Two-dimensional electron gas in a periodic magnetic-field lattice

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9.7 cm

Recent advances of nanotechnology made it possible to manufacture periodic lattices of magnetic nanocylinders, which can be used to realize a periodic magnetic-field superlattice for the two-dimensional electron gas. Using real parameters of such a field lattice, we theoretically analyzed electronic properties of the electron gas in this lattice. Due to the absence of average magnetic field, the spectrum of "magnetic-field crystal" consists of a set of electron energy bands, and the energy structure can be controled by varying the amplitude of periodic field. At relatively large fields, the electron bands are almost flat, and the electrons are localized in the vicinity of zero field lines. We found that these lines are closed and form some circles, with the equilibrium persistent currents along the lines, so that the whole "crystal" consists of a periodic lattice of persistent currents. This is related to the chirality of electron states in the magnetic-field lattice. We also demostrated the existence of anomalous Hall effect in the absence of average magnetic field and zero magnetization. We calculated the Chern numbers characterizing the filled electron bands and demonstrated the quantization of Hall conductivity if the chemical potential is located within the gap.

13.4 cm

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