



Foreword

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This special issue of CAIM is devoted to the proceedings of the minisymposium "Constitutive Equations for Heat Conduction in Nanosystems and Nonequilibrium Processes", which has been organized as a special session of the First Joint International Meeting of the Italian and Spanish Mathematical Societies RSME - SCM - SEMA - SIMAI - UMI, held in Bilbao, Spain, from June 30 to July 4, 2014. The organization of this minisymposium has been motivated by the need of bringing together different scientists whose research activity, from different perspectives, is devoted to modeling heat transport in far-from-equilibrium processes, as it happens in fast phenomena and/or in small systems.

Heat transport is currently experiencing a true revolution, which is enlarging its domain of applicability and discovering new phenomenologies where the classical Fourier's theory is no longer applicable. This new epoch has been stimulated by miniaturization, since several new aspects arise in connection to the relation between the heat carriers' mean-free path and the characteristic size of the system.

Nowadays, there is an increasing interest in mesoscopic modelizations based on generalized heat transport equations simpler than the much more complex and detailed microscopic models.

The special session lasted from June 30 to July 2, with 13 speakers and several participants from different countries. Special emphasis should be paid to the final round table on "Modeling non-equilibrium processes in continuum physics", in which different viewpoints on Nonequilibrium Thermodynamics have been analyzed and compared.

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The program of the special session is detailed below.

- **Monday, June 30 (Afternoon)** - Chairman: Miroslav Grmela
- Orazio Muscato: "Electron Transport in Silicon NanoWires"
- Yuan Dong: "Thermal rectification based on phonon hydrodynamics and thermomass theory"
- David Jou: "Phonon hydrodynamic description of heat rectification in some porous silicon devices"
- Patrizia Rogolino: "Thermoelectric coupling in Thermomass theory"
- Antonio Sellitto: "Nonlocal constitutive equations for thermoelectric effects and their implications on thermoelectric energy conversion"

- **Tuesday, July 1 (Morning)** - Chairman: Federico Vázquez
- Miroslav Grmela: "Hamiltonian and nonlocal continuum mechanics"
- Yu-Chao Hua: "The principle of least action in heat transfer process"
- Liliana Restuccia: "Non-equilibrium temperatures in systems with internal variables and implications on heat equation"

- **Tuesday, July 1 (Afternoon)** - Chairman: Orazio Muscato
- Federico Vázquez: "Thermal performance and entropy production in nanoscaled thermoelectric layers"
- Vito Antonio Cimmelli: "Entropy principle and non-local constitutive equations in nanosystems"
- Carla de Tomás: "The role of collective phonons in thermal transport"
- Michele Sciacca: "Effective thermal conductivity in narrow channels filled with Helium II: laminar, turbulent, diffusive, and ballistic regimes"
- Lidia Saluto: "Inhomogeneous vortex tangles in superfluid helium turbulence"

- **Wednesday, July 2 (Morning)** - Chairmen: David Jou and Vito Antonio Cimmelli

- Round table: "Modeling non-equilibrium processes in continuum physics"

Although this special issue is mainly devoted to the proceedings of the minisymposium, we welcomed the contributions of other colleagues, i. e., Peter Ván, Moran Wang, Hatim Machrafi and Yangyu Guo, who could not attend the conference in Bilbao but would like to contribute to our discussion on heat conduction in nonequilibrium processes.

The special issue consists of 12 articles, 11 research articles by the contributing authors and 1 review article by the guest editors.

- O. Muscato and T. Castiglione analyze transport phenomena in silicon nanowires with different cross-section by using an Extended Hydrodynamic model coupled to the Schrödinger-Poisson system. The closure of the moment system is achieved by applying the maximum entropy principle.
- Y. Dong studies the phenomenon of thermal rectification by applying both phonon hydrodynamics and thermomass theory. The thermal rectification effect in a trapezoidal silicon flake is analyzed through these models.
- A. Sellitto, P. Rogolino and I. Carlomagno analyze the consequences of the nonlinear terms in the heat-transport equation of the thermomass theory on the shape of heat pulses propagating in a nanowire in nonequilibrium situations.
- M. Grmela presents Nonequilibrium Thermodynamics as an universal framework for multiscale representation of mesoscopic dynamic theories.
- L. Restuccia deals with the definition and the meaning of nonequilibrium temperature in nanosystems with internal variables, and with its implications on heat transport.
- I. Rivera, A. Figueroa and F. Vázquez address the problem of optimization of the so called supercooling effect in thermoelectric nanoscaled layers. Their analysis is based on constitutive equations of the Maxwell-Cattaneo type describing the time evolution of dissipative flows.
- M. Sciacca and L. Galantucci present new results on the effective thermal conductivity of liquid helium II in rectangular channels with high aspect ratio.
- M. S. Mongiovì and L. Saluto investigate the evolution equation for the average vortex length per unit volume of superfluid turbulence in inhomogeneous flows.
- P. Ván explores and review the experimental basis and the theo-

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retical background of non-Fourier heat conduction from the point of view of non-equilibrium thermodynamics. The performance of different theories to reproduce heat pulse experiments is compared.

- Y. Guo and M. Wang present a generalized heat transport equation including relaxational, nonlocal and nonlinear effects, which contains diverse previous phenomenological models as particular cases.
- H. Machrafi presents a study on heat conduction in systems that are composed of spherical and cylindrical microparticles and nanoparticles dispersed in a bulk matrix.
- D. Jou and V. A. Cimmelli provide an overview on the problem of modeling heat conduction in nanosystems and nonequilibrium processes.

The manuscripts submitted by the contributing authors have been peer-reviewed according to the standard CAIM peer-review policy. The review article by the guest editors has been communicated by the Editor-in-Chief of CAIM, Dr. Giorgio Fotia. We gratefully acknowledge the precious help by the anonymous referees, who accepted to review the different versions of the papers.

We gratefully thank all the colleagues who participated to the minisymposium and contributed a paper to this special issue.

Thanks are also given to the members of the Scientific and Organizing Committees of the First Joint International Meeting of the Italian and Spanish Mathematical Societies RSME - SCM - SEMA - SIMAI - UMI, for allowing us to organize this very special event. In particular, we acknowledge the important help received by our colleague Prof. Javier Duoandikoetxea, of the local Organizing Committee, who provided us any kind of support and also a friendly atmosphere during the conference.

The technical support by Dr. Francesca Sechi, editorial assistant of CAIM, is acknowledged as well.

Last, but not least, special thanks to the Editor in Chief of CAIM, Dr. Giorgio Fotia, for his precious help during the editorial process. Without his continuous support this special issue would have not appeared.

Let's finish this short foreword by wishing that this experience in the future could be repeated and enlarged.

"Ad maiora".