Samarkand State University named after Sharof Rashidov

Samarkand International Symposium on Magnetism

2 – 6 July, 2023

BOOK OF ABSTRACTS

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Book of Abstracts

Main Topics

Spintronics, Magnonics, Magnetotransport
Magnetophotonics (linear and nonlinear magnetooptics, magnetophotonic crystals)
High Frequency Properties and Metamaterials
Diluted Magnetic Semiconductors and Oxides
Magnetic Nanostructures and Low Dimensional Magnetism
Magnetic Soft Matter (magnetic polymers, complex magnetic fluids and suspensions)
Soft and Hard Magnetic Materials
Magnetic Shape-Memory Alloys and Magnetocaloric Effect
Multiferroics
Topological Insulators
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5IT-A-1

MAGNETIC FRUSTRATION AND MAGNETOCALORIC EFFECT IN A DIPOLAR-HEISENBERG MAGNET $LiGdF_4$

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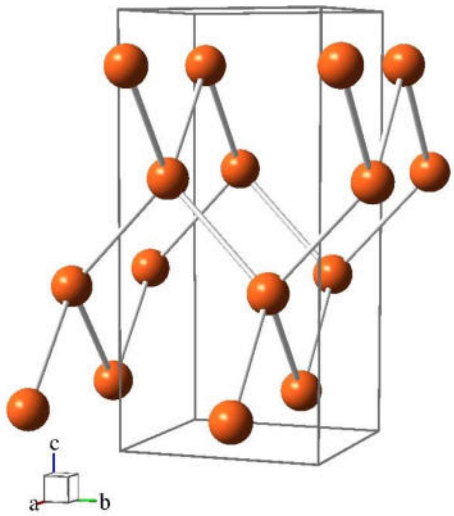

Figure 1. Position of magnetic rare-earth ions in tetragonal Li(Re)F4 crystal. Positions of Li and F ions are not shown.

Rare earth tetrafluorides $Li(Re)F_4$, are known for a long time as an optical media for lasers [1]. From the viewpoint of magnetism, these compounds provide an example of unusual kind of magnetic frustration: while the network of nearest-neighbor exchange bonds is not frustrated by itself (see Figure 1) various interactions have similar strength and final choice of the ordered phase and ordering temperature depends on a minute balance of these interactions. E.g., $LiHoF_4$ is an example of a dipolar Ising ferromagnet with Curie temperature T_C=1.53K, while $LiErF_4$ is an XY-antiferromagnet with Neel temperature T_N=0.38K [2]. We focus our study on a most isotropic member of this family, $LiGdF_4$, which is close to Heisenberg model, since Gd^{3+} is an S-state ion.

Electron spin resonance on a diluted isostructural nonmagnetic compound $LiY_{1-x}Gd_xF_4$ with x=0.005 revealed characteristic fine structure of ESR absorption spectrum, which allowed to determine single-ion anisotropy parameters. Single-ion anisotropy for S=7/2 Gd^{3+} ions turns out to be of easy-axis type with the splitting between two lowest-energy doublets equal to 0.82K. This value is comparable with the characteristic dipolar energy for $LiGdF_4$, which is 0.56K.

Besides of the fine structure due to the isolated Gd^{3+} ions, electron spin resonance spectra in a $LiY_{1-x}Gd_xF_4$ samples with higher concentration of magnetic ions x=0.05 features series of a much weaker absorption components, the later can be interpreted as an ESR absorption from the exchange coupled pairs. Positions of these weak absorption components were determined at different microwave frequencies (25-40 GHz) and field orientations, experimental values are in agreement with the model assuming nearest neighbors antiferromagnetic coupling with exchange integral J_{NN}=0.067K. This yields characteristic exchange energy $J_{NN}S^2$=0.82K, the value close to both dipolar energy and single-ion anisotropy energy scale.

Competing interaction results in unusual magnetic properties of the bulk $LiGdF_4$. M(T) measurements yields strongly anisotropic Curie-Weiss temperature: for the field applied along tetragonal axis Θ_c=0, while for the field applied in orthogonal direction Θ_a=1.37 K. These values of Curie-Weiss temperature are in a perfect agreement with the parameters of spin-Hamiltonian determined from ESR measurements [3].

This means, that for H||c effects of dipolar interaction, exchange couplings and single-ion anisotropy practically cancels each other and *concentrated* $LiGdF_4$ (with Gd-Gd distance of 3.8Å) behaves like an ideal paramagnet. Such a behavior is of interest for magnetic refrigeration applications. To check this possibility we have measured M(H) curves at different temperatures, which allowed to calculate $(\partial M/\partial T)_H=(\partial S/\partial H)_T$ and to estimate entropy absorbed by magnetic system on isothermic demagnetization process. We have found that, indeed, magnetocaloric effect in $LiGdF_4$

is anisotropic, the magnitude of this effect at T>2K for H||c is practically the same as for the ideal S=7/2 paramagnet.

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