Magnetism of the Cu-Gd-Ca "push-pull" intermetallic compound

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The $Cu_5Gd_{0.54}Ca_{0.42}$ intermetallic compound is the first known stable intermetallic compound of Cu, Gd and Ca. Copper acts as a mediating element between the immiscible Ca and Gd. Since Ca and Gd "repel" each other and Cu "attracts" them, they form together a "push-pull" compound. The compound was synthesized by the Czochralski technique in the form of a large single crystal, crystallizing in the hexagonal system, space group *P6/mmm*. The unit cell contains inherent disorder due to partial occupation of the Cu3 site and the substitutional disorder at the Gd/Ca mixed site located at the vertices of the unit cell, where Gd and Ca randomly substitute each other. The random substitution of magnetic Gd by nonmagnetic Ca atoms makes the magnetic Gd lattice disordered, which leads to interesting magnetic ordering at low temperatures that occurs below T_C = 24 K in zero and low external magnetic fields (Fig. 1).

The collective magnetic state in zero magnetic field can be described as a random-anisotropy ferromagnetic state, where random magnetic anisotropies originate from the magnetic dipole interactions between the Gd moments in the magnetically disordered lattice. Randomness and frustration of magnetic interactions are the two ingredients that allow classifying this state into the generic class of spin glasses [1].

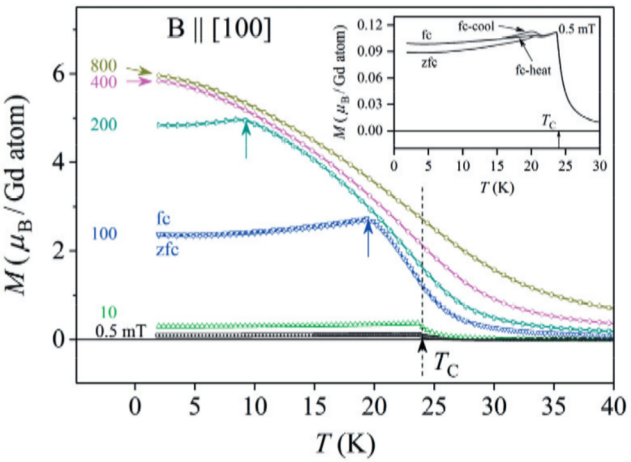

Figure 1: Temperature-dependent zfc and fc magnetizations below 40 K in magnetic fields between 0.5 mT and 0.8 T for the magnetic field along the [100] direction in the hexagonal plane. Inset: M_{zfc} and M_{fc} in the lowest investigated magnetic field of B = 0.5 mT for different measurement protocols: fc measurement on cooling (fc-cool), fc measurement on heating (fc-heat), and zfc measurement on heating.

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