

A thermodynamical approach to nonlinear wave phenomena

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The internal variables framework of thermodynamics is an efficient approach to wave phenomena of materials with internal structures where changes of mechanical, thermal, chemical a.o. character should be taken into account. The constructive application of the second law of thermodynamics enables one to derive nonlinear and dissipative theories in a consistent manner.

In the presentation, we shortly survey this framework, including the weakly nonlocal extensions [1, 2, 3, 4] and the method of current multipliers [5].

As new examples for applications, the various known nonlinear extensions of the Fourier heat conduction equation, including the Maxwell-Cattaneo-Vernotte, Guyer-Krumhansl and Green-Naghdi equations, are presented as special cases of a more universal theory derived by this methodology. We investigate perspectives of nondissipative wave propagation like the ballistic solutions, second sound, show the relation to nondissipative Green-Naghdi equation and explore further possibilities. On the example of heat pulse boundary conditions we numerically demonstrate the various solutions and compare the results with experimental data measured by the flash method. Our experimental investigations study samples of diverse origin, including porous rocks and biological tissues.

References

- [1] P. Ván, A. Berezovski and J. Engelbrecht. Internal variables and dynamic degrees of freedom, *Journal of Non-Equilibrium Thermodynamics*, 2008, 33(1), 235-254.
- [2] P. Ván, C. Papenfuss and A. Berezovski. Thermodynamic approach to generalized continua, *Continuum Mechanics and Thermodynamics*, 2014, 25(3), 403-420, (arXiv:1304.4977).
- [3] Berezovski, A. and Engelbrecht, J. and Berezovski, M.. Waves in microstructured solids: a unified viewpoint of modelling, *Acta Mechanica*, 2011, 220, 349-363.
- [4] A. Berezovski, J. Engelbrecht and P. Ván. Weakly Nonlocal Thermoelasticity for Microstructured Solids: Microdeformation and Microtemperature *Archive of Applied Mechanics*, 2014, online first.
- [5] P. Ván and T. Fülöp. Universality in heat conduction theory: weakly nonlocal thermodynamics, *Annalen der Physik*, 2012, 524(8), 470-478, (arXiv:1108.5589)