Concept of the local equilibrium and hydrodynamic states of phonons of a solid

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Non-steady transport phenomena in phonon subsystem of an insulator have been considered. The investigation is based on an usual kinetic equation [1] which is studied with the Chapman-Enskog method generalized according to Bogolyubov functional hypothesis. At phonon collisions their energy is conserved but their momentum is not conserved. We discuss transport of energy and momentum. In spatially uniform state of the system attenuation of its drift velocity v_l is observed. A case of small velocity v_l was considered in detail. It is shown that leading contribution to nonequilibrium phonon distribution function $f_k(v(t))$ is represented by Plank distribution with velocity $n_k(v(t))$ incorrect even in the linear approximation in velocity:

$$f_k(v) = n_k(T,0) + A_l(k)v_l + O(v^2), \quad A_l(k) \neq \left.\frac{\partial n_k(T,v)}{\partial v_l}\right|_{v=0} \tag{1}$$

$(n_k(T,v) = (e^{\hbar\beta(\omega_k - k_l v_l)} - 1)^{-1}, \beta \equiv T^{-1})$. The drift velocity is defined in this consideration with usual formula

$$\int d^3k f_k(v)k_l = \int d^3k n_k(v)k)_l. \tag{2}$$

So, this definition is a conventional one because the Plank distribution $n_k(v(t))$ is not a correct leading contribution. Taking into account this result theory of transport phenomena in the system (phonon hydrodynamics) is constructed. In its framework phonon distribution function has structure $f_k(x, T(t), v(t))$ and is a functional of variables $T(x,t)$, $v_l(x,t)$. Small parameter of such a theory λ is introduced by estimations of the type $v_l \sim \lambda$, $\partial T/\partial x_n \sim \lambda$, $\partial v_l/\partial x_n \sim \lambda^2$, $\partial^2 T/\partial x_n \partial x_m \sim \lambda^2$.

Analogously Bogolyubov polaron model has been investigated too.

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1. Lifshitz E.M., Pitaevskii L.P. *Physical Kinetics.*– Oxford: Pergamon Press, 1981, 452p.