UCMERCED UNIVERSITY OF CALIFORNIA Graduate MECHANICAL ENGINEERING

Fall 2021 Graduate Seminar

Progress on predicting the hypersonic wall-bounded turbulence

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https://ucmerced.zoom.us/j/88444729017

Abstract

In this talk, we will focus on the physics and modelling of the hypersonic wall-bounded turbulence. Firstly, the interaction of an incident shock wave with a Mach-6 laminar boundary layer is addressed using DNS and equilibrium wall-modeled LES (WMLES). The consequences of the interaction are that the boundary layer transitions to turbulence, and that transition causes a localized significant increase in the Stanton number and skin-friction coefficient. WMLES provides predictions of DNS peak loads within 10% at 150 times lower computational cost. In the fully-turbulent boundary layer, WMLES agrees well with DNS for the Reynolds-analogy factor, the mean velocity and temperature profiles, and the temperature/velocity correlations. Secondly, we will present our recent efforts in modelling the wall-bounded turbulence. A new wall model accounting for pressure gradient and Reynolds number effects and a method for determining the boundary-layer thickness in complex flows are introduced. The extension to high-speed flows is accommodated by proposing a novel transformation, which maps the mean velocity profiles of compressible wall-bounded turbulent flows to the incompressible law of the wall. Unlike existing approaches, the proposed transformation successfully collapses, without specific tuning, numerical simulation data from fully developed channel and pipe flows, and boundary layers with or without heat transfer. The performance of the transformation is verified for compressible wall-bounded flows with edge Mach numbers ranging from 0 to 15 and friction Reynolds numbers ranging from 200 to 2000. Based on physical arguments, we show that such a general transformation (i.e., compressible law of the wall) exists for compressible wall-bounded turbulence regardless of the wall thermal condition (Ref. PNAS 2021, JFM 2021, PRF 2021, etc.).

Biography

Prof. Lin Fu is an Assistant professor in the Department of Mathematics and the Department of Mechanical and Aerospace Engineering at The Hong Kong University of Science and Technology (HKUST). Before he joined HKUST, he was a postdoctoral fellow working with Prof. Parviz Moin at Center for Turbulence Research, Stanford University, for more than 3 years. And he also did postdoctoral research with Prof. Nikolaus Adams at Technical University of Munich, where he obtained his Ph.D. degree with a grade of Summa Cum Laude (passed with the highest distinction). His ongoing and future research involves the fundamental study of flow physics including turbulence, transitional flows, multi-phase flows, and electrically conducting fluids. He has published more than 30 journal papers on PNAS, JFM, PRF, JCP, CMAME, etc.

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