Topological Vector Acoustics

Ming-Hui Lu
School of Advanced Manufacturing Engineering, Nanjing University, China

Abstract— Conventional topological acoustics has mainly been based on scalar acoustic pressure fields. Particle velocity, as an intrinsic vector degree of freedom of acoustic waves, carries rich physical information such as polarization and spin, offering a new route to extend topological acoustics. This presentation shows how acoustic topology can be extended from scalar pressure to vector velocity fields. By exploiting velocity-related degrees of freedom in momentum space, real space, and the spatiotemporal domain, we construct novel topological acoustic fields and develop vector-velocity-enabled applications. (1) In momentum space, we reveal acoustic spin in evanescent waves, its spin-momentum locking, and the nontrivial topological evolution of velocity polarization through acoustic metamaterial design. (2) In real space, we construct acoustic skyrmions in velocity and spin fields, demonstrating robustness, tunability, and stable transport. (3) In the spatiotemporal domain, we realize two- and three-dimensional spatiotemporal acoustic vortices, enabling flexible control of orbital angular momentum and revealing spin-orbit interactions in velocity fields. (4) We further extend vector velocity to applications, achieving high-precision sound source localization, high-capacity acoustic communication, and multichannel acoustic holography. Overall, topological vector acoustics provides a new perspective for understanding and controlling acoustic waves and opens new possibilities beyond scalar-pressure-based applications.

Prof. Ming-Hui Lu is Dean of the School of Advanced Manufacturing Engineering at Nanjing University, where he is also a professor and doctoral supervisor. His research spans optics, acoustics, thermal science, condensed-matter physics, and related interdisciplinary fields, with primary interests in metamaterials, artificial microstructured materials, and photoacoustic detection. He has filed or been granted more than 40 Chinese and international patents, and has published over 260 papers in leading journals including Science, Nature, Nat. Mater., Nat. Phys., Nat. Rev. Phys., Nat. Commun., PRL, and NSR. His publications have received more than 20,000 citations, with an h-index of 68. He serves on the editorial boards of NSR, Chips, Nano Materials, and Frontiers in Acoustics.