NEUTRON OPTICS INSPIRED BY PHOTONIC AND PHONONIC CRYSTALS: BRAGG FILTERING, DEFECT MODES AND TOPOLOGICAL EDGE STATES IN PERIODIC AND QUASI PERIODIC MULTILAYERS

I. Zaky[1,2], V.D. Zhaketov[2]

[1] *Physics Department, Faculty of Science, Beni-Suef University, Beni Suef 62514, Egypt*
[2] *Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, 141980, Russia*

Neutron scattering at modern pulsed sources increasingly relies on engineered multilayers and superlattices, which are formally analogous to one-dimensional photonic and phononic crystals. In this contribution, we discuss how key concepts developed in electromagnetic and acoustic wave crystals, Bragg band gaps, defect modes, and topological edge states, can be systematically transferred to neutron optics using periodic and quasi-periodic multilayer structures.

First, We outline the mapping between the neutron optical potential in stratified media and the refractive-index or elastic-contrast profiles in photonic and phononic crystals, emphasizing the similar band-structure and transfer-matrix formalisms used to describe wave propagation and Bragg scattering. Second, we show that introducing controlled defects or interfaces between different “topological phases” of multilayers enables narrowband neutron transmission or reflection resonances, directly mirroring defect modes and topological edge states known from optical and acoustic systems.

As a concrete example, we present our recent simulation study on periodic superlattices composed of ferromagnetic and paramagnetic layers, originally proposed as tunable neutron filters and waveguides. These structures realize neutron band-gap engineering via magnetic contrast and can be extended towards quasi-periodic and topological designs for robust, spectrally selective neutron control. The approach suggests new possibilities for IBR-2 instruments, including compact neutron filters, waveguides and radiation detectors based on multilayer structures.