Metal-insulator transition of Brown-Zak fermions

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Abstract

The metal-insulator transition (MIT) is a fundamental phenomenon that occurs near band edges in semiconductors and in strongly disordered metals. In two-dimensional systems, it is commonly manifested by a reversal in the temperature dependence of the conductivity at the critical charge carrier density, n_c. At this point, the conductivity assumes a value on the order of the conductance quantum e^2/h [1]. In this work, we report the observation of MITs in Brown-Zak (BZ) minibands of graphene superlattices [2,3] at magnetic fields corresponding to a fraction $1/q$ of the magnetic flux quantum piercing each supercell. These transitions occur between the BZ metal state and the quantum Hall (QH) insulator state. We compare the critical parameters of MITs for different realizations of BZ minibands, expecting a degree of universality in the system's behaviour near the MIT. For q = 2 and 3, we find critical MIT conductivities of $(0.75 \pm 0.07)e^2/h$ and $(2.05 \pm 0.35)e^2/h$, respectively. The approximate 1:3 ratio of these values presents a puzzle that can be partly resolved by noting that the critical conductivity may depend on the fundamental degeneracy of the BZ minibands, which differs for different q. Even after accounting for this, however, the measured ratio remains twice as large as expected. Along with the observation of MITs in BZ minibands, we find a distinctive phenomenon appearing inside the QH insulating regime, where the thermal activation of BZ fermions across the miniband edge results in the reverse temperature dependence of BZ oscillations. The oscillations become more pronounced at higher temperatures, which is in stark contrast to the standard behaviour of quantum oscillations that are commonly suppressed by temperature.

References

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