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Review of the Habilitation Dissertation of Dr. Pavelka, by opponent (external examiner)

Christian Maes:

Let me start by mentioning that I have verified the originality check done by the Turnitin system. At first sight, a high percentage of coincidences has been found. Yet that is normal and not to be a warning as the Dissertation is a collection of reprints of several published papers co-authored by dr. Pavelka. Of course, the dissertation is more than that and many commentaries have been added.

I have read the thesis and I briefly mention my impressions and conclusions in what follows. The dissertation proves of excellent quality, reflecting a great scientific effort. I applaud its systematic search for pushing the program of nonequilibrium thermodynamics. My review has been teaching me quite some things. I would have loved to read even more connections with nonequilibrium statistical mechanics but clearly, the subject can and must be approached from different sides (and often by different people). I just want to mention that the “nonequilibrium” which is the main subject of this work, is mostly referring to the transient part of relaxation to equilibrium, not to the so called steady nonequilibria.

Dr Pavelka has chosen the route of geometric mechanics in connection with nonequilibrium thermodynamics, as mathematically described by cotangent bundles, Lie groups, and Lie algebras. We could also call it a Hamiltonian approach, as it starts from an action and variational principle. Dr Pavelka motivates that by referring, e.g. for complex fluids, to the absence of natural evolution equations for nonconserved quantities. That brings him to the framework of GENERIC, and his work on a multiscale analysis within that geometric framework. We could even say that his main contributions are clarity of exposition on the nature of place and usefulness of GENERIC, the application of reduction schemes in dealing with the multiscale nature of nonequilibrium thermodynamics and the working out of various physically relevant examples and models of dynamic reduction and irreversible relaxation. Important contribution of Dr Pavelka include the clarification of time-reversal transformations in the framework and the treatment there of the Ehrenfest reduction.

The work starts by recapitulating the main geometric aspects of the Hamiltonian formalism (Poisson geometry). An interesting addition there is to consider noncanonical Poisson



brackets. Another idea is to move from more microscopic treatments to more coarse-grained descriptions while keeping the Poisson structure. An example is the derivation of the Euler brackets. More generally, that is true for the reversible part of macroscopic evolution equations. An interesting discussion there is how the symplectic structure (skew-symmetric bivector) generating Hamiltonian mechanics is compatible with the symmetry of the metric in Riemannian geometry.

After describing in detail the framework of GENERIC, Dr Pavelka turns to the possibility on nonconvex thermodynamic potentials. The question arises where dissipation potentials arise in general. Here the lack-of-fit reduction appears, a method of dynamic reduction, reducing a detailed level of description with the GENERIC structure to a less detailed GENERIC. It applies a MaxEnt method.

In all, Dr Pavelka is very clear in describing the general context and motivation, plus his own contributions in various aspects. Furthermore, there appears a consistent outlook and plan of action to continue this broad and rich domain of research. Clearly, the work, both in general and for the contributions of Dr Pavelka is very well written. It is clear and understandable, as it moves from the elementary and introductory level to the more specialized and mathematical issues. The bibliography is extended and useful as well. In all, the wealth of publications of Dr Pavelka witnesses of his productivity and international visibility.

Given the high level of scientific research, its relevance, timely nature and importance in general, the clarity of the scientific writing and the excellent nature of the results and publications, I firmly and heartily recommend this thesis to be essential motivation to award habilitation to Dr Pavelka.

Yours Sincerely,

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