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THE BURGERS PROGRAM FOR FLUID DYNAMICS
THE FLUID DYNAMICS REVIEWS SEMINAR SERIES

PSUBS: FLOW INSTABILITY WAVES AND SUBSURFACE ELASTIC WAVES SYNCHRONIZED TO PERFECTION

Friday, March 24, 2023 | 4 pm

DeWalt Seminar Room
2164 Glenn L. Martin Hall

Speaker

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ABSTRACT

Flow control is a many-decades old applied physics problem of a multi-disciplinary nature. For streamlined bodies cruising through a flow, such as air or water, there is a key interest in the control of flow instabilities. These are disturbances or perturbations in the flow velocity field that grow naturally and ultimately trigger transition of the flow from laminar to turbulent, which in turn causes significant increases in skin-friction drag. A rise in drag reduces the fuel efficiency in aircrafts and ships. It is therefore desired to device intervention methods to impede the growth of these instabilities. Alternatively, the objective may be to speed up the growth of the instabilities, for example to prevent or delay flow separation.

In previous research, we have shown that phonon motion underneath a surface interacting with a flow may be tuned to cause the flow to stabilize, or destabilize, as desired [Hussein et al., Proc. R. Soc. A, 2015]. The underlying control mechanism utilizes core concepts from phonon physics, primarily, the principle of destructive or constructive interferences and the notion of topological symmetry breaking. This is realized by installing a phononic subsurface (PSub), which is an architectured structure placed in the subsurface region and configured to extend all the way such that its edge is exposed to the flow, forming an elastic fluid-structure interface. The PSub may take the form of a phononic crystal or a locally resonant elastic metamaterial, with finite extent, and is typically oriented perpendicular to the fluid-structure interface. It is engineered to exhibit specific frequency-dependent amplitude and phase response characteristics at the edge exposed to the flow. These two quantities represent the two core properties on which the PSub design theory is based on. I will present recent results showcasing perfectly synchronized, passive, and responsive, phased response and energy exchange between the elastic domain of a PSub and the perturbation (instability) field within an interfacing flow. Both phononic-crystal and elastic-metamaterial PSubs will be demonstrated [Kianfar and Hussein, New J. Phys., 2023, to appear].

BIO

Mahmoud I. Hussein is the Alvah and Harriet Hovlid Professor at the Smead Department of Aerospace Engineering Sciences at the University of Colorado Boulder. He holds a courtesy faculty appointment in the Department of Physics and an affiliate faculty appointment in the Department of Applied Mathematics, and he has formally served as the Engineering Faculty Director of the Pre-Engineering Program and the Program of Exploratory Studies. He received a BS degree from the American University in Cairo (1994) and MS degrees from Imperial College London (1995) and the University of Michigan–Ann Arbor (1999, 2002). In 2004, he received a PhD degree from the University of Michigan–Ann Arbor, after which he spent two years at the University of Cambridge as a postdoctoral research associate.

Dr. Hussein's research focuses on the dynamics of materials and structures, especially phononic crystals and metamaterials, at both the continuum and atomistic scales. His research considers areas that range from vibrations and acoustics of engineering materials and structures and passive flow control to lattice dynamics and thermal transport in semiconductor-based nanostructured materials. His studies are concerned with physical phenomena governing these systems, associated theoretical and computational treatments, and analysis of relevant mechanisms such as dispersion, resonance, dissipation, and nonlinearity. His team also conducts experiments to support some aspects of the theoretical work.

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