Objectivity and Wave Propagation

Peter Ván
Dep. of Theoretical Physics, KFKI, RMKI
1525 Budapest, Konkoly Thege Miklós u. 29-33., and
Department of Energy Engineering, BUTE
1111 Budapest, Bertalan Lajos u. 4-6.,
e-mail: vpet@rmki.kfki.hu
HUNGARY

ABSTRACT

A constitutive theory of continuum physics is a theoretical approach to find macroscopic material models. The two most important basic principles in a constitutive theory that could unify empirical data are the frame independence of constitutive functions - material frame indifference - and the Second Law of thermodynamics. At the same time these are the most problematic and discussed concepts of material modelling.

In the last years we have investigated the formulation and the mathematical representation of these ideas from the point of view of a rigorous non relativistic spacetime model, that represents an inherently objective approach. Due to the mathematical structure of the theory the basic physical quantities are defined independently of an observer. We have concluded, that a four dimensional non-relativistic formulation eliminates some ambiguities of the traditional definition of objectivity [1, 2, 3] and can be a suitable tool to construct a frame independent constitutive theory of classical continua.

In a parallel research we have developed a rigorous and constructive exploitation method of the Second Law for weakly nonlocal continua (see [4] and the references therein). Now we have started to unify these methods and build up an objective exploitation method of the Second Law. Our aim is an objective constitutive theory where the Second Law is applied constructively, beyond local equilibrium considering nonlocal effects both in space and time. Up to now we have investigated special relativistic fluids from this point of view [5] and started to elaborate the method for non-relativistic solids.

In this presentation we show the results of some further steps in this program introducing a constitutive theory of a frame independent first-order weakly nonlocal finite deformation continuum mechanics with a single internal variable. The resulted set of equations gives a coupling of rheological and mechanical interactions. We analyse the consequences of our approach to wave propagation by linearizing the system of equations and shortly compare the results to traditional approaches.

References

[1] T. Matolcsi and P. Ván. Can material time derivative be objective? *Physics Letters A*, **353**, 109-112, 2006.

[2] T. Matolcsi and P. Ván. Absolute time derivatives. *Journal of Mathematical Physics*, **48**, 053507-19, 2007.

[3] M. Frewer. More clarity on the concept of material frame-indifference on classical continuum mechanics. *Acta Mechanica*, **202**, 213-246, 2009.

[4] P. Ván. Weakly nonlocal non-equilibrium thermodynamics - variational principles and Second Law. In press, 2009, arXiv:0902.3261.

[5] P. Ván. Internal energy in dissipative relativistic fluids. *Journal of Mechanics of Materials and Structures*, **3**, 1161-1169, 2008.