**Quasi-linear versus potential-based formulations of force-flux relations and the GENERIC for irreversible processes: Comparisons and examples**

M. Hütter,(1) B. Svendsen(2)

(1) Eindhoven University of Technology, Polymer Technology, The Netherlands. Email: m.huetter@tue.nl

(2) RWTH Aachen, JARA, Material Mechanics, Germany. Email: bob.svendsen@rwth-aachen.de

**Abstract:** An essential part in modeling out-of-equilibrium dynamics is the formulation of irreversible dynamics. In the latter, the major task consists in specifying the relations between thermodynamic forces and fluxes. In the literature, mainly two distinct approaches are used for the specification of force-flux relations. On the one hand, quasi-linear relations are employed, which are based on the physics of transport processes and fluctuation-dissipation theorems [1,2]. On the other hand, force-flux relations are also often represented in potential form with the help of a dissipation potential [3]. We address the question of how these two approaches are related.

The main result of this presentation states that the class of models formulated by quasi-linear relations is larger than what can be described in a potential-based formulation. While the relation between the two methods is shown in general terms, it is demonstrated also with the help of three examples: (i) heat conduction in rigid bodies, (ii) homogeneous chemical reactions, and (iii) slippage in complex fluids. In particular, whereas the irreversible processes (i) and (ii) are dissipative, (iii) is not. Consequently, conditions for the existence of a dissipation potential for the models of (i) and (ii) can be formulated. On the other hand, the potential for the model of (iii) is identically zero. More generally, this is the case for the model of any irreversible process which results in no dissipation. Finally, the ramifications of these results on the General Equation for the Non-Equilibrium Reversible-Irreversible Coupling (GENERIC: e.g., [4-8]) are discussed.

**Acknowledgement:** MH gratefully acknowledges financial support from the High Potential Research Program at the Eindhoven University of Technology entitled “Multiscale Analysis of Intrinsic Properties of Polymer Systems”.

**References:**

[1] de Groot, S. R., Mazur, P., 1962. Non-equilibrium Thermodynamics. North-Holland.

[2] Lifshitz, E. M., Pitaevskii, L. P., 1981. Physical Kinetics. Vol. 10, Landau and Lifshitz Series on Theoretical Physics. Pergamon Press.

[3] Šilhavý, M., 1997. The Mechanics and Thermodynamics of Continuous Media. Springer.

[4] Grmela, M., Öttinger, H. C., 1997. Phys. Rev. E, 56, 6620–6632.

[5] Öttinger, H. C., Grmela, M., 1997. Phys. Rev. E, 56, 6633–6655.

[6] Öttinger, H. C., 2005. Beyond Equilibrium Thermodynamics. Wiley Interscience.

[7] Grmela, M., 2010. Adv. Chem. Engin., 39, 75–129.

[8] Grmela, M., 2010. J. Non-Newtonian Fluid Mech., 165, 980–986.

**Procedure:**

Authors wishing to contribute to IWNET 2025 are invited to submit a ***one-page abstract*** (using the template, see previous page) through [https://mathweb.aegean.gr/iwnet2025/abstract.php](https://mathweb.aegean.gr/hsr2025/abstract1.php) or by email to [iwnet2025@aegean.gr](mailto:iwnet2025@aegean.gr) by **February 28, 2025**. The authors will receive notification of acceptance or not of their proposed contribution by **March 15, 2025** (oral and poster).

**Instructions:**

Please adhere to the formatting of the template (previous page). Note that the abstract must not exceed 1 single page in total, including title, author names (“presenting author” must be underlined) with affiliations, abstract, acknowledgement, and references.

**Select preferred presentation style** (please indicate preference by putting “X”):

Oral [ ] Poster [ ]

**File name:**

Please name your abstract file according to the following scheme:

[last name of presenting author].docx

For example: Hutter.docx