Hydrodynamic evolution of polaron gas: relaxation and diffusion

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Hydrodynamic states of polarons in a polar insulator are discussed starting from kinetic equation discussed in paper [1] in the simplest model. This subsystem is considered as a low density gas weak interacting with equilibrium phonon subsystem. In the present work hydrodynamic states of polaron gas are described by density of particles $n(x,t)$, drift velocity $v_n(x,t)$ and temperature $T(x,t)$ (variables $\xi_\mu(x,t)$). The investigation is based on the Chapman-Enskog method in which polaron distribution function (DF) $\mathrm{f}_p(x,t)$ is considered as a functional $\mathrm{f}_p(x,\xi(t))$ of variables $\xi_\mu(x,t)$. Starting points of the proposed theory are conservation laws for number of particles, their momentum and energy in local form. Of course, equations of two last conservation laws contain sources that lead to relaxation $v_n(x,t)\to 0$ and $T(x,t)\to T_0$ (T_0 is phonon temperature). Usual consideration of transport phenomena in the system describes its state only by density of particles $n(x,t)$, temperature $T(x,t)$ and is based on the local equilibrium assumption: zero order in gradients of hydrodynamic variables contribution $\mathrm{f}_p^{(0)}(x,\xi)$ to DF $\mathrm{f}_p(x,\xi)$ coincides with the local Maxwell distribution $w_p(\xi(x))$. In this work we do not make this assumption and calculate DF $\mathrm{f}_p^{(0)}(x,\xi)$ in a perturbation theory in $v_n(x,t)$ and $T(x,t)-T_0$ as quantities of an order λ. Gradients of variables $\xi_\mu(x,t)$ are additionally small with parameter g (external electric field $E_n(x)$ has this order too). In was shown that *the local equilibrium assumption is not true* because $\mathrm{f}_p^{(0)}(x,\xi)\neq w_p(\xi(x))$. As a result new closed set hydrodynamic equations for variables $\xi_\mu(x,t)$ with relaxation terms has been obtained taking into account dissipative processes. On the basis of the obtained equations it was shown that after some time the drift velocity $v_n(x,t)$ becomes a functional $v_n(x,T(t),n(t))$ of temperature $T(x,t)$ and density $n(x,t)$. The functional $v_n(x,T,n)$ was found by the Chapman-Enskog method using time equation for velocity $v_n(x,t)$ as a kinetic one that leads to a generalized standard theory.

[1] S.A. Sokolovsky, Theoretical and Mathematical Physics, 168, 1150-1164 (2011).