NATIONAL TECHNICAL UNIVERSITY OF ATHENS
SCHOOL OF CIVIL ENGINEERING
INSTITUTE OF STEEL STRUCTURES

LECTURE

Tuesday June 2nd 2026, at 16:00

Auditorium of the Institute of Steel Structures, Zografou Campus, N.T.U.A.

ON THE INVERSE DESIGN OF METAMATERIALS AND WAVE-SHIELDING METASURFACES

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ABSTRACT

A wide range of applications in photonics and phononics, including band-gapping, cloaking, seismic metamaterials, noise and vibration control, energy harvesting, etc, stand to benefit from engineering the dispersive properties of periodic media. In this presentation, I discuss the inverse design of metamaterials for controlling the propagation of waves, which give rise to material and topology optimization problems. Of particular interest are wave-steering and wave-shielding applications. For shielding applications, we treat the metasurface design problem as an inverse medium problem: we seek to discover a metasurface's material composition to satisfy user-defined band gap(s) at prescribed frequency ranges. The band gap could be either directional or omni-directional. In the elastic wave case, it is of added interest that an omni-wave band gap be realized, i.e., a gap at the same frequencies for both shear and compressional waves. For steering applications, we use the engineered metasurface as a liner along the steering path. Mathematically, we cast the associated inverse problem as a dispersion-constrained optimization problem over the unit cell's irreducible Brillouin zone. We define a Lagrangian comprising the band gap objective cast as the vanishing of the group velocity at the gap frequencies, and the periodic medium's unit cell's side-imposed Floquet-Bloch eigenvalue problem. Next, we appeal to the Hellman-Feynman theorem to express the group velocity in terms of the Floquet-Bloch eigenpair, and convert the constrained optimization problem into an unconstrained problem amenable to a standard adjoint method. I report numerical experiments that demonstrate feasibility for constructing omni-wave and omni-directional shields exhibiting sub-wavelength performance in 2D and 3D.

BRIEF CV

Professor Loukas Kallivokas holds a Diploma in Civil Engineering (1985) from the National Technical University, Athens, Greece, a Master of Science (1990) in Civil Engineering and a PhD (1995) in Computational Mechanics from Carnegie Mellon University. He has held academic appointments in Civil Engineering, in Computer Science, and in the Robotics Institute at Carnegie Mellon University. Since 1999, he serves on the faculty of the Department of Civil, Architectural and Environmental Engineering at the University of Texas at Austin, where he is currently Associate Chair of Civil Engineering. In 2003 he was the recipient of a National Science Foundation CAREER award for research in full-waveform-driven site characterization; from 2008 to 2011 he was the Chair of the Computational Mechanics Committee of ASCE's Engineering Mechanics Institute. He has served on the Editorial Board of the Journal of Earthquake Engineering, and since 2012 he serves as an Associate Editor for ASCE's Journal of Engineering Mechanics. In 2020, he was elected Fellow of the Engineering Mechanics Institute of ASCE.

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