THERMOELECTRIC EFFECTS AND SIZE DEPENDENCY OF THE FIGURE-OF-MERIT IN CYLINDRICAL NANOWIRES

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EXTENDED ABSTRACT

The conversion of heat current into electric current through thermoelectric effects, i.e., the direct conversion of temperature differences to electric voltage and vice-versa, offers a promising avenue in energy management. From the practical point of view, one of the most explored possibilities is the junction of two nanostructured crystals of different type, in which the heat is carried by phonons and electrons, whose efficiency may be evaluated through the parameter ZT, being T the absolute temperature, and Z the so-called figure-of-merit, defined as

$$Z = \frac{\varepsilon^2 \sigma_e}{\lambda_e + \lambda_p},$$

ε being the Seebeck coefficient, σ_e the electrical conductivity, and λ_e and λ_p the thermal conductivities due to electrons and phonons, respectively.

An interesting aspect of nanosystems is the possibility of an additional control of the transport coefficients by getting sizes comparable to the mean-free path (MFP) ℓ of the different heat carriers (phonons, electrons, holes, etc.). For instance, in nanowires it is expected that whenever the radius of the transversal section is comparable to (or smaller than) the phonon MFP, the phonon contribution to the thermal conductivity λ_p will be reduced, leading to an increase of Z.

Thus, incorporating explicitly the effects of the several MFPs is useful to study new strategies for the optimization of these effects.

In the present poster we explore phenomenologically the size dependency of Z in nanowires. To achieve that task we use a phonon-hydrodynamic approach [1; 2] and a simple thermodynamic model [3], which is developed 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 [1; 2]. Our aim is to bridge the gap between the much detailed microscopic approaches (i.e., kinetic theory or numerical simulations) and the classical nonequilibrium-thermodynamic approaches lacking the explicit presence of the MFP.

In the particular case of a nanosample made by Bi_2Te_3 interesting results are also obtained.

REFERENCES

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