Experimental report

12/09/2022

Proposal: 5-54-353 **Council:** 10/2020

Title: Magnetic phase diagram of complex Dy/Ho rare-earth heterostuctures

Research area: Materials

This proposal is a new proposal

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Experimental team: Laura GUASCO
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Local contacts: Anton DEVISHVILI

Samples: Al2O3/Nb(40nm)/[Dy(6nm)/Ho(6nm)]34/Nb(10nm)

Instrument	Requested days	Allocated days	From	To
SUPERADAM	7	7	01/07/2021	08/07/2021

Abstract:

Rare-earth (RE) materials such as Er, Dy and Ho are well-known structures where complex magnetic structures exist as a competition of indirect exchange coupling of localized 4f electrons, anisotropic crystalline field and magnetoelastic interactions. In thin films and heterostructures thanks to reducing of dimensionality and presence of proximity the variety of the magnetic phases can be enriched. Up to now, however, attention was mainly focused on multilayered structures composed of ferromagnetic or helimagnetic RE layers alternating with non-magnetic or ferromagnetic RE, for example, Dy/Y, Ho/Y, Dy/Gd. On the other side, little is known about multilayers composed of two alternating helimagnetic layers. This proposal is aimed on PNR study of magnetic phase diagram of Dy/Ho superlattice comprised of two helical ferromagnets.

Experimental report on proposal: 5-54-353

“Magnetic phase diagram of complex Dy/Ho rare-earth heterostuctures”

Experimental team: Y. Khaydukov (main proposer), L. Guasco (co-proposer), A. Devishvili (local contact)

Samples: Al_2O_3/Nb/[Dy/Ho]×34/Nb

Instrument: SUPERADAM

Allocated days: 7

Sample Al_2O_3/Nb(40nm)/[Dy(6nm)/Ho(6nm)]×34/Nb(10 nm) with orientational relations [1120] Al_2O_3||[110]Nb||[0001]Dy/Ho in it was measured while heating from 10 K to 220 K in external magnetic field H=1kOe applied along the sample surface after being cooled from 220 K in zero magnetic field (ZFC measurements). Four magnetic satellites (0000^+) corresponding to periodical magnetic structures with different periods, coherently propagating through superlattice, were detected, as well as Bragg reflexes of the first and second order from periodicity of the superlattice (fig.1).

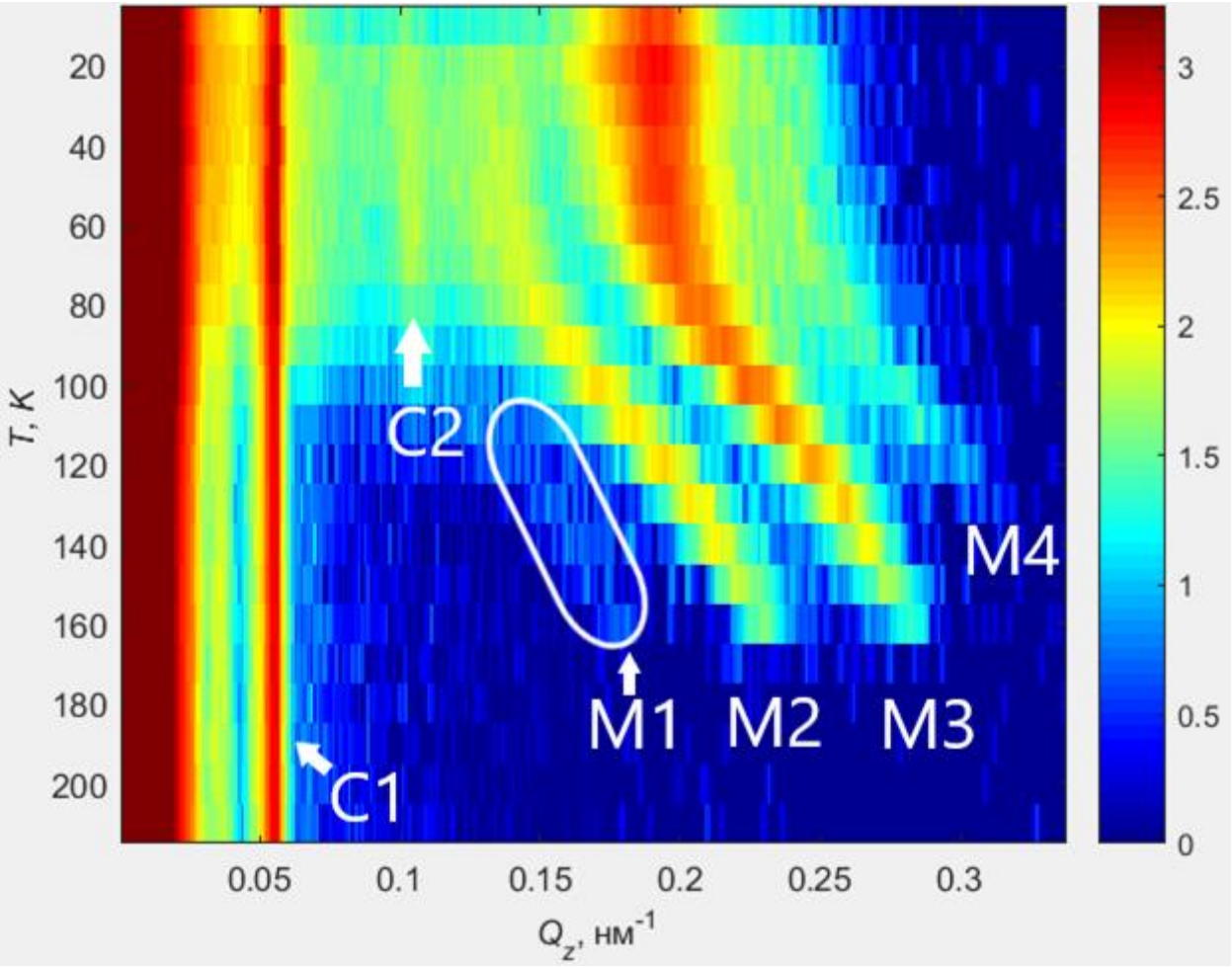

Fig. 1. Specular reflectivity curves for different temperatures with two bragg reflexes (C1, C2) from superlattice periodic structure and four magnetic sattelites (M1-M4) corresponding to magnetic helices with different periods

Analysis of temperature dependencies of periods of magnetic helices in the sample (fig.2 a) allowed to conclude, that M2 and M4 magnetic satellites are most likely propagating through Dy and Ho layers respectively, while conserving phase of the helices in between the layers. However, existence of two additional magnetic satellites M1 and M3 suggests nonuniform magnetic ordering is formed in the superlattice. Spin asymmetry (fig.2 b), which is present in the sample at temperatures below 130 K, allows to determine the onset of fan magnetic structure in Dy layers, which in explain the decrease of the magnitude of M1 and M2 magnetic satellites below 100 K.

Additional measurements in external magnetic field H=10 kOe applied along the sample surface proved, that complex magnetic ordering evident from fig.1 does not exist in such external fields and the sample remains ferromagnetic even when external magnetic field is disabled.

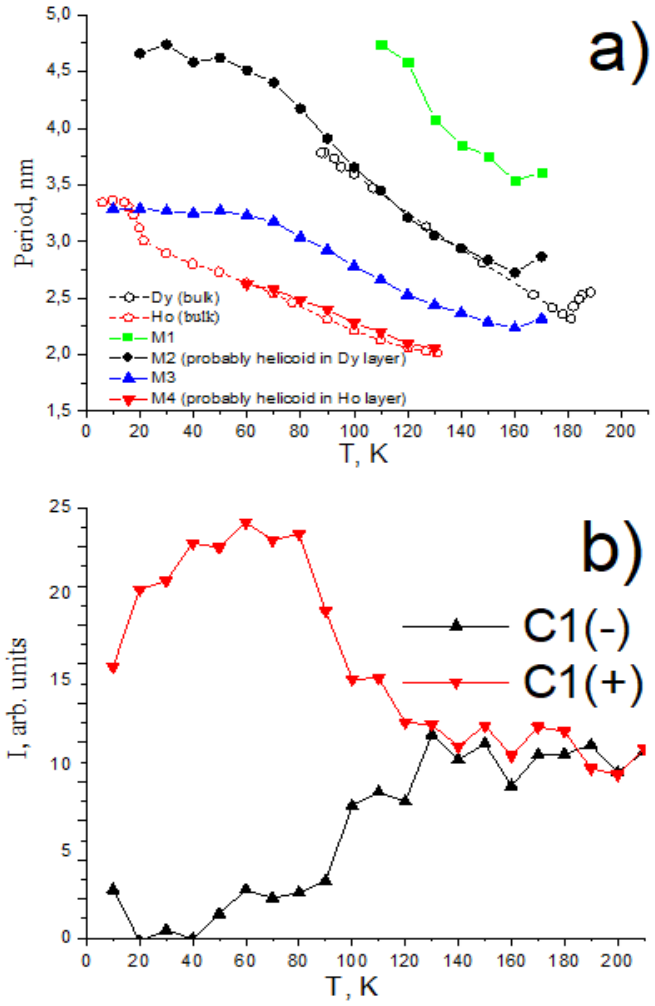

Fig.2. Temperature dependencies of periods of magnetic helices, corresponding to magnetic satellites (M1-M4), in comparison with periods of magnetic helices in bulk Dy and bulk Ho (a), and temperature dependencies of magnitude of C1 bragg reflex for two polarizations of incident beam (b)