Prospectives du LPC 2025

Acoustic panel

Detection of Very High Energy Neutrinos

LPC CAEN

cnrs IN2P3 Institut national de physique nucléaire et de physique des particules

ENSI CAEN ÉCOLE PUBLIQUE D'INGÉNIEURS CENTRE DE RECHERCHE

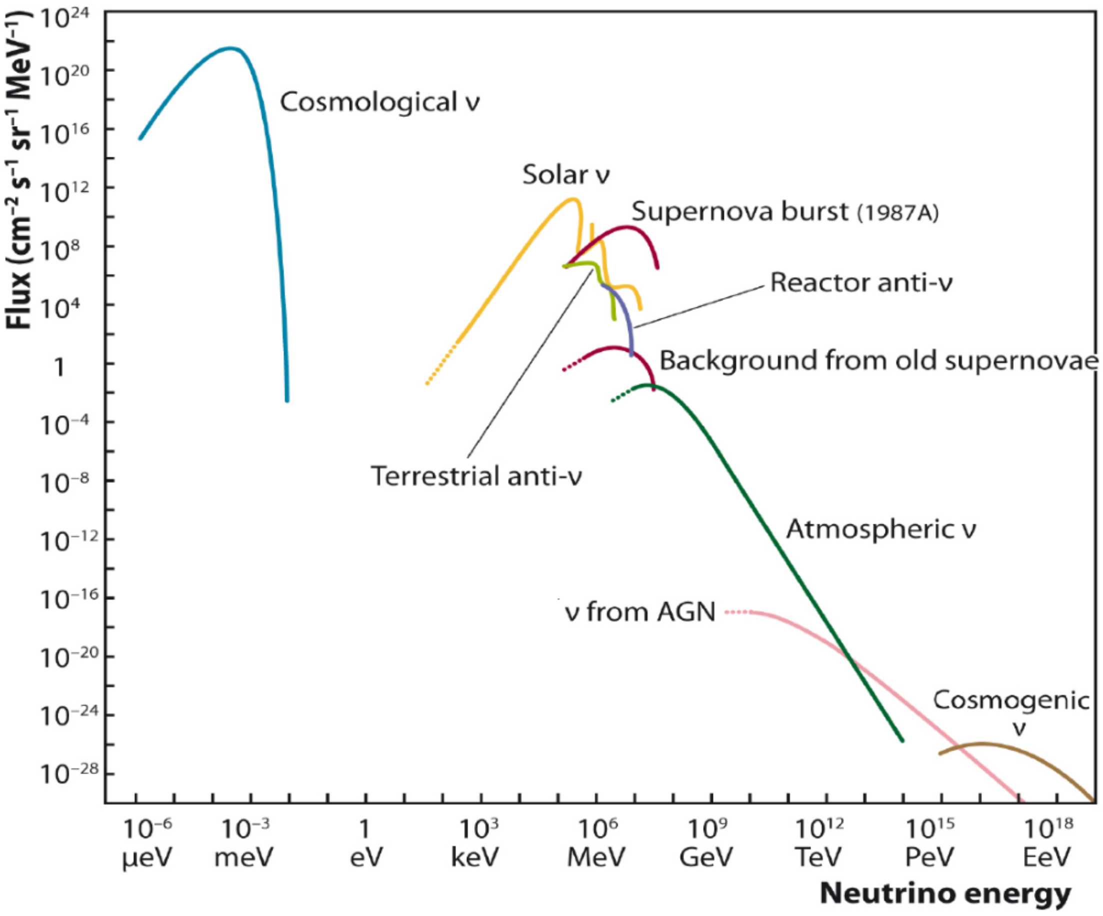
UNICAEN UNIVERSITÉ CAEN NORMANDIE

Normandie Université

Participants

- Ernst-Jan Buis is a Physicist at TNO in Delft, is a member of km3net, and responsible for the system engineer. He developed over the past years an expertise for the acoustic detection of cosmic neutrino.
- Yohann Brelet is an Engineer of the lab, working on instrumentation with past experiences in optical devices.
- Sylvain Girard is an Assitant Professor at the Ensicaen making his research in the cimap lab. His research interests are mainly focused on Solid-state lasers, Fibre lasers, Optical Sensors, and Non linear optics.

The neutrino Landscape



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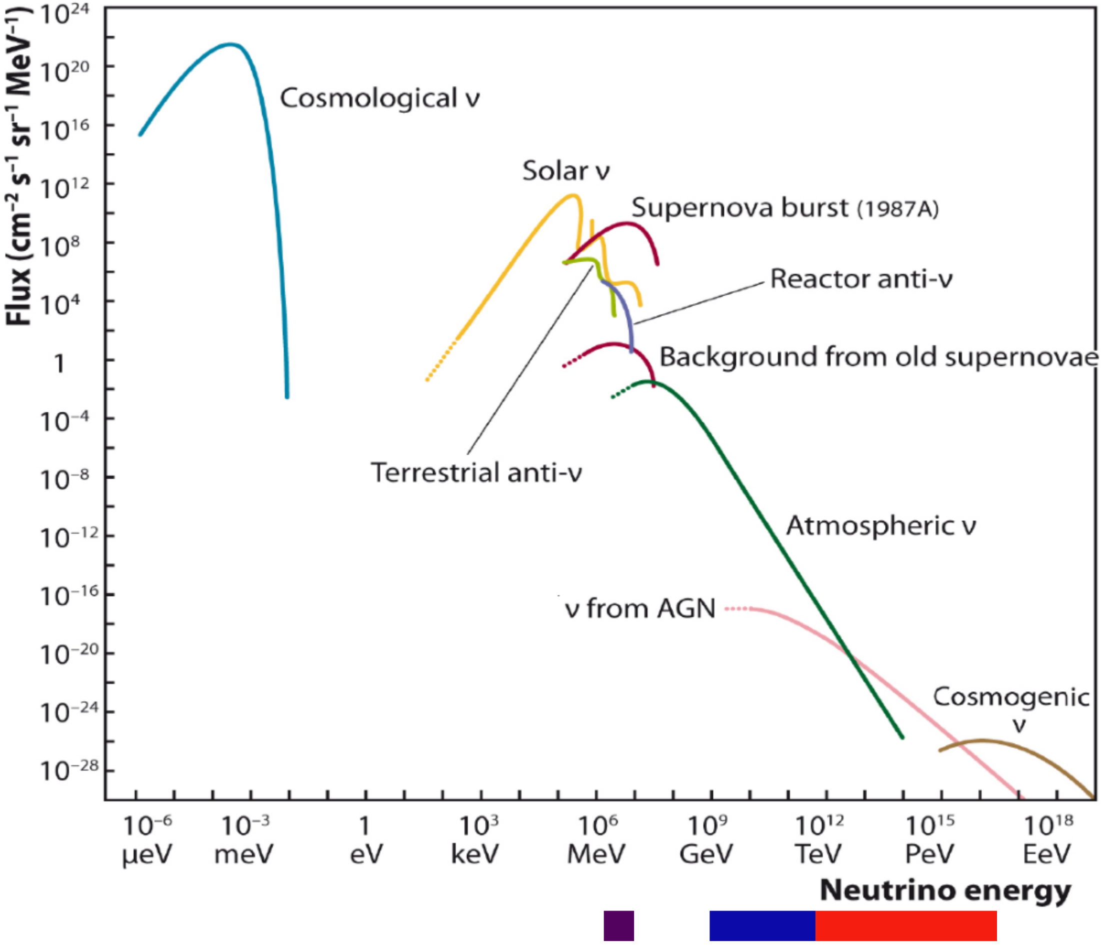
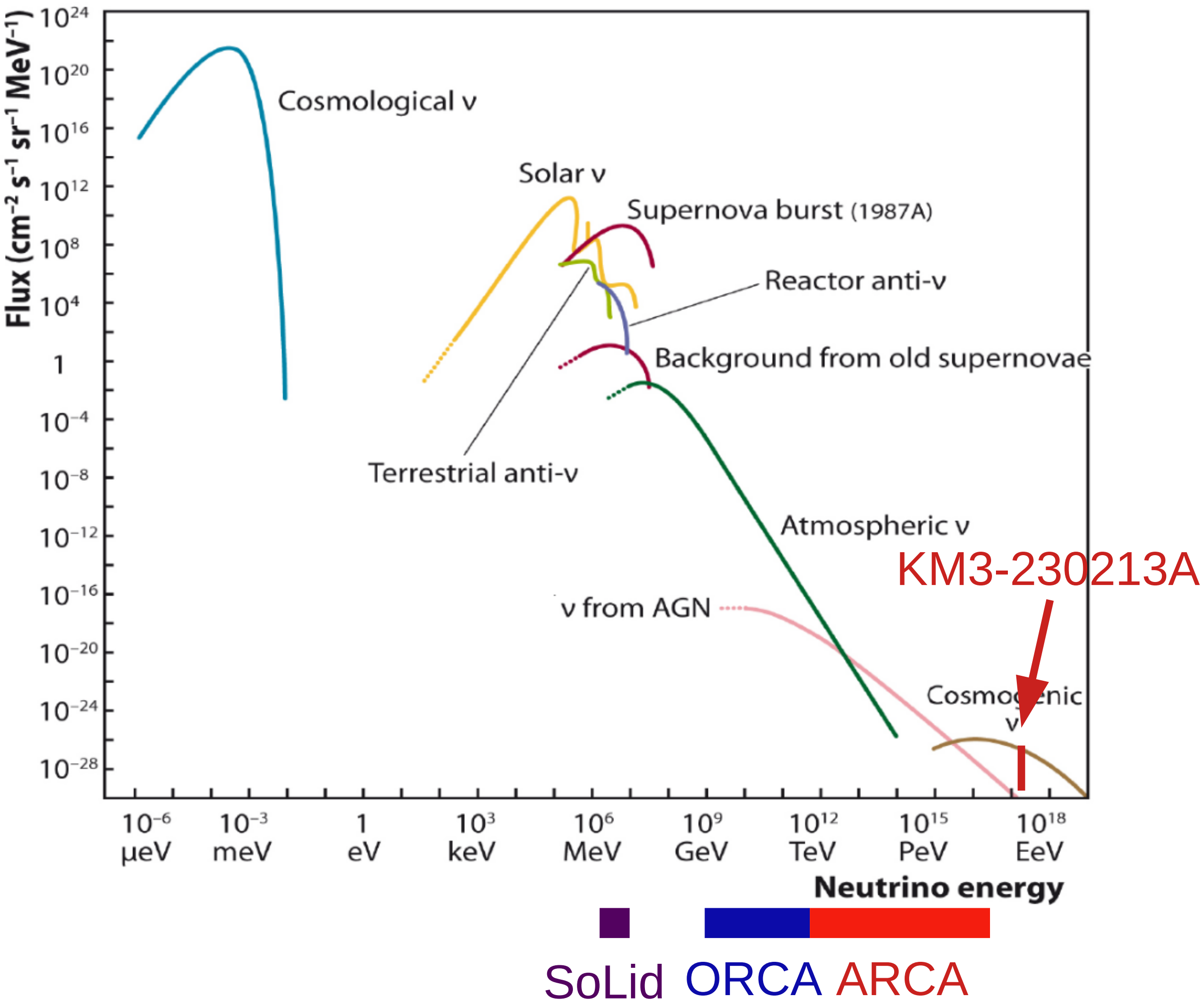


SoLid ORCA ARCA

- SoLid :
  - 1.6 m^3
  - 12800 cubes
  - 3200 MPPC

- KM3NeT :
  - ORCA :
    - 6 700 000 m^3 = 0.0067 km^3
    - 2 070 DOMs
    - 64170 PMTs
  - ARCA :
    - 1 km^3
    - 4 140 DOMs
    - 128340 PMTs

The neutrino Landscape



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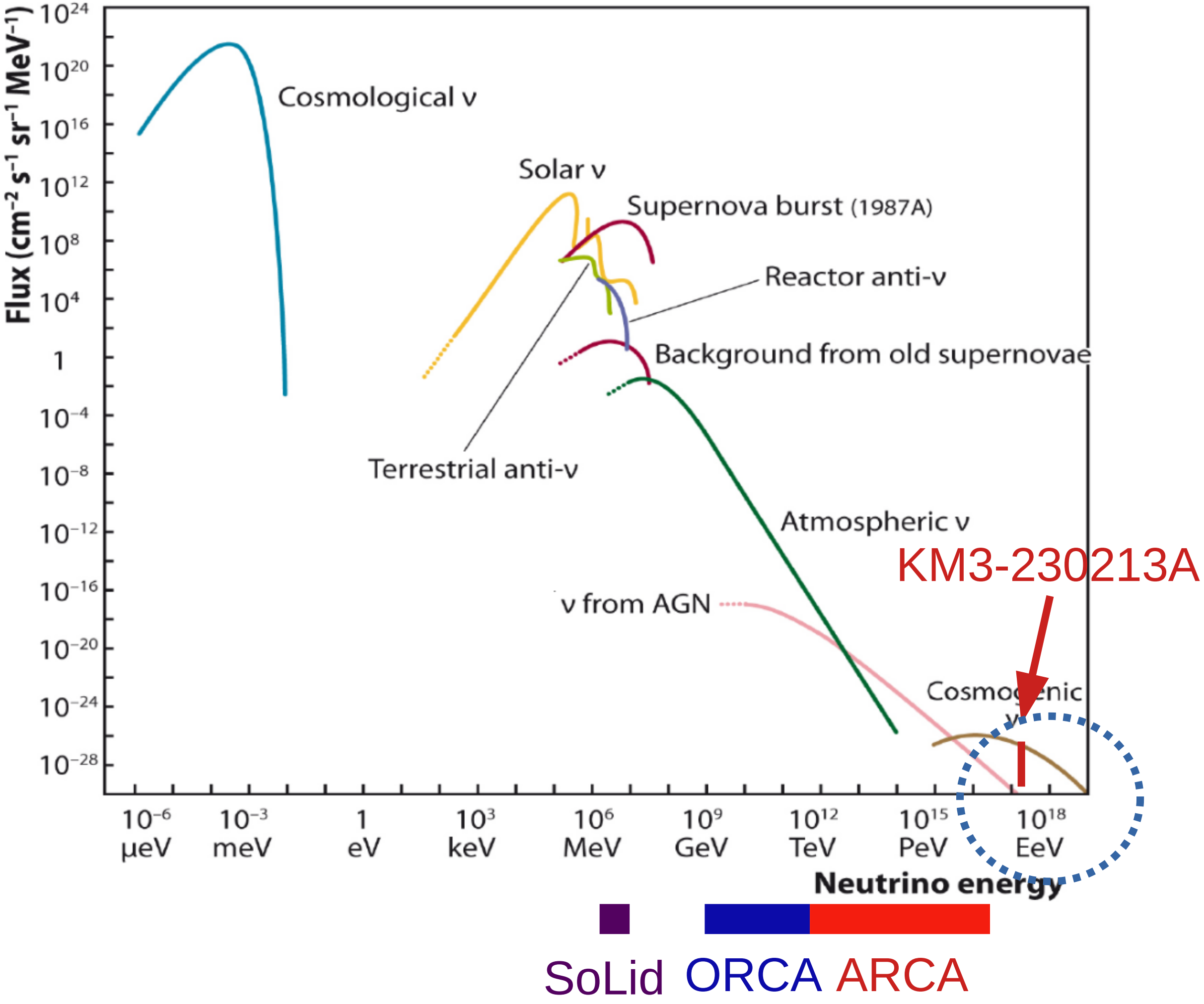

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How to reach higher energies ?
Bigger volume needs new methods.

Acoustic signal

- Signal generation
- Topology
- Frequencies and sensibilities to detect acoustic signal

Fiber-sensor

- How it works
- The multi-sensors

Fiber-Sensor as Acoustic detector

- Development at TNO

Mettre en œuvre des fibres photoniques creuses en configuration interférométrique (ou non ?) pour la détection d’ondes de pression mécaniques (domaine acoustique) de très faibles amplitudes, signature acoustique de l’interaction des neutrinos (> 100 PeV) dans l’océan profond.

Implementing hollow core photonic fibers (HCF) in interferometric configuration (or not?) for the detection of mechanical pressure waves (acoustic domain) of very low amplitudes, acoustic signature of neutrinos (> 100 PeV) interaction into the deep sea.

Some very recent litterature on the proof-of-principle

Detection of acoustic pressure with hollow-core photonic bandgap fiber

Meng Pang and Wei Jin*

Department of Electrical Engineering, Hong Kong Polytechnic University, Hong Kong, China
**Corresponding author: eewjin@polyu.edu.hk*

Appl. Phys. B (2015) 120:461–467
DOI 10.1007/s00340-015-6155-4
Applied Physics B
Lasers and Optics
CrossMark

Enhancing the pressure sensitivity of a Fabry–Perot interferometer using a simplified hollow-core photonic crystal fiber with a microchannel

Yongqin Yu[1,2] · Xue Chen[1,2] · Quandong Huang[1,2] · Chenlin Du[1,2] · Shuangchen Ruan[1,2] · Huifeng Wei[3]

2D diaphragm nanoparticles/flakes in a Fabry-Pérot configuration

Research Article
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Optics EXPRESS

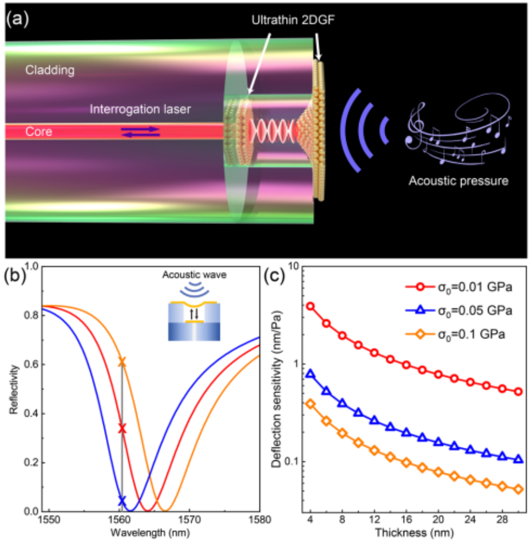

Fig. 1. Schematic diagram and working principle of EFPI-based fiber-tip acoustic sensor. (a) Schematic of an EFPI-based fiber-tip acoustic sensor with an ultrathin gold diaphragm.

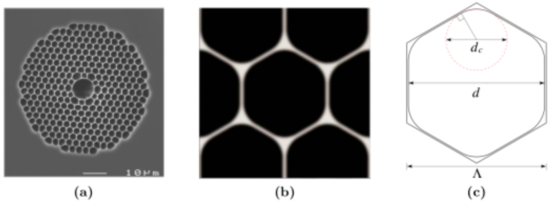

FIGURE 2.2 – (a) Image par microscopie électronique à balayage d'une HC-PCF (b) maille élémentaire de la gaine microstructurée à maille hexagonale [66], (c) définition de Λ et d du cristal d'une HC-PCF [74].

Thèse D. Ferachou (2012)

High-sensitivity fiber-tip acoustic sensor with ultrathin gold diaphragm

YUANBIAO TONG,[1] CHENXINYU PAN,[1] ZHIYONG LI,[1,2,6] HONGBO CHEN,[1] DONGSHENG XUE,[3] LIN CHENG,[4] YUQI ZHEN,[1] TONG ZHANG,[5] YANG GAO,[5] LEI ZHANG,[1] XIN GUO,[1,2] LIMIN TONG,[1] AND PAN WANG[1,2,7]

Studying New-Generation Hollow-Core Fibers for Acousto-Optic Sensors

Ricardo E da Silva, David J Webb, Jonas H Osório, Marcos a R Franco, Fetah Benabid, Frédéric Gérôme, Cristiano M B Cordeiro

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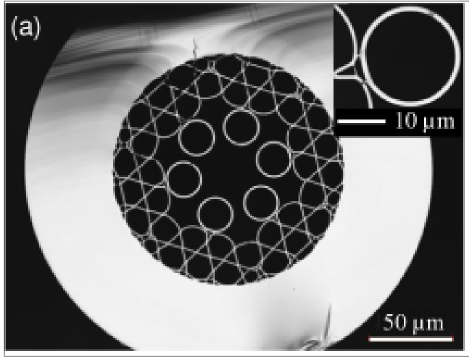

Da Silva et al. (2024)

Hollow core fiber (HCF) with *ad hoc* pattern (such as Kagomé, …) ?

Because, compared with standard silica fibers => more sensitive to mechanical constraint (Young's Modulus is lower), but is it (highly) sensitive enough to detect a pressure wave magnitude on the mPa, even µPa, order?

All-fiber acousto-optic interferometric device?

- Which gas: N2, Ar, Ne, Xe, Air, …?
- Which laser power? Pulsed?
- Which gas pressure?
- A (very) costly solution? But flexible!
- ...

X 10 to 100 km^3

Potential collaborations: NIKHEF, TNO, XLIM, LAAS, CEMES, FOTON, LAUM, LMA, CIMAP, CRISMAT, ….

Local ETPs (@LPC): Instru' + Meca + µElec => 2

Need for elaboration and characterization of HC fiber

Here, acoustic sensors would thus be based on the interferometric detection of pressure-induced phase shift of light propagating inside an optical fiber (air-silica honeycomb)

Miscellaneous and other (challenging) hints to explore:

- Phase-matching water-silice(polymer) interface
- Sea salinity OK with fiber
- The etched fiber was then coated with Parylene C
- Femtosecond structuring micromachining
- Acoustic/Optic Metamaterials
- MEMS hydrophone
- Wave-mixing (four, two, …. waves ….)
- MOEMS (MEMS + Optics)
- Opaques Scintillators (embedded)
- Photonic integrated Microresonator
- 2D membrane (2D material) => But must manage the deep-sea pressure! (biomimetism)
- Acoustic valley edge states (valleytronics equivalent)
- Acoustic Topological Chiral Metamaterials/Insulators (confine, guide, amplify, select, absorb, modulation, …)
-

Could be a mix of some of them + use of Additive Plastronics

Why? To gain in high-sensitivity, decrease propagation losses, sturdy, ….

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Materials Research Express

PAPER

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Honeycomb locally resonant absorbing acoustic metamaterials with stop band behavior

Salman Ebrahimi-Nejad and Majid Kheybari
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Keywords: acoustic metamaterial, honeycomb, cubic, resonator, noise attenuation, stop band behavior, transmission lo

JOURNAL OF APPLIED PHYSICS 123, 091713 (2018)

Acoustic valley edge states in a graphene-like resonator system

Yahui Yang,[1] Zhaoju Yang,[1,a)] and Baile Zhang[1,2,a)]
[1]Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore 637371
[2]Centre for Disruptive Photonic Technologies, Nanyang Technological University, Singapore, Singapore 637371

; accepted 14 January 2018; published online 30 January 2018)

Novel Opaque Scintillator for Neutrino Detection

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Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany
E-mail: christian.buck@mpi-hd.mpg.de

Abstract: There is rising interest in organic scintillators with low scattering length for future neutrino detectors. Therefore, a new scintillator system was developed based on admixtures of paraffin wax in linear alkyl benzene. The transparency and viscosity of this gel-like material can be tuned by temperature adjustment. Whereas it is a colorless transparent liquid at temperatures around ... cintillator

National Science Review
10: nwac246, 2023
https://doi.org/10.1093/nsr/nwac246
Advance access publication 3 November 2022

EVIEW

PHYSICS

Underwater acoustic metamaterials

Erqian Dong[1,2], Peizheng Cao[1,2], Jinhu Zhang[1,2], Sai Zhang[4], Nicholas X. Fang[3,*,†] and Yu Zhang[1,2,*]
Laboratory of ... water Acoustic ... unication and

sensors MD

Article

MEMS Underwater Directional Acoustic Sensor in Near Neutral Buoyancy Configuration

Fabio Alves *, Jaehyun Park, Leland McCarty, Renato Rabelo and Gamani Karunasiri
Naval Postgraduate School, Monterey, CA 93943, USA; jaebbong85@gmail.com (J.P.); leland.mccarty@gmail.com (L.M.); rcrabelo.br@nps.edu (R.R.); gkarunas@nps.edu (G.K.)
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10. Metamaterial devices designed with optimization and machine learning algorithms

The use of metamaterials greatly expands the toolbox available to the photonic designer, allowing an unprecedented control over the optical properties of the materials in integrated photonics. Most of the devices discussed in the previous sections are based on periodic or semi-periodic nanostructures whose unit cells are realized with simple geometrical shapes, for example cylinders or cuboids. Their design is often performed conventionally (i.e., without advanced algorithms) and relies on the possibility to develop effective models describing light propagation in the metamaterial, as we discussed in Section 2. Removing constraints on periodicity or introducing non-conventional shapes for the unit cells can substantially expand design capabilities. Recently, this strategy has been used to demonstrate increasingly compact structures and multi- f ... omes ... e the

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IOP Conf. Series: Materials Science and Engineering 281 (2017) 012002 doi:10.1088/1757-899X/281/1/0120

MEMS-based Optic Fiber Fabry-Perot Sensor for Underwater Acoustic Measurement with A Wavelength-switched System

J Xia [1, 2], F Y Wang [1], H Luo [1], Y M Hu [1] and S D Xiong [1*]

Communication

Acoustic Optical Fiber Sensor Based on Graphene Oxide Membrane

Catarina S. Monteiro [1,2,*], Maria Raposo [3], Paulo A. Ribeiro [3], Susana O. Silva [1] and Orlando Frazão [1,*]

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3 Centro de Física e Investigação Tecnológica (CEFITEC), Departamento de Física, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal; mfr@fct.unl.pt (M.R.); pfr@fct.unl.pt (P.A.R.)
* Correspondence: catarina.s.monteiro@inesctec.pt (C.S.M.); ofrazao@inesctec.pt (O.F.)

Abstract: A Fabry–Pérot acoustic sensor based on a graphene oxide membrane was developed with the aim to achieve a faster and simpler fabrication procedure when compared to similar graphene-based acoustic sensors. In addition, the proposed sensor was fabricated using methods that reduce chemical hazards and environmental impacts. The developed sensor, with an optical cavity of around 246 μm, showed a constant reflected signal amplitude of 6.8 ± 0.1 dB for 100 nm wavelength range. The sensor attained a wideband operation range between 20 and 100 kHz, with a maximum signal-to-noise ratio (SNR) of 32.7 dB at 25 kHz. The stability and sensitivity to temperatures up to 90 °C was also studied. Moreover, the proposed sensor offers the possibility to be applied as a wideband microphone or to be applied in more complex systems for structural analysis or imaging.

Keywords: Fabry–Pérot interferometer; fiber optic sensor; acoustic sensor

check for updates

Appl. Math. Mech. -Engl. Ed., 45(7), 1119–1138 (2024)

APPLIED MATHEMATICS AND MECHANICS (ENGLISH EDITION)

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Topology optimization of chiral metamaterials with application to underwater sound insulation*

Chao WANG, Honggang ZHAO†, Yang WANG, Jie ZHONG, Dianlong YU, Jihong WEN

Laboratory of Science and Technology on Integrated Logistics Support,

Where is the next place to fish neutrinos ?

- Noise and wave propagation

Where to put some effort ?

- Simulation (Shower and acoustic, detector)
- Sensors
- Acquisition
- Mechanical implementation