Qingdao, China
April 8 – April 13, 2024

BOOK OF ABSTRACTS

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School on Acoustics: From Fundamentals to Frontiers

We are cordially inviting you to participate in the “School on Acoustics: from Fundamentals to Frontiers” which will be held on 8-13 April 2024 in Qingdao, China (off-line format)

The school aims to create a collaborative environment for students and young researchers to acquire fundamental knowledge and practical skills in the field of fundamental and applied acoustics. The school includes lectures both on fundamentals of acoustics and on the latest achievements in acoustic metastructures and their real-world applications. The program will consist of lectures, practical classes with numerical and experimental tracks, hands-on workshops, and poster sessions, covering a wide range of topics such as:

1. Acoustic and elastic metamaterials and metasurfaces
2. Acoustic resonators and resonant states
3. Underwater acoustics
4. Underwater metamaterials
5. Waves in solids
6. Absorption of acoustic waves
7. Numerical acoustics
8. Art of acoustic experiment

The spring school is an excellent opportunity to network with peers and establish new collaborations with leading experts in the field of fundamental and modern acoustics.

School Chairs

- **Prof. Andrey Bogdanov**
  ITMO University, Russia; Harbin Engineering University, China
- **Prof. Mihail Petrov**
  ITMO University, Russia
- **Prof. Yongyao Chen**
  Harbin Engineering University, China
- **Prof. Badreddine Assouar**
  Université de Lorraine, France
- **Prof. Yabin Jin**
  Tongji University, China

School Secretaries

- **Mariia Krasikova**
- **Ekaterina Makarova**
- **Zhao Yue**

Invited Lectures

Day 1

Apr 8, 9:15 AM – 15:30 AM (GMT+8)

Basics and Fundamentals of Acoustics

Time: 9:15 - 10:00

Prof. Xinlong Wang
NANJING UNIVERSITY NANJING, CHINA

Wave equations governing sound waves in ideal fluid are derived from the fundamental equations of motion of fluids, and the intrinsic differences of sound waves from water waves are stressed. Basic properties of sound waves are discussed briefly. Then, sound reflection and transmission in layered media are formulated, with particular attention paid to the analogy with the transmission line of electrical circuits and the concept of impedance matching/mismatching to understanding the sound insulation and resonant transmission. Mathematical formulation of sound radiation is presented, with special emphasis on the role of Green function in solving radiation problems. Finally, propagation of acoustics waves in tubes and perforated plates are succinctly discussed, with emphasis on how viscosity affects attenuation of sound waves in artificial materials like metamaterials.

Mathematical models in periodic structures acoustics

Time: 10:30 - 11:15

Prof. Yifan Zhu
SOUTHEAST UNIVERSITY CHINA

In this talk, I will firstly show an introduction of acoustic metamaterial with some basic theory. Then I will display some works for the designs of different acoustic metamaterials with multifunctional sound manipulations, including one-way sound manipulations, acoustic holograms, origami acoustic metamaterials, etc. These different designs show the powerful ability of acoustic metamaterial for various sound manipulations.

How to engineer wavefronts by acoustic metasurfaces?

Time: 14:00 - 14:45

Dr. Yan Kei Chiang
UNIVERSITY OF NEW SOUTH WALES CANBERRA, CANBERRA, AUSTRALIAN CAPITAL TERRITORY

Acoustic metamaterials are advanced materials of subwavelength scale which possess anomalous properties that do not exist in conventional materials. It opens up an opportunity to engineer wavefront propagation in unusual ways. Conventionally, acoustic wave is reflected (or refracted) based of the Snell's law for reflection (or refraction) assuming that the phase of wave changes gradually with the propagating path. This classic Snell's law was revisit in 2011. It has been proven that a new degree of freedom for manipulating the wave propagation can be achieved by introducing abrupt phase shift along the surface between two media. The emergence of acoustic metasurfaces, which are the two-dimensional form of acoustic metamaterials, enables a fully spatial control of phase and/or amplitude of wave. It provides a promising ability to implement local phase shifts following the generalised Snell's law to generate complex wavefronts for beam steering, beam focusing, self-bending beam and perfect absorption. This lecture will cover the fundamental principle of the generalised Snell's law and introduce the metastructures that are commonly used to construct acoustic metasurfaces. It will discuss the general design principle of the acoustic metasurface for wavefront engineering.

Sound-absorbing materials

Time: 14:45 - 15:30

Prof. Yong Li
TONGJI UNIVERSITY, SHANGHAI, CHINA

Sound-absorbing materials (SAMs) have attracted significant interest for more than a century owing to their rich physical properties and extensive potential in acoustic engineering. In this talk, I will provide an overview of recent progress in and future prospects for SAMs, from single resonators to coupled resonant systems. Single resonant SAMs use resonances to achieve high-efficiency absorption in a certain bandwidth with a significantly smaller thickness than porous SAMs. The emergence of sound-absorbing metamaterials has led to further thinner structures at deep-subwavelength scales. Coupled resonant systems offer new opportunities for broadband sound absorption and multifunctionality. I will introduce the conservation equations for single resonators and general SAMs, outlining the design strategies for achieving tunable and broadband SAMs approaching the optimal conditions governed by the conservation equations. I will also review recent developments in multifunctional SAMs and metaliners. Finally, I will provide an outlook on potential directions and applications for future work in this rapidly evolving field.

Day 2

Apr 9, 8:30 AM – 15:30 AM (GMT+8)

Elastic waves in solids

Time: 8:30 - 9:15

Prof. Yabin Jin
EAST CHINA UNIVERSITY OF SCIENCE AND TECHNOLOGY CHINA

From nanoscale to macroscale, the behaviors and functions of elastic waves in solids are strongly demanded in various areas. Different from air-borne and water-borne acoustic waves, elastic waves can be dispersive and multimodal. It is important to make clear the properties of each kind of elastic waves that is the fundamental to different topics such as NDT, metamaterials, sensing, et al. In this lecture, you will learn about the basic information (such as equation of motion, dispersion equation, transmission and reflection) of elastic waves in infinite bulk solids, half infinite solids, plates and beams. By the end of the lecture, you will have knowledge of theoretical fundamentals to analyze elastic waves in a given type of solid and the link to study elastic wave functions in your study.

Elastic Metamaterials with Tunable Mechanical Properties

Time: 9:15 - 10:00

Prof. Yifan Wang
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Mechanical metamaterials are structured lattices whose properties arise from the selection of both their constitutive composition and underlying micro- or meso-structures. Most existing mechanical metamaterials are intrinsically passive, with shape and properties fixed once manufactured. This limits their applications in areas where material adaptivity and tunability are required. In this lecture, I will introduce the development of metamaterials whose shape and mechanical properties can be controlled and can adapt to varying environmental conditions. Firstly, I will show mechanical metamaterials with interlocking particles that has controllable stiffness and reconfigurable shape triggered by the jamming transition, which can be used for wearable robotics. Then, I will introduce deployable structures from architected building blocks, which combine multiple functions: shape-changing, stiffness-variation, and self-sensing into one monolithic structure. These lecture provides insights into the next generation of mechanical metamaterials that adapt and tune their properties to varying environmental conditions, with applications ranging from wearable robots, medical supports, reconfigurable architectures, etc.

The theory and application of nonlinear sound waves in solids

Time: 10:30 - 11:15

Prof. Xiaozhou Liu
NANJING UNIVERSITY, NANJING, CHINA

This report introduces the basic principles and analysis methods of nonlinear acoustics in solids, with a focus on the theory and applications of nonlinear acoustics in ultrasonic non-destructive testing, metamaterials, and other fields. It includes the foundations of nonlinear acoustics in solids and the nonlinear propagation of sound waves in solids, phononic crystals and metamaterials.

Medical applications of high intensity focused ultrasound

Time: 11:15 - 12:00

Dr. Sergey Tsysar
LOMONOSOV MSU, MOSCOW, RUSSIA

Low-power medical ultrasound is widely used for imaging and diagnostic clinical applications. High-intensity focused ultrasound (HIFU) can be used for destruction of tumors in various organs and performing neurosurgical operations in the deep structures of the human brain. Although in modern HIFU systems the main physical mechanism is tissue heating due to continuous waves absorption, there is growing interest in the use of pulsed modes with a large amplitude with nonlinear shock front formation at the focus. Such modes make it possible to significantly expand the range of bioeffects caused by ultrasound. New applications are rapidly developing, such as the destruction of blood clots and large hematomas, targeted drug delivery, abscess treatment and combined immunotherapy. A brief review of modern clinical applications in urology, cardiology, gastroenterology, bioengineering and immunology is provided. New experimental and numerical methods for accurate reconstruction of transducer vibration pattern for setting a boundary condition in the modeling and treatment planning are considered; examples of HIFU transducers to achieve the required amplitudes of the shock front at the focus are given; physical mechanisms of mechanical and thermal effects on tissue, cavitation effects in tissue, the influence of acoustic properties of tissue on nonlinear focusing and in situ field parameters, features of acoustic and MRI visualization of the affected area, features of morphological and ultrastructural changes in tissue caused by ultrasound are discussed. Current work was financially supported by the Russian Science Foundation (RSF 20-12-00145).

Computational underwater acoustics: recent advances and persisting challenges

Time: 14:00 - 14:45

Dr. Pavel Petrov
IL'ICHEV PACIFIC OCEANOLOGICAL INSTITUTE, VLADIVOSTOK, RUSSIA

A review of modern methods of sound propagation modeling based on their representation in the form of an expansion over normal modes is presented. Most of the described methods are within the framework of an approach to calculating mode amplitudes by solving parabolic equations of various types, both narrow-angle and wide-angle. Two-dimensional methods for calculating acoustic fields, to which the above-mentioned three-dimensional approaches can be reduced, are also considered. The computation of both time-harmonic acoustic fields and pulse signals is discussed. A number of numerical examples are considered in which such calculations are performed taking into account three-dimensional sound propagation effects. The calculation of particle accelerations at the pulse signal reception points, as well as the calculation of the acoustic energy density flux, can be also performed within this approach.

Underwater metamaterials: fundamental and frontiers

Time: 14:45 - 15:45

Prof. Yongyao Chen, Prof. Nansha Gao
HARBIN ENGINEERING UNIVERSITY CHINA, NORTHWESTERN POLYTECHNICAL UNIVERSITY CHINA

The development of novel hydroacoustic functional materials and devices is crucial for achieving breakthroughs in future ocean exploration, sonar systems, underwater communication, acoustic imaging and underwater stealth technologies. The underwater acoustic metamaterials can effectively control and manipulate sound waves in the underwater environment, which is an emerging front, not only conceptually fascinating but also hold great promise for broad applications. The objective of this lecture is to achieve a fundamental understanding of underwater acoustic metamaterials, for guiding, amplification, absorption and isolation of sound waves in underwater environment, and to explore novel methodologies for control and manipulation of underwater acoustic waves with functionalized metamaterials and devices. Through combined theoretical, numerical, and experimental lectures, researchers could enrich the knowledge in the growing field of underwater acoustic metamaterials, and learn useful skills such as theoretical analysis, numerical simulations and experimental methods for underwater acoustic metamaterials.

Day 3

Apr 10, 8:30 AM – 12:00 AM (GMT+8)

Non-Hermitian acoustic resonances

Time: 8:30 - 9:15

Dr. Lujun Huang

EAST CHINA NORMAL UNIVERSITY, SHANGHAI, CHINA

An open acoustic system with a non-Hermitian Hamiltonian support a series of acoustic resonances. The emergence of acoustic metamaterials and metasurfaces provides abundant freedom in tailoring acoustic resonances. Acoustic resonances are always acompanied by the amplication of pressure field and phase change of 180 degree. Thus, they have been widely used for manipulating the proprogation of acoustc wave and enhancing acoustic wave-matter interactions. In this talk, we discuss the fundamental physics of acoustic resonances in non-Hermitian systems and their applications in acoustic absorption, scattering and emission. We will also discuss a special type of acoustic resonances so called bound states in the continuum. Then, tunable acoustic metasurfaces will be surveyed to show how acoustic resonances can be actively controlled. Finally, we will discuss acoustic resonances engineering in parity-time symmetry system by introducing gain and loss.

Mathematical models in periodic structures acoustics

Time: 9:15 - 10:00

Dr. Alexander Hvatov

ITMO UNIVERSITY, SAINT-PETERSBURG, RUSSIA

We delve into the world of mathematical models in periodic structures. Namely we look at the several models of acoustic waveguides through the lens of the Floquet theory and unlock the secrets of pass- and stop-bands prediction. In this lecture, we will navigate through three topics: the acoustic waveguides models, the principles of classical Floquet theory, and simplifying computations using symmetric cell eigenfrequencies. Several modern research directions are also be tackled.

High-frequency acoustic sensors

Time: 10:30 - 11:15

Prof. Wei Luo

HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY CHINA

High-frequency acoustic sensors have always been hotspot in the field of sensing systems. There are two types of acoustic sensors. One is to use sound waves to detect physical quantities, such as gas, temperature, pressure, etc., and the other type is to use changes in physical quantities to detect sound waves. In this lecture, we will introduce the basic principles of these two types of devices in detail. In order to meet the needs of miniaturization and integration for practical application, we will introduce the design, preparation and characterization of high-frequency acoustic sensors based on MEMS platforms. The latest research progress and application of these devices will be also introduced in the lecture. By the end of the lecture, you will have knowledge of the theoretical basis and practical application skills of high-frequency acoustic sensors.

Underwater Acoustic Transducers: History, Current Status and Challenges

Time: 11:15 - 12:00

Prof. Shuangjie Zhang

HARBIN ENGINEERING UNIVERSITY CHINA

Due to severe absorption of electromagnetic waves in water, acoustic wave has been considered to be the only effective long-range underwater information carrier. Underwater acoustic transducers, which are the key components of SONAR (Sound Navigation and Ranging) system, are responsible for generation and reception of underwater acoustic waves. Nowadays, underwater acoustic transducers and have been widely applied in various applications such as underwater target detection, identification and tracking, underwater communication, marine resources exploitation, and marine environmental monitoring, etc. This lecture includes a brief introduction on the development history, typical structures, and key specifications of underwater acoustic transducers. The current status of underwater acoustic transducers, and challenges to meet the growing demands in both civil and defense applications will also be discussed.

Poster Session

Day 1

Apr 8, 16:00 AM – 18:30 AM (GMT+8)

Electromagnetically driven fluid acoustic mode control based on Tesla valve

Poster ID: D1

Linjun Jiang
Institute of Fundamental and Frontier Sciences,UESTC(Institute of Fundamental and Frontier Sciences),Chengdu

According to the principle that conductive particles experience Lorentz forces in a magnetic field ,we designed a fluid cavity driven by electric and magnetic fields based on Tesla valve, and coupled it with ultrasound to realize the control of acoustic mode. We can easily change the magnetic and electric fields, Thus, the flow rate and direction of the conductive liquid in the cavity are controlled. Under this fluid control mechanism, the device can suppress the ultrasonic amplitude with the negative flow and achieve acoustic non-reciprocity of up to 30db at Different specific frequencies by switching different ultrasound modes.

Broadening stop-band of noise-mitigation metastructure via tuning of a local coupling between resonators

Poster ID: D2

Aleksandra Pavliuk
ITMO University

We investigate effects of tuning of local coupling in semi-infinite structure made of coupled Helmholtz resonators. It is shown that by adjusting coupling between the resonators broad stop-bands covering frequency range 200 – 2100 Hz in the transmission spectra can be achieved. This property is linked to band structures of the equivalent infinitely periodic systems and is discussed in terms of band-gap engineering. The local coupling strength is tuned via introduction of defects of a periodic structures such as chirping the structures and insertion of porous materials. This work was performed with the financial support from the Russian Science Foundation (Project № 24-21-00275).

Mathematical modeling of MEMS hydrophones

Poster ID: D3

Xin Wang
Ocean university of China, Faculty of Information Science and Engineering

The mechanical domain vibration model is obtained based on the Kirchhoff thin plate model and modal analysis, the electrical domain model is derived using the piezoelectric system of equations, and the acoustic domain is modeled by introducing the acoustic radiation impedance, which is expressed uniformly in the lumped parameter circuit model. The model can be used to describe the impedance spectrum and dynamic sensitivity of the hydrophone, providing a powerful tool for size optimization.

Acoustic measurements in an RF anechoic chamber

Poster ID: E1

Vladimir Igoshin
School of Physics and Engineering, ITMO University

The work investigates the experimental study of acoustic waves in the radio frequency (RF) anechoic chamber (AC). It presents a method for measuring the spatial distribution of an acoustic field, including the phase and amplitude of a pressure field. The possibility of measuring scattered fields of plastic resonators in air is discussed, along with the application of the optical theorem to determine the scattering cross section. This work was performed with financial support of the Russian Science Foundation (Project № 20-72-10141).

Experimental observation of the quasi-BIC in the open system of coupled Helmholtz resonators

Poster ID: E2

Mikhail Kuzmin
Faculty of Physics, ITMO University

Resonant states play major role in acoustic engineering, especially in the context of metamaterials. One of the particular types of resonances are bound states in the continuum (BIC), which are characterized by infinitely large quality factor. However, excitation of such states is a challenging engineering task, especially in open systems. In this work, BIC are studied in the open system of two coupled Helmholtz resonators. Basing on the analysis of eigenmodes, the parameters required for excitation of quasi-BIC are found. The occurrence of these states is demonstrated numerically and verified experimentally via measurements of both the amplitudes and phase difference inside the resonators. The obtained results are promising for the development of subwavelength resonant structures allowing the efficient control of acoustic waves.

Seismic Metamaterials Foundation

Poster ID: E3

Arpan Gupta
Indian Institute of Technology Delhi

The poster would focus on some work related to using metamaterials for the application of earthquake protection or seismic waves. Finite element simulations are used to simulate the seismic wave propagation over the metamaterials foundation designed to protect buildings from earthquakes.

Observation of Optoacoustic Spin

Poster ID: MP1

Tayyba Shoukat
University of Electronic Science and Technology of China

Acoustic waves traditionally lack the ability to induce spin, as they are described by scalar pressure fields, unlike optical waves. In this study, the existence of spin in acoustics is demonstrated. Optoacoustic waves are employed to set a ferrofluid-filled sphere into rotation under a magnetic field. Spin angular momentum in water is observed as a result of the particle velocity's rotation by allowing acoustic waves and light waves to interfere perpendicularly. In this unique interaction, spin-momentum locking in acoustic waves is identified where the propagation direction is influenced by the spin's sign. The optoacoustic signals generated in a ferromagnetic fluid carry information about its optical properties. With this ability, it can measure how much light is absorbed by the fluid and generate a chart illustrating its distribution across the depth of the fluid. Acoustic spin has been recently explored for many applications. The newfound understanding of acoustic spin may revolutionize acoustics, offering innovative possibilities for wave propagation control and particle rotation.

Acustomechanics of particles near the elastic substrate

Poster ID: MP2

Vsevolod Kleshchenko
Faculty of Physics of ITMO University

We studied the influence of excited surface acoustic waves on the effects of acoustomechanical control of objects above the substrate. Specifically, we examined the contributions of bulk and surface waves in elastic substrate to the acoustic force acting on monopole particles placed in a plane wave. We demonstrate that at certain angles of incidence, the acoustic force exhibits resonant behavior due to the presence of excited surface waves, unlike the case of a hard substrate. Finally, we investigated the acoustic binding effects that promote self-organization of particles into the stable configurations near the substrate where several coupling channels exist. Our findings revealed that particles near the substrate can induce surface waves even under normal incidence of the external field, enabling the formation of acoustically bound particle configurations over significant distances. This work was performed with financial support of the Russian Science Foundation № 22-42-04420

Design of enlarged phononic bandgap 2.5D acoustic resonator via active learning and optimization.

Poster ID: MP3

SYED MUHAMMAD IBRAHIM
Sogang university

Identifying the phononic crystal (PnC) with bandgap is a problematic process because all phononic crystals don't have bandgap. Predicting the Phononic bandgaps (PnBGs) is a computationally expensive task. Here we explore the potential of machine learning (ML) tools to expedite the prediction and maximize the resonator based PnBG. The Gaussian process regression (GPR) model is trained to learn the relationship between complicated shape and band structure of cavity. Bayesian optimization (BO) derives a new shape by leveraging the fast inference of the trained model, which is updated with the augmentation of newly explored structures to escalate the prediction power over performance expansion through active learning. Artificial intelligence (AI) assisted optimization requires a small number of generations to achieve convergence. The results obtained are validated via experimental measurements.

Strongly coupled phonon-magnon dynamics in a single BiIG nanocylinder.

Poster ID: MP4

Khristina Albitskaia
Russian Quantum Center and Moscow Institute of Physics and Technology

Coupling to the phononic system is a little known avenue for the manipulation of magnons. We develop an analytic description to model the dynamics in three dimensions.The coupling between the spin and phonon systems in nanostructures were performed using Comsol software. In the experimental part of this work, we utilize the vibrational modes of a single, isolated bismuth-substituted iron-garnet nanocylinder to optically initiate phononic dynamics in the GHz frequency range along with the intrinsic magnetic resonances of the structure using pump-probe spectroscopy.

Day 2

Apr 9, 16:00 AM – 18:30 AM (GMT+8)

Machine learning-based optimization technique for the matching layer in transcranial ultrasound applications — **Poster ID: L1**

Chengxuan You
Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences

This method introduces a machine learning-based optimization technique for the matching layer in transcranial ultrasound applications. Transcranial ultrasound offers advantages such as being non-invasive, radiation-free, and capable of dynamic focusing. It enables monitoring and treatment of brain diseases through intracranial tissue imaging and neural stimulation. To effectively utilize transcranial ultrasound for therapeutic purposes, it is crucial to overcome challenges related to impedance mismatch due to the significant difference between the skull and water, leading to low transmission rates, and phase mismatch caused by the anisotropy of the skull. The current best solution for impedance mismatch involves multi-layered gradient impedance matching layers, but the complexity of manufacturing these layers is increased due to the small impedance differences between layers and the large number of layers required. This work employs machine learning to model the one-dimensional physical transmission process through the skull, achieving optimization by reducing the number of layers in existing complex multi-layered gradient impedance matching layers without compromising transmission effectiveness, and designing matching layers for specific transmission spectra. This lays the groundwork for future two-dimensional and three-dimensional studies.

Multi-plane acoustic hologram generation with a physics-enhanced neural network for micro-particle manipulation — **Poster ID: L2**

Rujun Zhang
Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences

The precise forming of three-dimensional (3D) acoustic field is crucial for a variety of applications. In our work, a physics-enhanced multi-plane acoustic hologram deep neural network (PhysenNet MPAH) approach is proposed for reconstructing multi-plane acoustic hologram. By combining a convolutional neural network with a physical model, the PhysenNet MPAH approach can generate high-quality acoustic holograms for holographic rendering of targeted acoustic intensity fields at multiple planes. This approach is capable of reconstructing both strong and weak-targeted multi-plane fields, with superior quality compared to traditional iterative angular spectrum approach. The reconstructed multi-plane acoustic fields are also demonstrated to be useful for three-dimensional particles manipulation, indicating potential applications in dynamic particles manipulation and volumetric display.

Realization of the Quantum Spin Hall Effect Using Tunable Acoustic Metamaterials

Poster ID: M1

Jia-he Chen
Soochow University

We report pseudospin-dependent hybrid topological acoustic metamaterials constructed from tunable acoustic metamaterials and honeycomb-latticed sonic crystals. Using a theoretical model analogous to electrostatic interactions, we provide an efficient approach to evaluate intra- and interlattice couplings, whose competition is the major physical reason arousing the quantum spin Hall effect. The intralattice coupling is from the intrinsic design of the acoustic metamaterial, and the interlattice coupling is affected by multiple scattering among periodic scatterers. By independently manipulating the acoustic metamaterial and sonic crystal, we can successfully induce topological phase transitions at will. An alternative type of topological material is thus realized with great tunability. With identical building blocks for all hybrid topological acoustic metamaterials, a simple tuning of the corotation angle of each acoustic metamaterial can directly induce a topological phase transition, which makes the reconfiguration of the topological domains very convenient. A tunable multiport acoustic power divider is designed and demonstrated using numerical simulations and experiments. An alternative method to control the transmission rate and direction is thus reached and alternative routes for designing hybrid topological acoustic metamaterials with different functionalities and versatile applications are thus paved.

Topological pseudospin switcher: mechanism and acoustic realization

Poster ID: M2

Yiyin Chen
Soochow University

The control of the pseudospin of sound wave has attracted increasing attention in recent years. Utilizing the finite-size effect of topological acoustics, we successfully construct an H-shaped acoustic topological pseudospin switcher that sound wave energy can be easily switched through different passages. The interesting phenomenon of pseudospin flipping is numerically and experimentally demonstrated. A quantitative interference theory is proposed that the constructive and destructive interference of pseudospin states leads to pseudospin flipping and preserving in multiple frequencies. We verify the key parameters of the design, including the length of the passage and its interface state dispersion, and the theory can be extended to other topology acoustics and photonics systems. Moreover, the tunable topological sonic crystal we use provides adjustable convenience to pseudospin switcher design. The pseudospin switching behavior offers an efficient method to control the acoustic topological edge state transport, which has great potential in versatile applications, such as integrated acoustics, acoustic security, and information processing.

Noise-mitigation Structures Inspired by Duct Acoustic Black Holes

Poster ID: M3

Farid Bikmukhametov
ITMO University, Saint Petersburg, Russia

Conventional noise-insulating systems typically represent bulky structures not allowing air ventilation, which is crucial for many engineering applications, including ventilation ducts. This work is dedicated to the development of noise-mitigation metamaterials consisting of rectangular plates with varying distance between them. Such structures represent a 2D analog of the so-called duct acoustic black holes, which typically represent 1D structures. It is shown that the developed metamaterial allow efficient noise insulation in the target range 1000 - 1500 Hz and simultaneously allow air propagation through them. These results can be useful for the building industry and the development of noiseless ventilation ducts in particular. This work was performed with the financial support from the Russian Science Foundation (Project № 24-21-00275).

Metalens for Ultrasound Focusing in Water

Poster ID: M4

Alexsandra Zheleznova
ITMO University, Russia

Focusing of ultrasound plays a crucial role in a variety of medical applications, including surgeries, imaging, power and information transfer. Nevertheless, focusing of ultrasound in water, which acoustically is similar to a human body, using passive planar structures represent a complex engineering task due to the low contrast of impedances between water and most of the bio-compatible solid materials suitable for medical purposes. The presented work is dedicated to the development of transmission metalens allowing focusing of ultrasound in water. The lens is based on the set of diffraction gratings in which the diffraction in a particular channel is maximized. The gratings are combined in such a way that the diffracted waves converge to a specific focal point. Importantly, the structure is scalable and hence its parameters can be easily tuned to achieve focusing at the specific target frequency. This work was performed with financial support of the Ministry of Science and Higher Education of the Russian Federation (Project No. 075-15-2022-1120).

Composite Metasurfaces for Low-Frequency Absorption

Poster ID: M5

Yaroslav Muravev
Saint Petersburg National Research University of Information Technologies, Mechanics and Optics

Low frequency absorption still remains on of the unresolved challenges of modern acoustics. One of the possible solutions of this problem may be based on resonant metasurfaces allowing efficient control of field propagation at subwavelength scales. In this work a novel design of absorbing metasurfaces is proposed. In particular, the structure consists of two Helmholtz resonators coupled via labyrinth channel with thermoviscous losses. It is shown that coupling of the resonators leads to the shift of the absorption peak towards the low frequencies. For instance, the structure with the thickness 12 cm demonstrate nearly perfect absorption around 100 Hz. Importantly, the absorption properties weakly depend on the angle of incidence, and moreover, the oblique incidents results in a symmetry break leading to the occurrence of additional absorption resonance. The results of the work might be useful for the development of novel lightweight noise-insulating deeply subwavelength structures. This work was performed with the financial support from the Russian Science Foundation (Project № 24-21-00275).

Ocean circulation models' data in the modeling of the long-range sound propagation experiments in the Sea of Japan.

Poster ID: T1

Mikhail Sorokin
V. I. Il'ichev Pacific Oceanological instutute FEB RAS

The precision of acoustic ranging and navigation depends on the accuracy of the information about the sound speed field in the area of interest. Large-scale inhomogeneities in the bottom relief and water column can significantly affect the horizontal rays corresponding to vertical modes (in the framework of Burridge-Weinberg formalism), which can lead to delays in the acoustic signal modal components, as compared to propagation along the geodesics on the Earth's surface. The ocean circulation models are supposed to be a promising source of hydrological information in the area of interest. Moreover, the models' data allows us to perform sound propagation modeling without direct sound speed measurements and take the possible ocean eddy influence into account. This feature is essential while modeling the sound propagation on long-range acoustical tracks. This study considers the influence of horizontal refraction on the modal components' delay times. In particular, it is studied to what extent the presence of a synoptic eddy near the source-receiver path increases the effective propagation distances due to horizontal refraction. The elongation of horizontal eigenrays relative to the geodesic connecting the source and the receiver is also estimated. The influence of hydrological inhomogeneities on the propagation time of different modal components of a broadband acoustic signal is investigated. This is accomplished by integrating the group slowness (reciprocal to the group speed) along the horizontal eigenrays connecting the locations of the source and the receiver. Implications for improving the accuracy of the solution of acoustic ranging problems are discussed. The main result is the fact, that anticyclonic eddies in Sea of Japan weakly affect the sound propagation either in terms of horizontal rays or in terms of modal components' arrival times.

Exceptional points in the systems of coupled acoustic resonators

Poster ID: T2

Mark Miroliubov
ITMO University, Saint Petersburg, Russia

Introducing frequency detuning or loss detuning into the system of coupled acoustic resonators may result in the appearance of the exceptional point. In the work, the described mechanisms for exceptional point forming are described for the system of Helmholtz resonators coupled via waveguide, and for the system of two Fabry Perot resonators coupled via small channel. This work was performed with financial support of the Russian Science Foundation (Project № 22-12-00204)

Acoustic Förster Energy Enhancement

Poster ID: T3

Mikhail Smagin
School of Physics and Engineering, ITMO University

The effect of Resonance Förster Energy transfer designates the non-radiative dipole-dipole interaction in quantum optics and classical microwave electrodynamics. We extend the formalism of a classical description of Förster Energy transfer from microwave to acoustics based on the scalar Green's function, which demonsrates a consistent analogy. Using the developed formalism, we are able to apply it for design and analysis of meta-structures for acoustic energy transfer enhancement. This work was performed with financial support of the Russian Science Foundation № 20-72-10141