SPATIALLY RESOLVED ANALYSIS OF EDGE-CHANNEL EQUILIBRATION IN QUANTUM HALL CIRCUITS

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Interference phenomena are a fundamental manifestation of the quantum mechanical nature of electrons and have promising applications in solid-state quantum information technology[1]. Two-dimensional electron systems in the quantum Hall (QH) regime are especially suited for this purpose given the large electronic coherence length brought by edge-channel chiral transport. In particular, the realization of electronic Mach–Zehnder (MZ) interferometers in QH systems appears at present a sound technology for the implementation of quantum information schemes. In these devices the electronic analog of a beam splitter is obtained by a quantum point contact. Despite this success, the edge topology of the single-channel MZs limits the complexity of these circuits to a maximum of two interferometers[2]. In order to overcome this constraint, new device architectures were recently proposed, where interference paths are built using two different parallel edge channels[1]. In this configuration, a beam splitter can be realized by sharp, localized potentials capable of inducing coherent inter-channel scattering. Appropriate design of such interferometers requires the detailed understanding of the physics of co-propagating edges.
In order to address these issues we use scanning gate microscopy (SGM) to control the trajectory and interaction of edge channels in the integer QH regime[3]. Experiments were performed at 400mK with magnetic field up to 9T.
Inter-channel transport between edges at different bias was studied in the past by several authors[4], but only in devices with fixed channel interaction length *d*. Here we demonstrate for the first time the use of SGM to realize devices in which *d* can be tuned continuously. This allows us to investigate how current-voltage characteristics evolve when the junction length *d* is changed. For large values of *d* the bias imbalance shows an exponential decay whose characteristic length is the equilibration length. For small *d*, however, we are able to reveal the effect of individual scattering centers in transferring electrons among co-propagating edges[5]. Numerical simulations based on the Landauer-Büttiker formalism show that inter-channel scattering can occur while coherence is maintained, suggesting the possibility that such mechanisms could be used as the basic ingredient to build simply connected, easily scalable interferometers. An extension of these concepts to the fractional QH regime will be discussed.

References

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