Hopping conductivity spectroscopy of carbon nanocluster materials

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The carbon nanocluster materials (CNM), i.e. materials possessing artificial or natural physical inhomogeneities on a nanometer scale, in many cases demonstrate various types of hopping conductivity (HC). The studying of the HC gives an advantage of scanning over various microscopic scales in the sample structure and, consequently, provides a unique tool for studying of the electronic states in CNM. However, the realization of this "HC-spectroscopy" requires a quantitative interpretation of the magnetoresistance (MR) in CNM, which generally fails due to an incorrect description of the MR temperature dependence [1, 2].

Here we show that consistent description can be obtained in a recently developed spin polarization theory [2] demonstrating an importance of both spin-dependent transport and wave function shrinkage effects. For experimental check of the spin polarization mechanism a new CNM based on SWNT and mixture of C_{2N} fullerens (48<2N<180) have been synthesized by means of high (up to 8 GPa) pressure treatment [3].

Basing on the measurements for the temperature/field domain 1.8-300 K/7 T we found that in a HC region the universal MR scaling expected in spin polarization theory $\ln[\rho(H)/\rho(0)] = \xi_c \cdot F(x)$ holds (here $\xi_c \sim T^{-\alpha}$ defines resistivity in zero field, $\ln\rho \sim \xi_c$, and scaling parameter is $x = \mu^* H / k_B T$). Taking into account the analytical expression for $F(x)$ [2] it is possible to show that an effective magnetic moment of electron in CNM surprisingly becomes renormalized $\mu^* \sim (0.7-0.8)\mu_B$. In conclusion, we suggest a new method for determination of the localization radius and density of states in CNM and discuss a possible way of creation of the CNM with colossal magnetoresistance.

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[1] S.V. Demishev et al., *JETP Letters* **78**, 511 (2003).
[2] S.V. Demishev, A.A.Pronin, *Fiz. Tv. Tela* **48**, 1285 (2006).
[3] A.A. Pronin et al., *Fiz. Tv. Tela* issue 7 (2007), *in print.*