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Editorial: Ultrasound micromanipulations and ocean acoustics: from human cells to marine structures

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Editorial on the Research Topic
Ultrasound micromanipulations and ocean acoustics: from human cells to marine structures

1 Introduction

This Research Topic focuses on acoustic phenomena spanning from the manipulation of micro-particles and fluids in micrometer-sized cavities (e.g., [1]; [2]) to ocean exploration at macro scales (e.g., [3]). From the point of view of physical acoustics, some general theories and numerical models are uniform. For instance, the form functions of acoustic scattering from a sphere in an ideal medium are the same for a typical radius $a = 1$ m at the incident frequency $f = 1$ KHz in the field of ocean acoustics and for $a = 100$ μm at $f = 10$ MHz in the field of ultrasound manipulation since the dimensionless frequency ka of these two cases are the same (with the wavenumber $k = 2\pi f/c$ and sound speed c in the medium.) This also convinces readers that the underlying equations and the physical modeling remain the same over those length scales. The underlying research topic presents a collection of recent developments in acoustofluidics, wave modulation with artificial materials, and ocean acoustics. Additional goals of this Research Topic are to help researchers from different fields to understand the common principles of physical acoustics and conduct interdisciplinary research or collaborations. More details as well as the collected papers can be found at the link: https://www.frontiersin.org/research-topics/45393.

2 Recent developments in three groups

In this section, we will briefly introduce the main contents and scientific contributions of each work into three groups.

2.1 Acoustofluidics

The paper by Pavlic et al. introduces an efficient hybrid method combining the Fully Viscous modeling approach with the existing limiting velocity method for the acoustic streaming computation in sharp-edge acoustofluidics. This hybrid method was validated in 2D and extended for 3D configurations. This method may facilitate a full understanding of 3D streaming and new devices for this rapidly growing field.

2.2 Wave modulation with artificial materials

Xia et al. demonstrates that near-perfect absorption of low-frequency sound can be achieved in an open tunnel by using two deep sub-wavelength Mie resonators composed of a multiple-cavity structure and an outer frame on three sides. Increasing the number of Mie resonators in the tunnel enables broadband near-perfect sound absorption. The proposed Mie resonator has potential applications in architectural acoustics and mechanical engineering, as well as in sound communication, bio-sensing, and noise reduction. Qu et al. investigate interface phenomena in Willis media both analytically and by the finite-element method. The main findings are that wave transmission at an interface depends on the magnitude and direction of the coupling vector. Additionally, they found that edge waves exist at the interface between a Willis media and a hard boundary, an ordinary fluid, or another Willis media. The study of Ye et al. presents a general design scheme of Luneburg lenses for focusing higher-order Lamb waves based on physical properties of the phase velocity dependence on various plate thickness. This work may help guide the experimental implementation with the aid of phononic crystals (PCs) and metamaterials for applications of wave manipulation and energy harvesting in fields such as non-destructive testing techniques and spatial modulation of ocean acoustics.

2.3 Ocean acoustics: propagation, radiation, and scattering

Shi et al. use the spherical microphone arrays (SMAs) extrapolation method to enlarge the array aperture virtually to improve the performance of SMA signal processing algorithms for sound source localization and identification. Although the present simulation and experimental demonstration are conducted in air, it shows great potential for the source location and identification of marine structures in ocean acoustics. Tian et al. study the influence of physical properties on the compression wave speed of seafloor sediment with numerical models and experimental measurements from 42 samples collected from the South China Sea. The intergranular friction model is demonstrated effective to show the dependence of the compression wave speed on the physical properties of seafloor sediments, which could be used to predict the unknown compression wave speed assuming the physical parameters are provided. Li et al. proposes a coupled CFD-BEM approach to predict the acoustic radiation and scattering of moving bubbles for low velocities. Results indicate that as the frequency increases, the acoustic directionality of radiation and scattering exhibit main and side lobes, and the scattering energy gradually concentrates in the forward direction of the incident wave. The displacement and velocity of a moving bubble significantly impact the directionality of the scattered sound field, making it possible to study bubble localization based on directionality shift. Yang et al. extend the traditional semi-analytical and semi-numerical T-matrix method to compute the acoustic scattering of a pair of rigid spheroids with the addition theorems of the spherical basis functions. The physical mechanism of the interference and time delay between specular reflection and Franz waves is revealed. This work has potential applications in the detection of underwater objects in ocean engineering and particle assembly in the field of acoustofluidics. The study of Tang et al. focuses on the optimization of complex geometries of underwater vehicle models with conning tower to improve the acoustic stealth based on the physical acoustic method. The Kirchhoff-approximation-based planar element method is verified by on-site lake experiments. More importantly, this work provides an option to design new 3D shapes of underwater vehicles with the good ability of acoustic stealth. Qu et al. conducted a similarity analysis of the flow-induced noise of a benchmark submarine and tried to establish a similarity law based on the dimensional analysis method. An important rule of the sound power level spectrums is revealed for the scale effect if the inflow speeds are the same. This work makes it possible to predict the flow-induced noise of large-scale marine structures by using scaled models if the similarity law based on the dipole source is followed.

Author contributions

ZG prepared the first draft of this Editorial. FC, WL, and TB help work out the introduction of the papers they edited. All authors read throughout, revised, and approved the work for publication.

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