INSTITUT POLYTECHNIQUE DE PARIS

Mechanics Seminar series 2024 – 25

On the use of the Single Generator Bracket Formalism of Non-Equilibrium Thermodynamics for the development of the equations of Continuum Mechanics

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Abstract

In this presentation we will first offer an introduction to one of the modern formulations of Non-Equilibrium Thermodynamics, that based on the single generator bracket formalism, first described in our research monograph (Beris and Edwards, Thermodynamics of Flowing Systems, Oxford U. Press, 1994). We will then illustrate several example applications in the modeling of the flow behavior of complex fluids. First, we will show how this formalism can be used to effortlessly describe inner variables, reference-based, description of viscoelastic fluids, extending Oldroyd's pioneering work. Most of the commonly used viscoelastic fluid models can be described within this formalism. Advantages include the possibility of extensions as well as the investigation of their thermodynamic consistency. Second, an example from the description of liquid crystals will be offered as an illustration of the capability to handle easily within this formalism the presence of constraints as the unit magnitude of the director used to describe nematic liquid crystals. An advantage is the extension to cover biaxial nematics with allowance for partial disorder. We will close with a preliminary description of dielectrics. The advantage is the possibility to extend this description to complex elastomers. The key element to describing these complex systems is the use of system's Hamiltonian (representing the total free energy). The promise is that this thermodynamically based methodology provides a systematic modeling approach that can be followed in the development of much more complicated (and therefore more realistic) systems with many applications.

About the speaker

Antony Beris holds a Ph.D. in Chemical Engineering from Massachusetts Institute of Technology (1985). He is currently the Arthur B. Metzner professor of Chemical and Biomolecular Engineering and he is also an affiliate faculty member of the Department of Biomedical Engineering. He has also served on the board of directors of the Center of Composite Materials. Antony Beris's research is concerned with the modeling and simulation of the interplay of flow processes and nonequilibrium thermodynamics in systems with a complex internal microstructure, where multiple length and time scales are important. Typical examples include the study of liquid crystal flows, polymer and surfactant-induced turbulent drag reduction, blood flow circulation in the human arterial system, thixotropy effects in aggregating concentrated suspensions, stress-induced migration and crystallization in polymers, free-surface flows in polymer processing, etc. He has published a seminal research monograph on "Thermodynamics of Flowing Systems" (together with B.J. Edwards) and more than 150 refereed articles. He is a fellow of AAAS, of APS (Division of Fluid Dynamics) and of the Society of Rheology and has received the 2015 Willem Prins prize, awarded by the Delft Association of Polymer Technology from Delft UT in the Netherlands.

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