

MULTITEMPERATURE MIXTURE OF PHONONS AND ELECTRONS AND NONLOCAL THERMOELECTRIC TRANSPORT IN NANOSYSTEMS

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EXTENDED ABSTRACT

In the past decades the need for more efficient materials for electronic refrigeration and power generation has driven a heightening interest in the field of thermoelectricity. Different thermoelectric materials are currently under investigation by many research groups. Some of them are focusing their efforts on minimizing the lattice thermal conductivity and others on getting large power factors.

Usually, the analysis is especially focused on computer simulations, or statistical mechanical analyses, while scant attention is paid to continuous models which may give strong physical grounds to practical research and to investigate new frontiers.

In this poster we present a mesoscopic model of thermoelectric effects in rigid bodies, leading to a system of enhanced thermoelectric balance equations, accounting for different phonon and electron temperatures and mutual energy exchanges. In particular, following the way drawn in recent papers [1; 2], we assume that the overall heat flux \mathbf{q} has two different contributions: the electron heat-flux contribution $\mathbf{q}^{(e)}$ and the phonon heat-flux one $\mathbf{q}^{(p)}$, such that

$$\mathbf{q} = \mathbf{q}^{(e)} + \mathbf{q}^{(p)}.$$

We regard the phonons and electrons as a mixture of gases flowing through the crystal lattice, each of which is endowed with its own temperature. Accounting for two different temperatures may be important, for instance, in

1. **Time-dependent situations: fast laser pulses.** When a laser pulse hits the surface of a system, initially the electrons capture the main amount of the incoming energy, with respect to the phonons. Subsequently, through the electron-phonon collisions, they give a part of it to the phonons. This may be of interest, for example, in the Raman thermometry (which is often utilized to measure the temperature in small electronic devices) or in information recording on optical discs (CD, DVD, Blu-Ray).
2. **Steady-state situations: nonequilibrium temperatures.** As the electron mean-free path ℓ_e is usually shorter than the phonon mean-free path ℓ_p , in heat propagation and when the longitudinal distance z is such that $\ell_e < z < \ell_p$, it is expected a very high number of electron collisions, and only scant phonon collisions. This yields that the electron temperature may reach its local-equilibrium value, whereas the phonon temperature is still far from its own local-equilibrium value.

Our goal will be pursued in the framework of Extended Irreversible Thermodynamics, the theory in which the dissipative fluxes are updated to the rank of thermodynamic variables and the gradients of the unknown fields are allowed to enter the state space [3; 4]. We also take advantage from the theory of mixtures of fluids with different temperatures, recently proposed in the literature [5; 6].

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