PROXIMITY EFFECTS IN HETEROSTRUCTURES OF SUPERCONDUCTING NIOBIUM AND RARE EARTH METALS WITH HELIMAGNETIC ORDERING

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The rare earth metals holmium (Ho) and dysprosium (Dy) are of particular interest due to their ability to form complex magnetic structures, including helical magnetic ordering. This magnetic structure provides a good platform for studying proximity effects, since weak magnetic ordering can bring the energies of magnetic and superconducting interactions into proximity. Studies of heterostructures and thin films based on rare earth metals and superconductors are of interest both for fundamental physics and for applications, for example, in spintronics [1].

Polarized neutron reflectometry is one of the best methods for studying such effects in layered structures. The measurements described here were carried out on the REMUR reflectometer at the IBR-2 reactor (JINR, Dubna).

In a previous study on a periodic structure Nb(25nm)/[Dy(6nm)/Ho(6nm)]$_{34}$, partial suppression of the transition to the fan-shaped magnetic state and restoration of the spiral state at temperatures below the superconducting transition temperature of niobium were demonstrated. This work presents a more detailed analysis of the reflectometry curves, in particular of the Bragg peaks arising from the magnetic spiral.

A magnetic helix in a simpler three-layer structure Nb(40nm)/Dy(200nm)/V(10nm) was modeled first. Comparison of the calculated and experimental reflectometry curves indicates that the magnetic helix in this structure propagates coherently over approximately 10 helical periods (~330A), with a period deviation from the mean of approximately 8%. A more complex periodic structure Nb(25nm)/[Dy(6nm)/Ho(6nm)]$_{34}$ was then modeled. The magnetic helix in such a superlattice propagates coherently over approximately 6 layers of dysprosium and holmium (~600A). This means that even when transitioning from one substance to another, the period deviation from the average value is approximately 10%. Calculations were performed for experimental data at 100 K. Future studies are planned to examine the data at lower temperatures in more detail to obtain information on changes in the parameters of the helimagnetic structure under the influence of superconductivity.

[1] N.G. Pugach et al. (2022). Superconducting Spin Valves Based on a Single Spiral Magnetic Layer**.** Phys. Rev. Appl. **18**,5, 054002.
[2] V.D. Zhaketov et al. (2023). Structural Properties of Nb/Dy and Nb/Ho Superlattices. Physics of the Solid State, 65,7,1076-1080.