Hiroaki Yoshimura, Waseda University, Japan

Variational Formalisms, Dirac Structures, and Dynamical Systems for Nonequilibrium Thermodynamics

In this talk, we present a Lagrangian variational formulation for nonequilibrium thermodynamic, which is an extension of Hamilton's principle in mechanics to thermodynamics including irreversible phenomena. The irreversibility is encoded into a nonlinear phenomenological constraint, which is given by a nonlinear nonholonomic constraint in the form of entropy production associated with all the irreversible processes involved. Our theory enables us to treat various discrete (finite-dimensional) systems such as mechanical systems with friction, matter transfer, electric circuits, chemical reactions, and diffusion across membranes as well as (infinite-dimensional) continuum systems such as multicomponent reacting viscous fluids. Finally, we show the underlying structures of the nonequilibrium thermodynamics; in particular, we show how the nonlinear nonholonomic constraint can be incorporated into Dirac structures together with the associated dynamical systems. We will also take a brief look at the variational discretization for nonequilibrium thermodynamics.

Hiroaki Yoshimura is a Professor of Waseda University at the Department of Applied Mechanics & Aerospace Engineering and the Department of Mathematics & Applied Mathematics. He has been focused on Dirac geometry and its applications to mechanics, physics and engineering since he started to study Dirac structures, variational principles, and reduction at Caltech in collaboration with Jerry Marsden in early 2000s. His recent research has been dedicated to the variational approach to nonequilibrium thermodynamics. He is also concerned with space mission design based on the four-body problem, Lagrangian coherent structures in fluids, and mathematical modeling of cavitation bubbles with induced shock waves.