FERROMAGNETIC-SUPERCONDUCTING FIBONACCI LAYERED QUASICRYSTALS: NEUTRON-OPTICAL MODELING AND PROSPECTS FOR STUDYING STRONGLY CORRELATED STATES

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Quasicrystals exhibit long-range order without translational periodicity, which gives rise to unusual electronic phenomena such as fractal superconductivity [1] and the potential coexistence of superconducting and ferromagnetic order parameters [2-4]. Here we propose the design of artificial layered quasicrystals consisting of alternating superconducting and ferromagnetic films arranged according to the Fibonacci rule. Such heterostructures are ideal for investigation by polarized neutron reflectometry, a technique sensitive to both nuclear and magnetic scattering-length densities. Neutron-optical simulations have been carried out for Fibonacci sequences of orders from F_6 to F_{12}. It is shown that starting from F_{10} the neutron reflectivity coefficient becomes essentially stable, indicating the formation of a robust quasiperiodic structure. The reflectivity spectra display distinct "quasi-Bragg" peaks arising from hidden long-range order, in contrast to disordered systems. Remarkably, under certain conditions the quasiperiodic arrangement can absorb more neutrons than its periodic counterpart. Stability simulations reveal that the quasi-Bragg peaks are insensitive to missing layers and thickness inaccuracies, which is important for experimental feasibility. Of special interest is the low-temperature phase ($T < 1$ K), where competition and possible coexistence of superconductivity and ferromagnetism are anticipated in the absence of translational invariance. Quasiperiodicity may induce a spatial modulation of the order parameter, which will affect the shape and intensity of neutron peaks detected by polarized reflectometry. The obtained results provide a foundation for experimental searches of fractal superconductivity and long-range magnetic order in quasiperiodic systems, as well as for the study of quantum critical phenomena in strongly correlated layered nanoheterostructures.

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