Microscopic phase separation at the impurity induced AFM ordering.

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- V.N.Glazkov, A.I.Smirnov, H.-A.Krug von Nidda, A.Loidl, K.Uchinokura, T.Masuda, "Field-controlled phase separation at the impurity-induced magnetic ordering in the spin-Peierls magnet $CuGeO_3$", Physical Review Letters 94, 057205 (2005) (also cond-mat/0404715)
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Impurity induced magnetic ordering is an intriguing phenomena observed in the variety of different spin-gap systems, e.g. spin-Peierls, Haldane or dimer magnets. A unique feature of this type of ordering is the microscopic phase separation — namely, the coexistence of the paramagnetic and antiferromagnetic phases below the Neel temperature T_N in the macroscopically uniform sample. This coexistence manifests itself as a coexistence of easily resolved paramagnetic and antiferromagnetic resonance absorption signals in the wide temperature range below T_N (Glazkov *et al.* Phys.Rev.B. **65**, 144427 (2002), Smirnov *et al.* Phys.Rev.B **65**, 174422 (2002)) Moreover, the fraction of the sample remaining paramagnetic just below the transition point could be about the same as the ordering fraction of the sample. This phenomenon is due to the random distribution of the impurities which provide that at any given size of the droplet of correlated spins certain droplets remains isolated from others by the "sea" of spin-liquid state (see Figure 1).

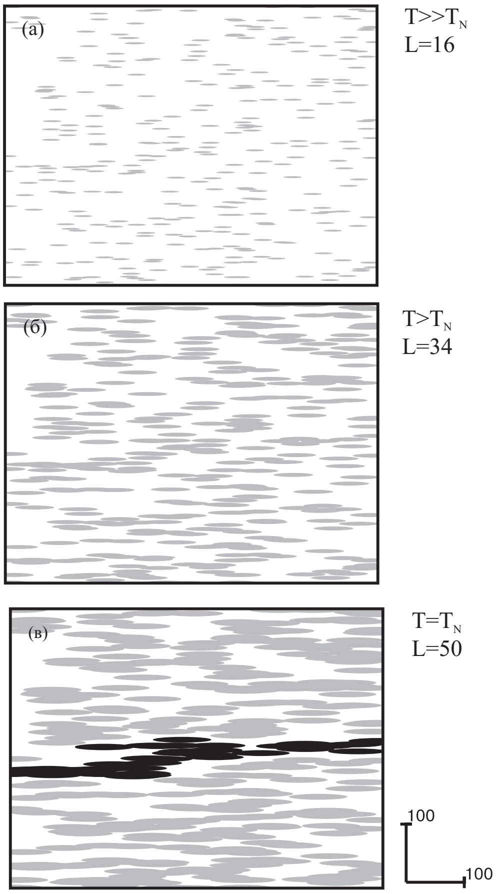

Figure 1: Illustration of the two dimensional modeling of the formation of the long-range antiferromagnetic order. Spin chains are directed horizontally, drops of the correlated spins are shown by grey filling, singlet spin-Peierls matrix is white, the macroscopic group of drops is marked by black filling. The scale is given in interspin distances. The modeling is performed for $x = 0.1\%$ and the following values of L (in interspin distances): *a)*$L = 16$, *b)* $L = 34$; *c)* $L = 50$.

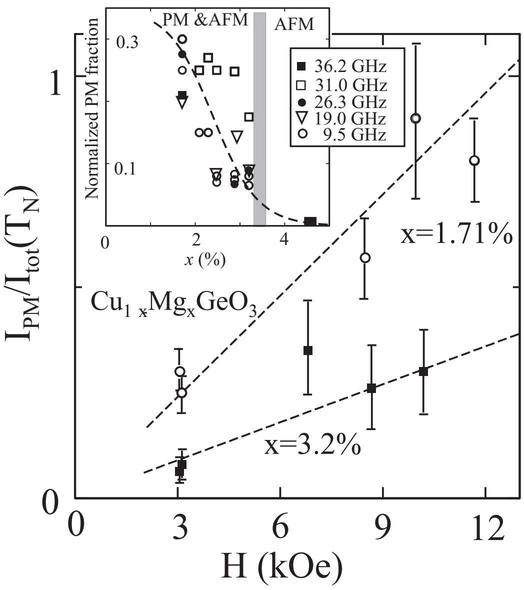

Figure 2: Field dependence of the PM fraction slightly below T_N. Dashed lines are guides to the eye. Inset: the concentration dependence of the PM fraction. PM fractions, measured at different frequencies ν are renormalized by the multiplication factor 9.5 GHz/ν. The dashed line is a guide to the eye. The gray band marks the upper limit ($x \sim 3.5\%$) of the concentration range, where the dimerization takes place

Thus even below T_N, when macroscopic "continent" with coherent antiferromagnetic order is formed, there remains isolated "islands" contributing to paramagnetism due to their net magnetic momentum.

Non-zero net magnetic moment of the droplets leads to the possibility to tune the fraction of the paramagnetic (antiferromagnetic) phase by the moderate magnetic field. It could happen that condition of the coherent antiferromagnetic correlations in the neighboring droplets will require antiparallel orientation of the droplets' own net magnetic moments. Thus, application of the external magnetic field will destroy antiferromagnetic correlations between these droplets and will increase the number of the "islands" in the paramagnetic "archipelago" (Glazkov *et al.* Phys.Rev.Lett. **94**, 057205 (2005)). Example of the field dependence of the paramagnetic fraction is given at the Figure 2.

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