29th International Scientific Conference of Young Scientists and Specialists (AYSS-2025)

Contribution ID: **2039** Type: **Oral**

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Monday 27 October 2025 14:15 (15 minutes)

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Layered nanostructures are of interest for research in the field of information storage and spintronics. Spintronics, as an alternative to electronics, promises more energy efficient and compact devices through the use of electron spin. Of interest are quasi-periodic structures that are devoid of periodicity, but retain long-range order, allowing for the realization of effects that are unattainable in periodic systems. These structures can be constructed using substitution rules such as the Fibonacci sequence (A⟶AB, B⟶A).

As shown in studies of multilayer Fe/Cr layers [Machado et al., Phys. Rev. B 85, 224416 (2012)], such quasi-periodic superposition of magnetic (Fe) and non-magnetic (Cr) layers leads to non-collinear magnetization and anomalous magnetoresistance. It is noteworthy that these systems exhibit a pronounced parity effect, when the even and odd generations of the Fibonacci sequence exhibit different magnetic resistance (MR) profiles. In addition, under certain conditions (for example, for the growth direction [100] with a strong biquadratic bond), these structures can exhibit a positive change in MR (DMR/ΔH > 0), in which the resistance increases with the applied magnetic field.

The study of such complex magnetic states, including spiral magnetic structures due to magnetization, requires advanced characterization techniques. Polarized neutron reflectometry (PNR) is a powerful non-destructive technique that allows obtaining information about the structural and magnetic profile of layered systems with nanometer resolution. Due to the magnetic interaction between the neutron spin and the material, PNR has a unique sensitivity for determining the potential of magnetic interaction and the order of arrangement of complex magnetic structures. Its high spatial resolution makes it possible to study the effect of interface defects and roughness on magnetic properties, which is important for fine-tuning nanostructures for use in devices.

Recent research has expanded to study superconducting/ferromagnetic quasi-periodic heterostructures (e.g., Nb/Gd), which are ideally suited for PNR studies [Zhaketov et al., poster (2024)]. These systems offer a platform for the study of non-trivial strongly correlated phenomena, such as the coexistence of fractal superconductivity and long-range magnetic order in a quasi-periodic potential. Neutron-optical calculations confirm that such layered quasicrystals produce pronounced "quasi-Gregg" peaks on the reflection curves, which differ from both periodic and disordered systems.

Thus, simulation of the neutron experiment for quasi-periodic magnetic and superconducting multilayer materials opens up new possibilities for controlling the properties of materials in a quasi-periodic manner. The quality of spintronic devices will depend on the improved magnetic properties of nanostructures with optimal parameters of the helicoid and nanostructure thickness.

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Session Classification: Condensed Matter Physics

Track Classification: Condensed Matter Physics