High Frequency Cutoff in $1/f$ Spectra of Hole Doped $La_xCa_{1-x}MnO_3$ Manganite Single Crystals

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Electronic transport in phase separated managanites has been a topic of intensive investigations in the last decades. Nevertheless, recent investigations of low temperature properties of hole doped manganites brought new surprising discoveries. Among them, experimental evidence for appearance of the electronic glass state at low hole doping level at low temperatures, associated with ferromagnetic insulating phase, contradicting the conventional double exchange magnetic coupling model is a subject of continuous interest.[1]

Hole-doped $La_{1-x}Ca_xMnO_3$ (LCMO) manganites at Ca-doping levels $0.125 < x < 0.225$ are ferromagnetic insulators (FMI) at low temperatures, unlike the ones with x above 0.225, which are ferromagnetic but also metallic, or with x below 0.125, which are insulating antiferromagnets in the ground state. Long range interactions in the ferromagnetic insulating phase lead to the opening of the Coulomb gap in the density of states and to hopping conduction in the presence of such gap.[1,2] Slow relaxations of charge carriers arising from a large number of low-lying states separated by barriers lead to enhanced low-frequency non-Gaussian $1/f$ resistance noise.[3,4]

Until now, experimental investigations of $1/f$ noise in Coulomb glass state were limited to the doped semiconductors with electron density close to the critical concentration for the metal-insulator transition and to two-dimensional electron glass in MOSFET-like structures. Observations of $1/f$ non-Gaussian electronic glass in doped manganites in which, in a marked difference to disordered semiconductors, electronic glass arises for the polarized polaronic carriers, significantly widens the class of materials exhibiting such properties.

One of the main topics of discussion in the subject literature was the issue of the low frequency cutoff in the $1/f$ spectra which appears at frequencies much lower than those predicted by the theoretical models.[2,3] We discuss here the high frequency cutoff of the $1/f$ noise in hole doped manganites in the Coulomb glass state. It is clear that usually the issue of the high frequency $1/f$ noise cutoff is typically experimentally irrelevant because the $1/f$ component simply disappears in the background noise. In our case the cutoff was experimentally observed due to high level of the $1/f$ noise in the investigated crystals and relatively low level of background noise of our electronic set-up.

The experiments were performed using $La_{0.82}Ca_{0.18}MnO_3$ crystals in-house grown by floating zone method with radiative heating. As grown crystal was cut into rectangular bars with the longest dimension being parallel to [100] direction and equipped by vacuum evaporated contacts for transport measurements. The Curie temperature of the crystal, T_C=182 K, was determined by measuring dc magnetization as a function of temperature in the field of 10 Oe.

For the noise measurements, voltages developing across dc current biased sample were amplified by a chain of very low noise preamplifiers and the further FFT analysis was processed by a computer. Because of relatively high impedance of the samples, especially at low temperatures, a particular attention was paid to the level of the input signals at the amplifier chain in order not to saturate the amplifiers and not to exceed the allowed common voltage level during the data acquisition. In-

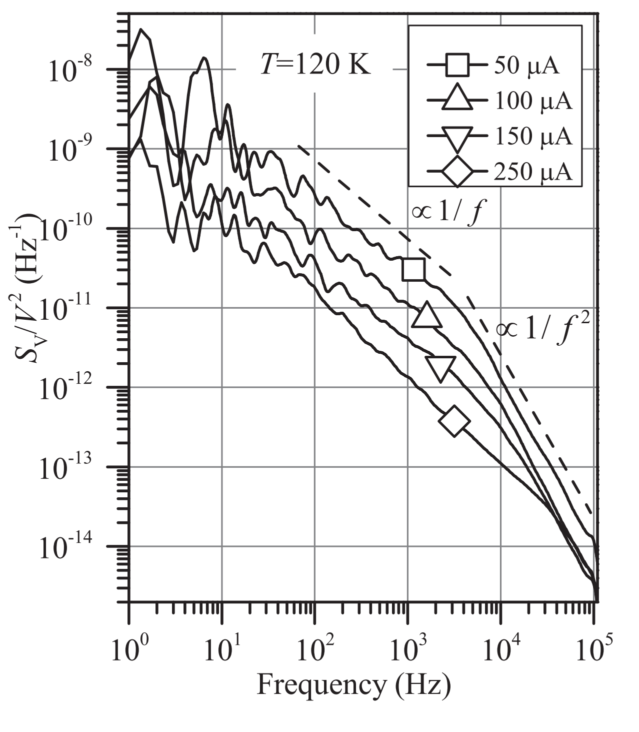

FIG. 1. Normalized noise spectra at temperature T=120 K for different currents flowing through the sample. The spectra have been smoothed for better legibility.

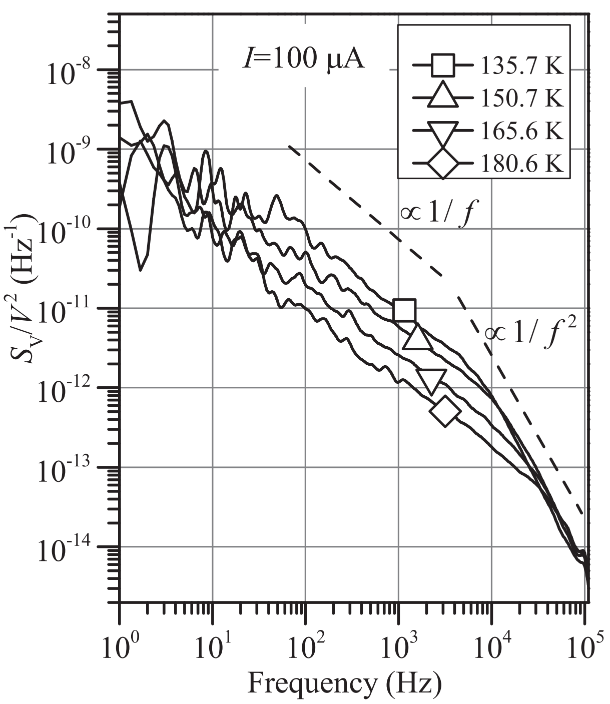

FIG. 2. Normalized noise spectra for different temperatures at current I=100 μA flowing through the sample. The spectra have been smoothed for better legibility.

strumental noise originating from the measuring chain was eliminated by subtracting the reference spectrum, recorded at zero current flow in the LCMO sample, from the spectrum acquired with bias current.

Typically, noise spectra have $1/f$-like form both below and above the Curie temperature. However, with temperature decreasing below T_C a clear high frequency lorentzian cutoff sets on in the $1/f$ spectra, as illustrated in example shown in Fig. (1) The frequency of the cutoff decreases with decreasing bias current and temperature - see Fig. 1 and Fig. 2.

We tentatively associate the high frequency cutoff of the $1/f$ spectra in the Coulomb glass regime with intrinsic limits of the appearance of $1/f$ noise in the hopping regime. The conclusion of the existence of the glassy state in the investigated material comes from the low temperature dependence of conductivity following the Efros-Shklovskii law and very strong increase of the noise level following approximately the power law with an exponent close to 5.5.

The open questions following our experimental observations and proposed interpretation of the data will be outlined in the presentation.

ACKNOWLEDGMENTS

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