Anomalous magnetism and quantum critical phenomena in VO_x multiwall nanotubes

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Recently synthesized new nanoscale magnets, vanadium oxide multiwall nanotubes (VO_x-NTs), have attracted attention due to a number of unusual magnetic properties, which have been assigned to various fragments of spin chains formed by V^{4+} S=1/2 magnetic ions including antiferromagnetic (AF) dimers [1]. However the quantitative accounting of the magnetic susceptibility $\chi(T)$ and magnetization data leads to severe difficulties [1, 2].

We report results of the high frequency (60 GHz) electron spin resonance (ESR) and static magnetic susceptibility study of the VO_x-NTs (fig. 1) carried out in the temperature range 4.2-300K. The ESR experiments have allowed obtaining the first direct experimental evidences of the presence of the antiferromagnetic dimers in VO_x-NTs [2] and of an unusual low temperature growth of the magnetic susceptibility for quasi-free spins, which obey power law $\chi(T)\sim 1/T^{\alpha}$ with the exponent $\alpha\approx 0.6$ in a wide temperature range 4.2-50K [2]. The observed strong departure from the Curie-Weiss behaviour manifest the onset of the quantum critical (QC) regime and formation of the Griffiths phase as a magnetic ground state of these spin species [2]. As far as we know the QC phenomena have not been observed in nanotubes up to now. The quantitative analysis of the static and dynamic $\chi(T)$ data shows that about 98% of V^{4+} ions forms AF dimers and only ~2% of V^{4+} ions constitute spin clusters in the Griffiths phase which are responsible for the low temperature anomalies of magnetic susceptibility. The estimate of the exchange integral J~60 K in vanadium spin chains is obtained. Support by the programmes of RAS ‘‘Strongly correlated electrons’’, “Quantum physics of condensed matter” and by the RFBR grants 07-03-00749-a, 07-03-12182-ofi is acknowledged.

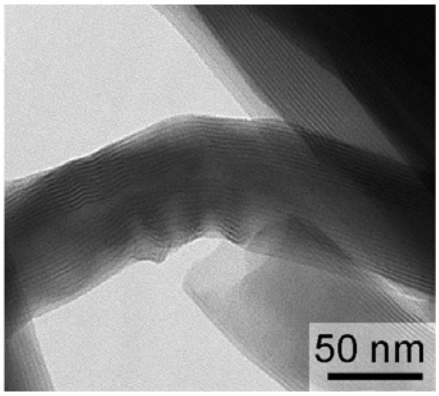

Fig. 1. The SEM image of the fine structure of individual VO_x-NTs.

[1] E.Vavilova et al., *Phys. Rev. B* **73**, 144417 (2006).
[2] S.V.Demishev et al., *Phys. Stat. Sol. (RRL)* **2**(5), 221 (2008).