Applications of Edelen's dissipation potentials to mechanics and transport phenomena

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Abstract

This talk deals with the application of generalized dissipation functions and the associated *dissipation potentials* to a variety of *strictly dissipative* mechanical and physicochemical processes.

As generalizations of the classical Onsager-Rayleigh forms, dissipation potentials have been employed in plasticity theories for some seventy-five years or more. Arguments for the existence of such potentials have been based mostly on appeals to special microstructures and/or on the dubious assumption of maximum entropy generation [4]. By contrast, in a remarkable but largely ignored body of work, Edelen [1, 2] offers a purely mathematical construct that yields a generalized force-dependent velocity (or "flux") as gradient of a dissipation potential, *modulo* a non-dissipative term representing a "powerless" or "gyroscopic" flux. When the latter is absent, one obtains *non-linear Onsager symmetry* and a *hyperdissipative* response that constitutes the mirror image of the *hyperelastic* response of reversible processes.

Casting Edelen's formulae in a simpler form, the speaker [3] provides the extension to Legendre-Fenchel dual potentials, emphasizing the special role of homogeneous potentials and laying down correct variational principles.

Following the above general review, some recent applications to symmetry relations and variational principles for other processes will be discussed, including visco-plastic drag laws, networks of chemical and biochemical reactions accompanied by diffusive mass and heat transfer, and biochemo-mechanics. It is conjectured that the latter exhibit gyroscopic behavior, with breakdown of non-linear Onsager symmetry.

[1] D. G. B. Edelen. A nonlinear Onsager theory of irreversibility. *Int. J. Eng. Sci.* **10** 481–90, 1972.

[2] D. G. B. Edelen. On the existence of symmetry relations and dissipation potentials. *Arch. Ration. Mech. Anal.* **51** 218–27, 1973.

[3] J. D. Goddard. Edelen's Dissipation Potentials and the Visco-plasticity of Particulate Media. *Acta Mech.* **225** 2239–59, 2014.

[4] H. Ziegler and C. Wehrli. On a principle of maximal rate of entropy production. *J. Non-Equil. Thermo.*, **12** 229–44, 1987.

CV of Speaker

Joe Goddard received his Ph.D. in chemical engineering from the University of California, Berkeley in 1962. He joined the chemical engineering faculty of the University of Michigan, Ann Arbor, in 1963, and in 1976 he accepted the position of Fluor Professor and Chair in the Department of Chemical Engineering at the University of Southern California in Los Angeles. He has been Professor of Applied Mechanics and Engineering Science in the University of California, San Diego, since 1991, becoming Professor Emeritus in 2016,

He has published research in a variety of fields, including the mechanics of complex fluids and solids, and the thermodynamics and transport properties of of physical and biological systems. He has served on various editorial boards and U.S. national committees on mechanics and has been a visitor at several academic and research institutions, most recently Springer Visiting Professor in Mechanical Engineering at the University of California, Berkeley, 2012, visiting researcher in the Ben Gurion University, Be'er Sheva, Israel, and the École Polytechnique, Palaiseau, France, 2014, and Senior Fellow in the University of Durham (U.K.) Institute of Advanced Study, 2016. Other professional distinctions include, NATO, NSF and Fulbright Postdoctoral and Senior Postdoctoral Fellowships, 1963-84, D.L. Katz Lecturer, University of Michigan, 1983, President of the U.S. Society of Rheology, 1991-93, and G.I. Taylor Medalist of the Society of Engineering Science, 2012.