

## Phonon drag effect in three- and two-dimensional electron systems

N V ZAVARITSKY

Institute for Physical Problems, USSR Academy of Sciences, Moscow, USSR

**Abstract.** The nonequilibrium phonon flow drags the electrons, and depending upon experimental conditions manifests itself in the acoustoelectric current, acoustomagnetic field or acoustoelectric field. The results of these phenomena in Sn, Al, Ga, Ag measured with SQUID technique are discussed.

In the two-dimensional (2D) case the phonon drag is studied on the interface of bicrystals and on the cleavage (111) surface of Ge and on the inversion layer on (111) (100) planes of Si. In all these cases the phonon drag is about two orders of magnitude larger than in metals with the same charge density. This is due to the drag of surface electrons by nonequilibrium phonon of the whole specimen.

The Kohn resonance of phonons with Fermi surface and topological transitions on Fermi surface of 2D electrons produced sharp singularities of phonon drag effect in 2D cases.

**Keywords.** Phonon drag effect; three-dimensional electron system; two-dimensional electron system.

PACS No. 63.20

### 1. Introduction

Conduction electrons and the lattice vibrations in a solid influence each other. The phonon-electron interaction plays a major role in the theory of transport properties of solids. The most obvious method of measuring this interaction is to send a beam of nonequilibrium phonons or electrons and watch them being scattered and absorbed. In the experiments of this kind we study the thermal or the electrical conductivity, the ultrasonic attenuation etc. It seems reasonable to measure directly the reaction of the lattice or the electrons on the action of flow of the non-equilibrium quasiparticles. This reaction is shown on the Tcerenkov effect—sound generated by beam of electrons, and the phonon drag effect—the reaction of electrons on the action of a beam of nonequilibrium phonons.

### 2. Acoustoelectric field

Let  $W$  be the flow density of non-equilibrium phonons. Then the loss of their energy to interaction with electrons is

$$\Delta\varepsilon = \Gamma_{\text{ph}, e} W, \quad (1)$$

where  $\Gamma_{\text{ph}, e}$  is the attenuation of phonons due to their interaction with electrons. Along