PHOHON DRAG IN DISORDERED FILMS AND STRUCTURES

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Quantum transport in disordered systems has been studied for many years, yet many open problems remain. One focus of these investigations is the interference of inelastic electron scattering due to electron-phonon interaction and elastic electron scattering due to impurities, boundaries and defects. Electron-phonon interaction determines the electron energy loss rate and also manifests itself in various transport phenomena. In a pure conductor, the electron energy and momentum relaxation rates are described by the same matrix element of the electron-phonon interaction. In an impure conductor, the interrelation of kinetic and transport phenomena is complicated by the interference between electron-phonon and elastic electron scattering. Quantum interference of scattering processes violates the Mathiessen rule, according to which the contributions to transport coefficients due to a random potential and phonons should be additive. Recently there has been significant interest to the interrelation of the phonon-drag thermopower and electron energy relaxation in semiconducting structures [1]. These papers have raised a number of issues about the interference corrections to the phonon-drag thermopower.

In the current work we study the effect of elastic electron scattering on the phonon drag thermopower in degenerate conductors. To solve this problem we use following methods. First, we employ the quantum transport equation based on the Keldysh diagram technique. This approach deals only with electron self-energy diagrams, while the Kubo method requires more complicated diagrams to be considered. Second, we calculate the electric current of electrons as a response to the temperature gradient in the phonon subsystems. The symmetric problem of the phonon thermal flux due to the electric field turns out to be significantly more difficult, because one should take into account specific terms in the form of Poisson brackets. According to the Onsager relation, both approaches give the same result for the thermoelectric coefficient. Third, considering the vibrating potential, we employ the Tsuneto transformation, which allows one to simplify the electron-phonon-impurity Hamiltonian.

We have obtained universal relation between the inelastic electron scattering rate and the phonon-drag thermopower. Our results show that elastic electron scattering does not affect phonon-drag thermopower in bulk materials, where phonon-electron scattering is the leading scattering mechanism of phonons. In thin films and structures the phonons scatter mainly in substrate. In this case the phonon-drag thermopower correlates with the electron energy relaxation rate, which is strongly modified by disorder.

[1] R. Fletcher et al., Phys. Rev. **B 56**, 12 422 (1997); Semicond. Sci. Technol. **14**, R1 (1999).