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LOW-FREQUENCY NOISE AND CHARGE FLUCTUATIONS IN $\mathbf{SmB_6}$*

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Following to the comprehensive study of the low temperature transport properties of SmB_6 the noise characteristics of high quality single crystals have been investigated in this archetypal intermediate valence compound. The measurements along different crystallographic directions revealed the anisotropic strong enhancement of the low-frequency resistance noise at temperatures below 15K. The anomalies observed in this cubic compound are discussed in terms of a many-body states formation resulting from fast valence fluctuations on Sm-sites.

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During last four decades the unusual low-temperature physical properties of classic intermediate valence compound SmB_6 were intensively discussed in more than 100 theoretical and experimental papers (see, *e.g.*, [1–6]). The commonly used treatment is based on the suggestion that a small insulating

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gap which is opened in samarium hexaboride below liquid nitrogen temperature arises from a strong many-body interaction due to coherent Kondo scattering [1]. However, some convincing arguments against the applicability of the "Kondo-insulator" model [3–5] gave evidence in favor of the exciton-polaronic description of this system with fast on-site valence fluctuations [6]. In present study new results of transport and noise measurements in SmB_6 are obtained and discussed in the framework of the model which seems to be very fruitful for understanding the nature of ground state in this extraordinary compound.

The comprehensive study of low temperature transport performed on single crystals of SmB_6 in a wide range of temperature (1.6–300 K) and magnetic fields (up to 50 T) allowed to distinguish three specific temperature regions. An activation above a small hybridization gap $E_g \approx 20$ meV determines the *intrinsic* transport behavior in SmB_6 below 70K (Fig. 1, region I). The decrease of the concentration of temperature-excited carriers results in a transition to *"extrinsic"* regime with energy scale $E_a \approx 3.5$–5 meV at 14 K (Fig. 1, region II, see also [7]). The measurements performed along different crystallographic directions allowed to distinguish between various contributions from *(i) dispersion of bound energy of intra-gap states* and *(ii) carriers scattering effects* in the matrix of samarium hexaboride. In this approach it is possible to explain the dispersion of the transport activation energy values by considering this parameter as a sum of two contributions from *(i)* "bare"

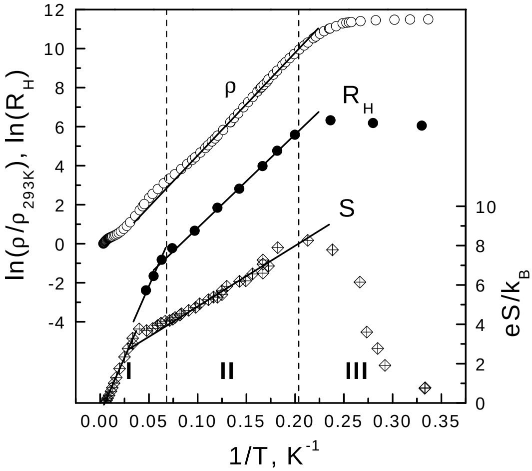

Fig. 1. The reciprocal temperature dependencies of resistivity ρ as well as Hall R_H and normalized Seebeck S coefficients measured along [110] axis in SmB_6. Linear fits correspond to activation behavior with parameters $E_a = 4.4$ meV for ρ and R_H and $E_a = 2.9$ meV for S.

excitonic component $E_{\text{ex}} \approx 3$ meV and *(ii)* strongly asymmetric "polaronic well" $E_{\text{pol}} \approx 0.5$–3 meV. Using the data, the *"induced anisotropy"* appearing in this cubic compound at temperatures below 15 K can be interpreted in terms of a short range (∼4 Å) exciton–polaron complexes' formation resulting from fast charge fluctuations in vicinity of Sm-centers [7].

The unusual saturation of resistivity and Hall coefficient as well as the drastic decrease of normalized thermopower (Fig. 1, region III) has been detected when lowering the temperature below 6 K. The data obtained give an experimental evidence in favor of an electron-type phase transition in SmB_6 which results to *a coherent state formation* in the system of strongly interacted exciton–polaron complexes.

To obtain an additional information about the nature of the ground state in SmB_6 the low-frequency (up to 200 Hz) noise characteristics have been investigated in a temperature range 4.2–40 K. It was found that the noise voltage temperature dependencies $U_{\text{noise}}(T)$ are characterized by an anomalous maximum at $T \sim 11$ K (Fig. 2). Additionally, the strong dependence of the fluctuation amplitude from the sample orientation has been established in the cross-correlation noise measurements carried out along various crystallographic directions (inset in Fig. 1). It is worth to note that this anomaly

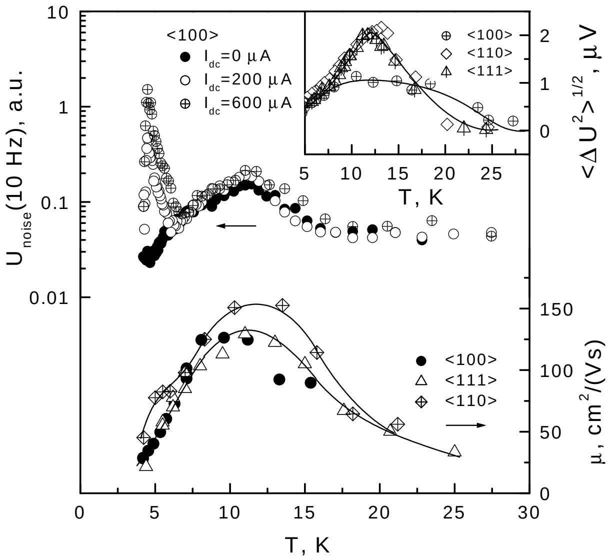

Fig. 2. The resistance noise voltage U_{noise} and Hall mobility μ temperature dependencies measured along different crystallographic directions in SmB_6. Inset shows the amplitude of voltage fluctuation as integrated from correlation spectra (see text).

is very similar to the maximum of the Hall mobility temperature dependence $\mu = R_{\mathrm{H}}/\rho$ (Fig. 2) which is also characterized by a pronounced anisotropy in the temperature range 5 K $<T<$15 K [8]. In our opinion, this observation may serve as an additional argument in favor of unique approach in which the exciton–polaron complexes are formed below 15 K and determine the low-temperature properties of $\mathrm{SmB_6}$ in the regime of fast charge fluctuations. However, the peak of linear expansion coefficient $\alpha(T)$ at $T = 11.5$ K [9] and the maximum of thermal conductivity $\kappa(T)$ at $T = 13$ K [10] require an adequate consideration of thermal effects in the analysis of the low-temperature noise characteristics of $\mathrm{SmB_6}$. Detailed investigation of these correlations in thermal, noise and transport properties is in progress now.

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