Magnetotransport properties of Bi wires under effect of uniaxial deformation

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The effect of high magnetic field on the transport properties of semi-metallic bismuth has been a subject of increasing interest in the last years because a lot of unexpected findings detected far above the quantum limit of the electrons [1, 2].

The presented investigations of the magnetotransport measurements of Bi wires complement the series of recently published experimental results on bulk Bi in high magnetic field. The design of measurements in magnetic field was diversified by using uniaxial deformation directed along the wire axis. By combining high magnetic field and uniaxial strain, the electronic structure of the bismuth wires was modified; as a result, the quantum limit for light and heavy electrons could be changed in different ways.

Measurements of the longitudinal resistance and Seebeck coefficient of up to 35 T oriented along the bisector axis of Bi wires have revealed some anomalies in magnetic field far above the quantum limit of the electrons; the most prominent feature is a sharp peak of magnetoresistance at 33 T (figure 1).

Investigation of magnetoresistance under uniaxial strain (inset in figure 1) has revealed that the sharp peak of the magnetoresistance at 33 T is reproduced in lower magnetic fields at 28 T according to a decrease in the light electron concentration under strain. Since the detected in the strained wires magnetoresistance peak fades after the Lifshitz Transition, we conclude that the peaks at 33 and 28 T have the same origin, which is attributed to the crossing of the Fermi level by the last Landau level of light electrons. The present conclusion is consistent with the previous assumption [3] based on the model of Vecchi et al. [4]. Thus, a correlation between the exit of the last Landau level of light electrons and the Lifshitz Transition has been found. The result is that the critical magnetic field of the Electronic Topological Transition has decreased; thereby, the magnetic field range of the occurrence of magnetic-field-induced instabilities associated with the last Landau level of electrons has been extended.

Measurements of the thermoelectric response (Seebeck coefficient) in quantizing magnetic field T have revealed some oscillating instabilities in the magnetothermopower dependence in a magnetic field of 15 - 20 T. Observed correlation between a simultaneous shift in a magnetic field of the position of the anomalies and of the quantum limit of electrons, when modifying of the electronic structure under strain, allows us to attribute of unidentified peaks to the complex structure of the lowest Landau level of electrons when one of the lowest spin-polarized Landau sublevel of heavy electrons approaches and crosses the Fermi energy level.

It should also be noted that a decrease in the resistance in higher fields with the apparent metallization of bismuth indicates possible changes in the mechanism of carrier scattering associated also with the Lifshitz Transition and with the substructure of the last Landau level of electrons.

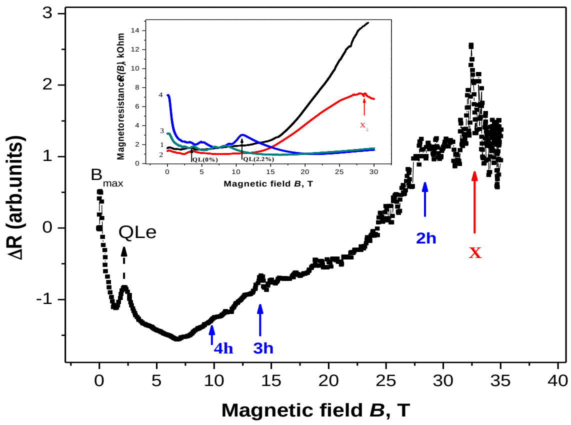

Figure 1 *Longitudinal magnetoresistance for Bi wire with d = 400 nm in a magnetic field up to 35 T at T = 4.2 K. Arrows indicate: QL_e – quantum limit of electrons, Red arrow - the position of the unidentified peak X. in the non-deformed state. Inset: The magnetoresistance for Bi wire at various strain values: (1) 0%, (2) 0.8%, (3) 1.8%, (4) 2.2%. The vertical arrows indicate the position of the QL_e of heavy electrons that shifts to high magnetic field. Red arrow indicates the position of the unidentified peak X_ε at strain value 0.8%.*

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