Center for Molecular & Engineering Thermodynamics Seminar

UNIVERSITY OF DELAWARE

ISMAIL HAMEDUDDIN

JOHNS HOPKINS UNIVERSITY

"TACKLING VISCOELASTIC TURBULENCE"

Fluid turbulence, and the process of its onset from a laminar state, are complex multiscale phenomena that are as technologically important as they are challenging to understand. Turbulence leads to undesirable drag in many flows, but also increases beneficial mixing. Turbulence in viscoelastic flow, obtained by adding polymers to a solvent, exhibits unique features with potentially dramatic technological impact, e.g. high mixing efficiency due to turbulence at very low Reynolds numbers (Re) and significant drag reduction at high Re. Traditional approaches used to understand and quantify viscous turbulence cannot be directly extended to the viscoelastic case as the dynamics depend not only on the velocities, but also on the polymer deformation which is encoded in the conformation tensor. The latter requires special treatment because, unlike the velocity field, it lives on a non-Euclidean manifold. This leads to several complications, including that standard vector space norms are not meaningful, and additive decompositions fail to define physically consistent fluctuating conformation tensors about given base-states. In this talk, I will propose a framework to obtain a fluctuating conformation tensor about a given base-state, scalar measures to quantify the resulting fluctuating conformation tensor, and also develop a physically consistent approach to generate general conformation tensor perturbations. The framework is derived based on a physical decomposition of the polymer deformation and the inherent non-Euclidean geometry of the manifold to which the conformation tensor is kinematically restricted. It thereby establishes, for the first time, a systematic method to study viscoelastic turbulence and has wider implications on how positive-definite tensors are analyzed in complex flows. Direct numerical simulations of drag-reduced channel flow, and also of Tollmien-Schlichting waves are used to illustrate the approach. The analysis uncovers interesting phenomena that were not apparent before, including a logarithmic decrease in anisotropy of the mean conformation tensor away from the wall in the drag-reduced flow.

BIOGRAPHY

ISMAIL HAMEDUDDIN is a PhD candidate at the Johns Hopkins University. He is interested in theory and simulation of non-Newtonian fluids, and particularly in transition and turbulence in wall-bounded viscoelastic flows. He earned a BS in Mechanical Engineering from the University of Missouri, Columbia in 2009, and an MS in Mechanical Engineering from the Johns Hopkins University in 2015.

CMET SEMINAR

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366 Colburn Lab

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