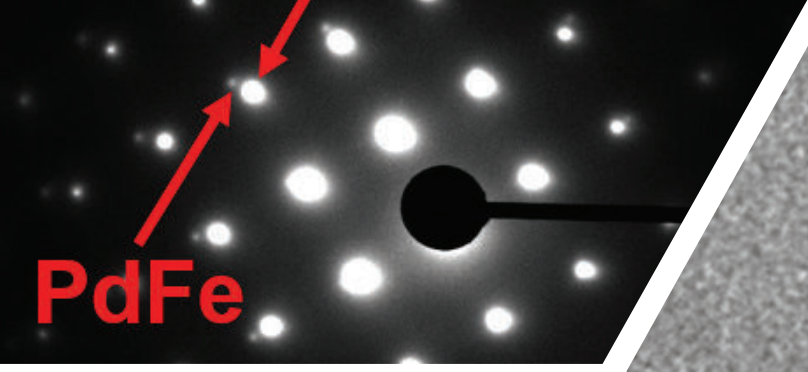

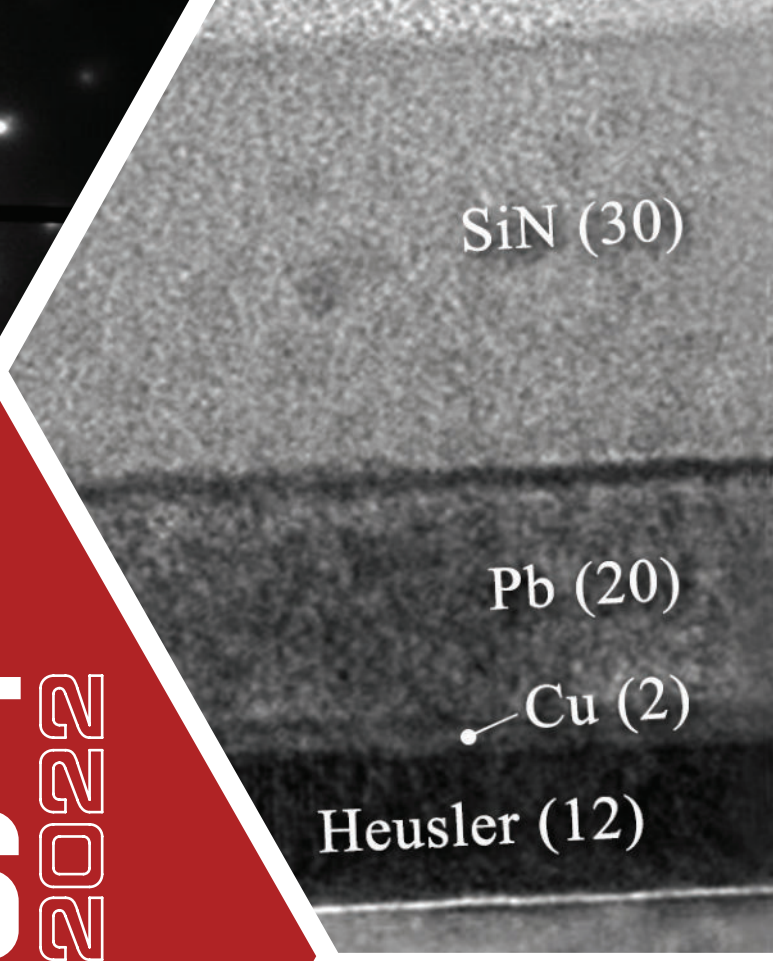

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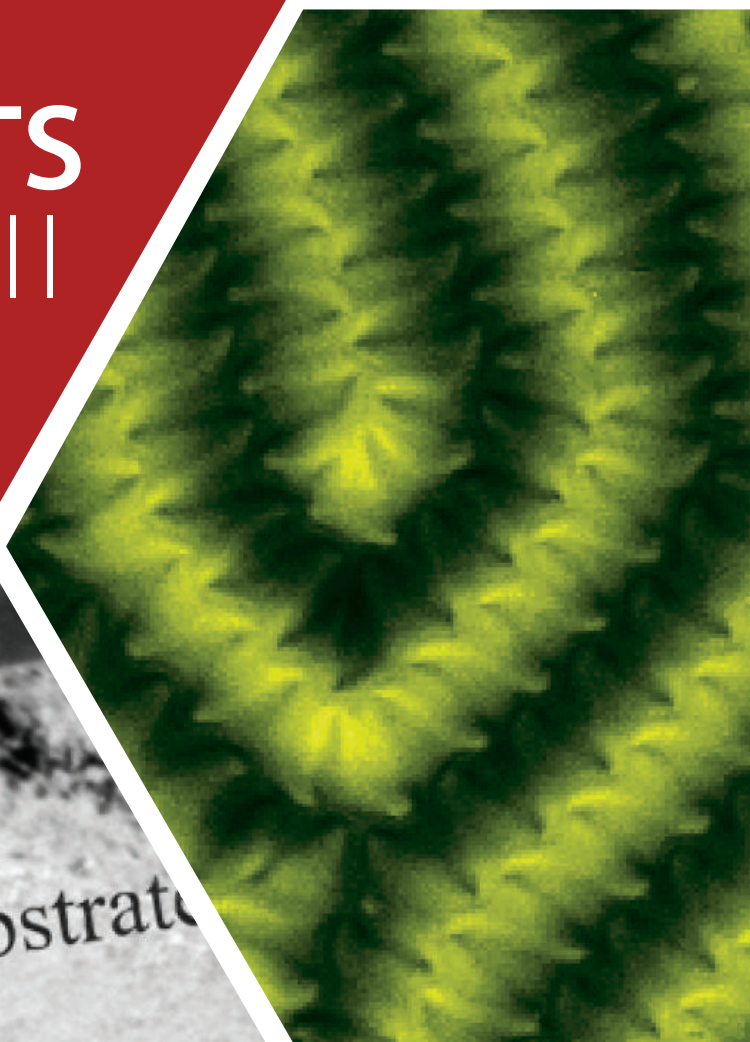

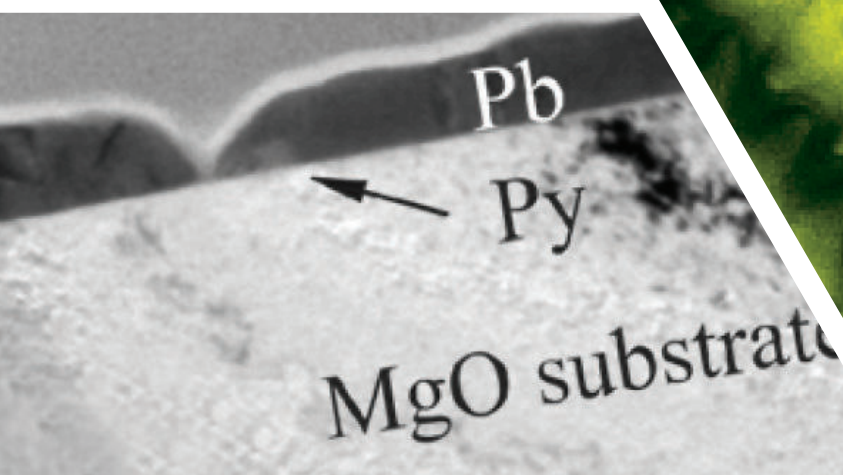

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G.06

EXACT DETERMINATION OF THE SINGLE ION AND PAIR INTERACTIONS PARAMETERS IN THE MAGNET WITH COMPETING DIPOLAR AND EXCHANGE INTERACTIONS $LiGdF_4$

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Rare earth tetrafluorides $Li(Re)F_4$, known for a long time as an optical media for lasers [1], provides an example of unusual sort of magnetic frustration: various interactions have similar strength and final choice of the ordered phase depends on a minute balance of these interactions.

For example, $LiHoF_4$ is an example of a dipolar Ising ferromagnet with Curie temperature T_C = 1.53 K, while $LiErF_4$ is an XY-antiferromagnet with Neel temperature T_N = 0.38 K and $LiGdF_4$ remains disordered down to at least 0.4 K [2].

Understanding of the physics of the magnet with competing exchange interaction, dipolar coupling and single-ion anisotropy requires accurate determination of the interactions parameters. To achieve this goal we have grown samples of $LiGd_xY_{1-x}F_4$ with x = 0.01, 0.05, 1 and we have studied their magnetic properties via magnetization measurements and electron spin resonance (ESR) spectroscopy.

Magnetization measurements on concentrated $LiGdF_4$ reveals highly anisotropic Curie-Weiss temperature, which varies from (1.6 ± 0.2) K for the field applied along tetragonal c axis to almost fully compensated (0.2 ± 0.2) K for the field applied in the (001) plane.

Electron spin resonance spectroscopy of diluted samples with x = 0.01 and 0.05 reveals complicated ESR spectra with the resolved fine structure of S = 7/2 Gd^{3+} ions. Besides of the ESR fine structure series of additional weak absorption lines are observed in diluted samples which can be interpreted as absorption signal of exchange and dipolar coupled pairs of Gd^{3+} ions.

To analyze these results numerically we model ESR absorption via exact diagonalization of the spin Hamiltonian for a single spin and for the coupled spins and fit measured spectra and their frequency-field and angular dependencies. Some of the spectral components appears to be highly sensitive to the value of exchange coupling parameter, which allows to determine both the parameters of single-ion anisotropy and exchange coupling parameter reliably.

Single ion anisotropy parameters up to fourth order are determined, main contribution comes from the easy-axis type second order term in spin Hamiltonian DS_z^2 with D/h = –2.00 GHz and agrees with the known values [3]. Exchange integral is determined to be antiferromagnetic $J/h \approx 1.4$ GHz. Both interactions are comparable to the strength of dipolar coupling of neighboring Gd^{3+} ions $(7\mu_B)^2/(hr^3) \approx 12$ GHz.

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