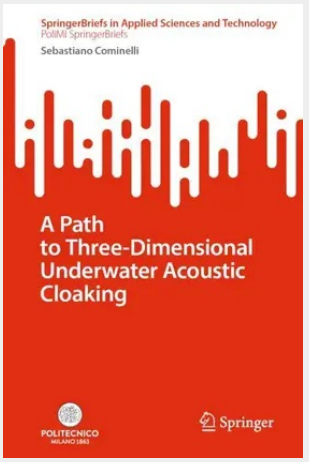
Cominelli

A Path to Three-dimensional Underwater Acoustic Cloaking



This book presents a comprehensive framework for the design of three-dimensional acoustic cloaks based on the principles of transformation acoustics and pentamode metamaterials. It bridges the gap between ideal theoretical cloaking concepts and physically realizable underwater devices through a systematic combination of analytical modelling and numerical investigation. Acoustic cloaking has emerged as a paradigm for controlling wave propagation, with potential applications ranging from underwater communication and sensing to noise mitigation and stealth technologies. Despite theoretical progress, the realization of three-dimensional acoustic cloaks remains an open challenge due to material requirements, geometric complexity, and intrinsic physical limitations. The work addresses these challenges through a theoretical and numerical study that combines rigorous physical principles with design strategies informed by practical constraints. It begins with an introduction to wave propagation in phononic crystals, low-frequency homogenisation, and the principles of transformation acoustics. Particular emphasis is placed on pentamode materials as artificial acoustic fluids, including the latest theoretical developments and numerical characterisation of the three-dimensional “metal water.” It further investigates the macroscopic design of spherical and cylindrical cloaks, examining the influence of discretisation, buoyancy, and material imperfections. It also explores the deployment of complex microstructures onto curved three-dimensional surfaces through tailored deformation and tessellation techniques.

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58,84 €
54,99 € (zzgl. MwSt.)

vorbestellbar, Erscheinungstermin ca. Oktober 2026

Artikelnummer: 9783032348814
Medium: Buch
ISBN: 978-3-032-34881-4
Verlag: Springer
Erscheinungstermin: 28.10.2026
Sprache(n): Englisch
Auflage: Erscheinungsjahr 2026
Serie: PoliMI SpringerBriefs
Produktform: Kartoniert
Seiten: 114
Format (B x H): 155 x 235 mm