ring and Combined Structure



PHYSICAL REVIEW B 99, 024302 (2019)

Acoustics 2019, 1, 590–607; doi:10.3390/acoustics1030035

Acoustic metamaterials for sound attenuation and air ventilation performance

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inspiration idea


highlight of
uns research and achievements
★ Batik Inspired Design
★ Open – Ventilated Metamaterials,
PPEA Series ★ Advances in SCs
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acoustic metamaterials for aircraft noise
Sound insulation layer for engine nacelle
Sound absorber, barrier material for cabin sidewall noise reduction
Sound absorption and noise reduction performance of cabin window material and structure
Constrained space exhaust muffler: multiple tonal noise controller.
N219
N245
R80
Norsonic
GeoNoise
Brüel & Kjær
an HBK company
RAI
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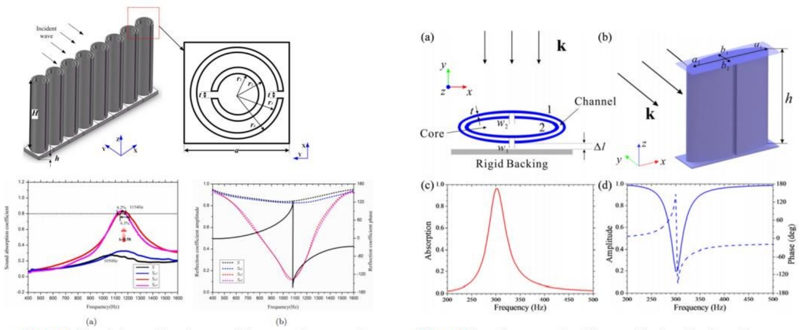
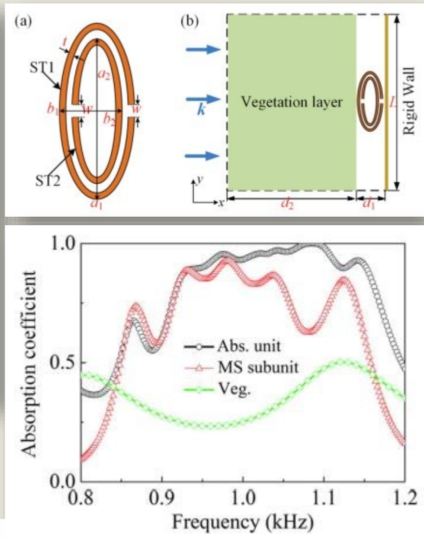
split tube / nested resonator



Gao et al. Sound absorption of a new oblique-section acoustic metamaterial with nested resonator.
Modern Physics Letter B (10 pages) 2018
DOI: 10.1142/S0217984918500409

Wu et al. Low-frequency tunable acoustic absorber based on split tube resonator
APPLIED PHYSICS LETTERS 109, 043501 (2016)
[http://dx.doi.org/10.1063/1.4959959]



Implementation Example

Enhancement of sound absorption via vegetation with a metasurface substrate
Xing-Feng Zhu , Siu-Kit Lau , Zhenbo Lu, Lai Fern Ow
Applied Acoustics 165 (2020) 107309

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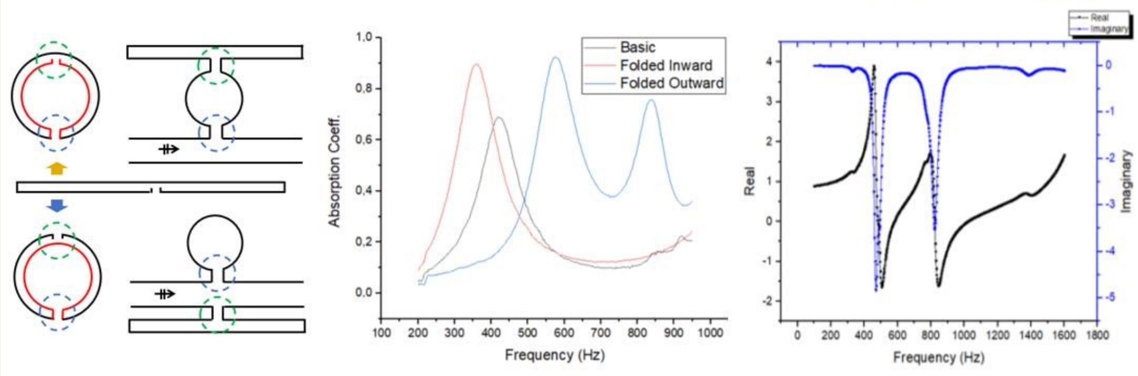
batik inspired structure:kawung

folded coplanar resonator **inspired by kawung batik design**



Tunable, multi-resonance, flexibility in design, high performance, low frequency absorption

Journal of Physics: Conference Series 1896 (2021) 012028. doi:10.1088/1742-6596/1896/1/012028

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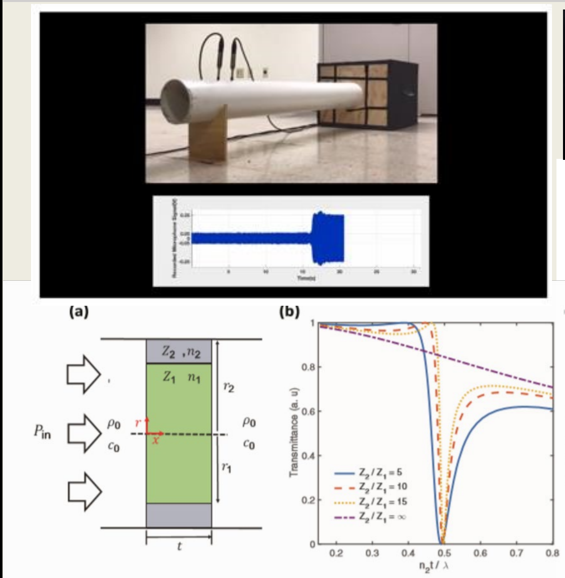
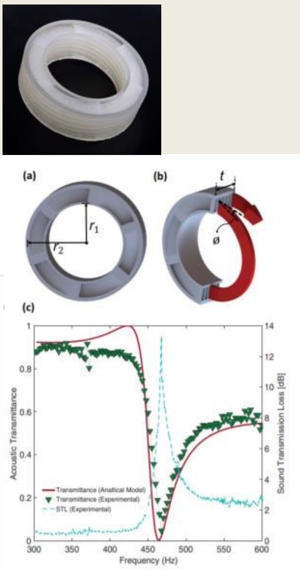
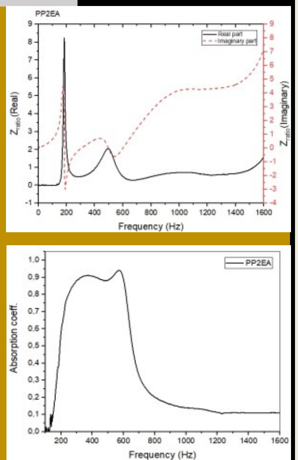
ventilated and open acoustic metamaterials





brandnew ppeaseriesopenventilated metamaterialresearchproject2021



Ghaffarivandavagh et al.
Ultra-open acoustic metamaterial silencer based on Fano-like interference.
PHYSICAL REVIEW B 99, 024302 (2019)
Acoustics 2019, 1, 590–607; doi:10.3390/acoustics1030035

Boston University Innovation
https://www.smithsonianmag.com/innovation/new-material-acts-like-giant-mute-button-180971848/

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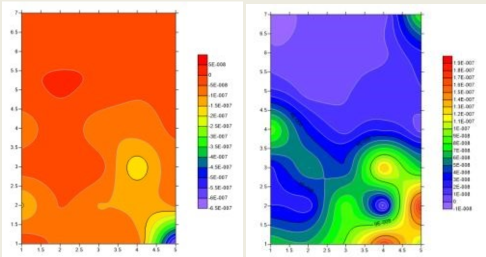
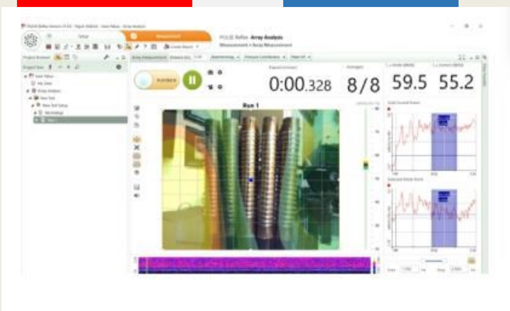
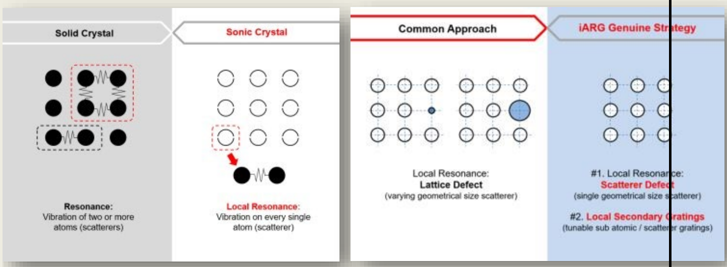
sonic crystals



collimatior deaf attenuation



our sonic crystal: tunable local resonance in a single geometrical dimension scatterers



Measured and recorded using nearfield acoustic camera. Real-time visualization of splitting and asymmetrical transmission on sonic crystals: all band spatial collimation and attenuation.

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Nissan Ariya Concept with acoustic meta-material for outstanding noise insulation

https://www.youtube.com/watch?v=yE0Djsp6Fug

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sekian

terima kasih

passion, pride and respect **alhamdulillah**

Presentation material available at the following link:
https://www.researchgate.net/publication/356818737_acoustic_metamaterials_and_metasurfaces_the_physics_principles_inspirations_idea_and_its_applications/stats

Physicists discover special transverse sound wave

By acousticssg | 9th December 2021

0 Comment

Physicists discover special transverse sound wave

Can you imagine sound traveling in the same way as light does? A research team at City University of Hong Kong (CityU) has discovered a new type of sound wave: The airborne sound wave vibrates transversely and carries both spin and orbital angular momentum like light does. The findings shattered scientists' previous beliefs about the sound wave, opening an avenue to the development of novel applications in acoustic communications, acoustic sensing and imaging.

The research was initiated and co-led by Dr. Shubo Wang, Assistant Professor in the Department of Physics at CityU, and conducted in collaboration with scientists from Hong Kong Baptist University (HKBU) and the Hong Kong University of Science and Technology (HKUST). It was published in Nature Communications, titled "Spin-orbit interactions of transverse sound."

Beyond the conventional understanding of sound wave

The physics textbooks tell us there are two kinds of waves. In transverse waves like light, the vibrations are perpendicular to the direction of wave propagation. In longitudinal waves like sound, the vibrations are parallel to the direction of wave propagation. But the latest discovery by scientists from CityU changes this understanding of sound waves.

"If you speak to a physicist about airborne transverse sound, s/he would think you are a layman without training in university physics because textbooks say that airborne sound (i.e., sound propagating in the air) is a longitudinal wave," said Dr. Wang. "While the airborne sound is a longitudinal wave in usual cases, we demonstrated for the first time that it can be a transverse wave under certain conditions. And we investigated its spin-orbit interactions (an important property only exists in transverse waves), i.e. the coupling between two types of angular momentum. The finding provides new degrees of freedom for sound manipulations."

The absence of shear force in the air, or fluids, is the reason why sound is a longitudinal wave, Dr. Wang explained. He had been exploring whether it is possible to realize transverse sound, which requires shear force. Then he conceived the idea that synthetic shear force may arise if the air is discretized into "meta-atoms," i.e., volumetric air confined in small resonators with size much smaller than the wavelength. The collective motion of these air "meta-atoms" can give rise to a transverse sound on the macroscopic scale.

Conception and realization of 'micropolar metamaterial'

He ingeniously designed a type of artificial material called “micropolar metamaterial” to implement this idea, which appears like a complex network of resonators. Air is confined inside these mutually connected resonators, forming the “meta-atoms.” The metamaterial is hard enough so that only the air inside can vibrate and support sound propagation. The theoretical calculations showed that the collective motion of these air “meta-atoms” indeed produces the shear force, which gives rise to the transverse sound with spin-orbit interactions inside this metamaterial. This theory was verified by experiments conducted by Dr. Ma Guancong’s group in HKBU.

Moreover, the research team discovered that air behaves like an elastic material inside the micropolar metamaterial and thus supports transverse sound with both spin and orbital angular momentum. Using this metamaterial, they demonstrated two types of spin-orbit interactions of sound for the first time. One is the momentum-space spin-orbit interaction, which gives rise to negative refraction of the transverse sound, meaning that sound bends in the opposite directions when passing through an interface. Another one is the real-space spin-orbit interaction, which generates sound vortices under the excitation of the transverse sound.

The findings demonstrated that airborne sound, or sound in fluids, can be a transverse wave and carry full vector properties such as spin angular momentum the same as light does. It provides new perspectives and functionalities for sound manipulations beyond the conventional scalar degree of freedom.

"This is just a precursor. We anticipate more explorations of the intriguing properties of the transverse sound," Dr. Wang said. "In future, by manipulating these extra vector properties, scientists may be able to encode more data into the transverse sound to break the bottleneck of traditional acoustic communication by normal sound waves."

The interaction of spin with orbital angular momentum enables unprecedented sound manipulations via its angular momentum. "The discovery may open an avenue to the development of novel applications in acoustic communications, acoustic sensing and imaging," he added.

Dr. Wang is the first author and the corresponding author of the paper. Dr. Ma is another corresponding author. Collaborators include Professor Li Jensen from The Hong Kong University of Science and Technology, Ms. Tong Qing, a Ph.D. student from CityU, and other researchers from HKBU.

Source: https://phys.org/news/2021-12-physicists-special-transverse.amp

VI. PRODUCTS ON ACOUSTICS

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BLOG

For the past few months, AVCM has been actively updating our blog contents, covering acoustical-related topics of various levels, suitable for readers of all ages. Everyone is welcome to learn and provide feedback about our contents, no matter which field you are from!

Recent blog posts:

- Acoustics in Hospitals
- Human Response to Vibration

Check out the **Malaysian News** section to read some of the recent noise and vibration related articles with reference to reliable local resources:

- Noisy vehicle exhaust pipes may lead you to imprisonment and fine.
- Malaysian HR Ministry task force: Cutting workplace noise-related hearing disorders by 20%
- Noisier than before
- Alerting the public about construction noise

Social Activeness

AVCM Sdn. Bhd. is now a corporate member in the **Society of Acoustics Singapore (SAS)** and the **Society of Vibration and Acoustics Malaysia (SVAM).**

The International Year of Sound 2020
*****In view of the coronavirus (COVID-19) pandemic, the IYS 2020 Steering Committee has decided to extend the celebration of the IYS 2020 into the year 2021*****
The IYS 2020 is a global initiative to highlight the importance of sound and related sciences and technologies for all in society.
A list of events and programs have been scheduled to stimulate the understanding throughout the world of the important role that sound plays in all aspects of our society, and to encourage an understanding of the need for the control of noise in nature, in the built environment, and in the workplace.
For more info, visit: https://sound2020.org/

Stay safe during the pandemic. Let's fight through this together!

VII. ACOUSTICAL NEWS

Joint zoom seminar held on 21 September 2021 with the Thailand Acoustics and Vibration Association.

Speaker: Prof Kwanchanok Yimtae

Title of talk: Bridging the Silence with Technology and Possibilities

This joint zoom seminar organised jointly with the Thailand Acoustics and Vibration

Association on 21 September 2021 has been a great success, with 42 participants . Out of which

28 were from Thailand. Compared with the usual number of 20 plus participants

when organised solely by SAS ,this showed joint organisation does work well.

Joint zoom seminar held on 7 December 2021 with the Association of Acoustics and Vibration

Indonesia(AAVI)

Theme: International Year of Sound 2020-2021:Acoustics for People

Speakers: Dr Iwan Yahya from Indonesia

Dr Linus Ang from Singapore

Titles of Talks: Acoustic Metamaterials and Metasurfaces:the physics principles,inspirations idea and its applications by Dr Iwan Yahya

Remote work: Aircraft Noise in the Built Environment amid COVID-19 Pandemic by Dr Linus Ang

Again it has been a great success with 54 to 58 participants.

Formation of ASEAN Acoustics and Vibration Association

This is the first step of collaboration with acoustical societies from ASEAN countries. We are planning a joint seminar with the Association of Acoustics and Vibration Malaysia to be held on the International Noise Awareness Day in 2022.

We are looking forward of organising joint seminars/workshops with the Acoustics and

Vibration Associations of Indonesia and Malaysia and even regional conferences.

In this pandemic age, regional collaboration can work better than international

collaboration. We have already organized the First Regional Conference on Acoustics and Vibration (RECAV 1) with AAVI of Indonesia in 2017.**We will be looking forward in forming a regional ASEAN Acoustics and Vibration Association compared with the Western Pacific Acoustics Commission.**

There is tremendous scope for regional collaboration in acoustics and vibration.

VIII.REPORT ON CONFERENCES

The Regional Conference on Acoustics and Vibration (RECAV) organised by the Society of Acoustics(Singapore) and the Association of Acoustics and Vibration Indonesia(AAVI) was successfully held in Bali,Indonesia from 27 to 28 Nov 2017. There were 110 presentations from 14 countries with 60% of them from Indonesia. There were also some 18 exhibition booths. This reflected strong local participation and the international nature of the conference.

IX. BID FOR FUTURE INTERNATIONAL CONFERENCES

The Society of Acoustics(Singapore) will be hosting the ICSV28 in Singapore from 24 to 28 July 2022 at the Marina Bay Sands Hotel.

The Society of Acoustics(Singapore) will be bidding for hosting the ICA 2031 in Singapore in 2031.

The Society of Acoustics(Singapore) will bidding for hosting the ISTU 2024 in Singapore in 2024.

Government Bodies

www.mom.gov.sg

www.nea.gov.sg

www.lta.gov.sg

Technical and Research Sites

Corporate Sites

www.metaultrasound.com

www.noisecontrols.com

(The Society welcomes interested parties to contribute relevant websites to the above useful links. For more information, please contact us. Thank you.)

Disclaimers

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