COLLEGE OF ENGINEERING

Research Seminar Series

University of Nebraska-Lincoln

Department of Chemical and Biomolecular Engineering

# Recent Applications of Non-Equilibrium Thermodynamics in the Modeling of Complex Fluid Flows


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*Host: Dr. Yasar Demirel*

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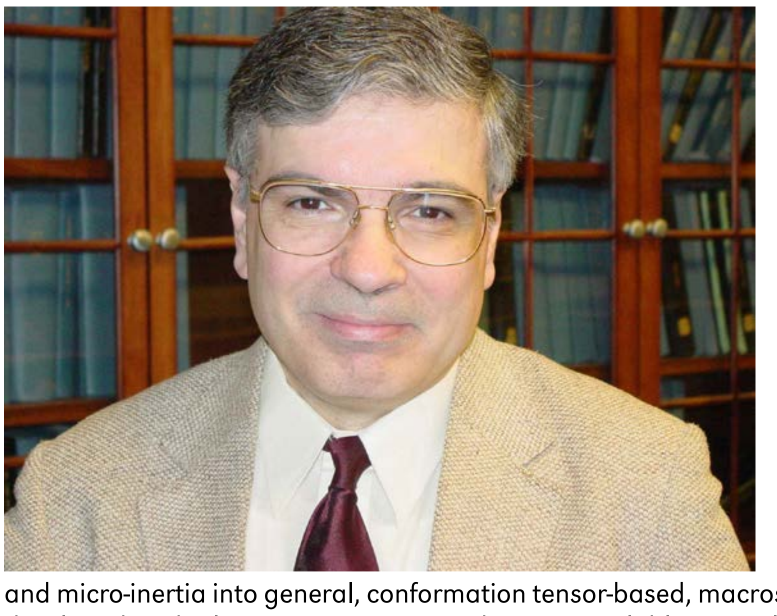
10:00 a.m. – 11:00 a.m.

Othmer Hall Room 205

**Refreshments provided*

## Abstract




Following the Non-Equilibrium Thermodynamics bracket formalism, as described in our research monograph (Beris and Edwards, Thermodynamics of Flowing Systems, Oxford U. Press, 1994), we will illustrate here several new example applications in the modeling of the flow behavior of complex fluids. The common element is that they both involve dilute emulsions of a binary system of two immiscible liquids corresponding to a monodisperse population of drops. First, we show how one can in this way extend to significantly higher values of the Capillary number asymptotic results available in the literature valid for infinitesimally small values. Second, the same system allows us to test the introduction of micro-inertia effects into macroscopic models of particulate flows. Both these applications are based on the use of an internal conformation tensor structural variable. This is physically identified with the deformed ellipsoidal geometry of the dispersed phase. The key element to describe these multiphase systems is the use of a surface energy term in the system's Hamiltonian (free energy). In addition, when microinertia effects are important, a new kinetic structural term in the Hamiltonian is introduced along with a new non-affine dissipative term that couples the conformation and the vorticity tensors in the evolution equation for the conformation tensor. This derivation and resultant constitutive equation provide a new pathway to rigorously incorporate microstructural deformation and micro-inertia into general, conformation tensor-based, macroscopic models for multiphase systems. The micro-inertial model is consistent with previously developed in the literature asymptotic theories available not only in the limit of small capillary, *Ca*, but for small particle Reynolds, *Re*, numbers as well. These asymptotic solutions are also used to uniquely determine all the model parameters. The promise is that similar approaches can be followed in the development of much more complicated (and therefore more realistic) systems with applications ranging from food processing to cosmetics, fracking and tertiary oil recovery.


## Biography

Professor 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 and a member of the Center for Molecular and Engineering Thermodynamics. He has also served in the past in the board of directors of the Center of Composite Materials.

Professor Beris 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 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 135 refereed articles. He is a fellow of AAAS 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.