MSc project proposal: Plasmonic exchange interactions in QAH edge states and charge fractionalization

Quantum Electronics, II. Physics Institute University of Cologne

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What is our goal?

Magnetically doped topological insulators exhibit the Quantum Anomalous Hall (QAH) effect, where electron transport occurs through a single ballistic edge state, with directionality set by the material's magnetization. This project aims to explore interactions between counter-propagating edge states in these systems, thereby deepening our understanding of charge dynamics in one-dimensional conductors.

With expertise in electronic transport across frequencies from DC up to several GHz, we will investigate interactions between counter-propagating edge states. Structuring a thin film of QAH material into two separate regions enables these edge states to couple capacitively, as depicted in Fig. 1b. This coupling can be adjusted via a small gold island, acting as a capacitor that enhances interaction. If sufficient coupling occurs, injected electrons may fractionalize into anyons—exotic quasi-particles unique to 2D systems that obey neither fermionic nor bosonic statistics. The long-term objective of this project is to study the statistical behavior of these anyons.

How will we achieve this?

The Quantum Anomalous Hall effect is delicate and observable only at extremely low temperatures. Our experiments are conducted in a state-of-the-art dilution refrigerator, cooling samples to a base temperature of 10 mK (Fig. 1a). This project involves two crucial stages: First, the fabrication of the devices in a cleanroom using standard lithography techniques and secondly, the development of a high-frequency detection scheme to determine the coupling strength and dynamics.

As a master's student, your thesis will focus on a key aspect of this project, with close supervision from a dedicated PhD student or PostDoc. This experience offers hands-on involvement with advanced fabrication techniques, ultra-low-temperature measurements, and high-frequency signal processing.

Are you interested in joining us? Just contact us: qelec@ph2.uni-koeln.de

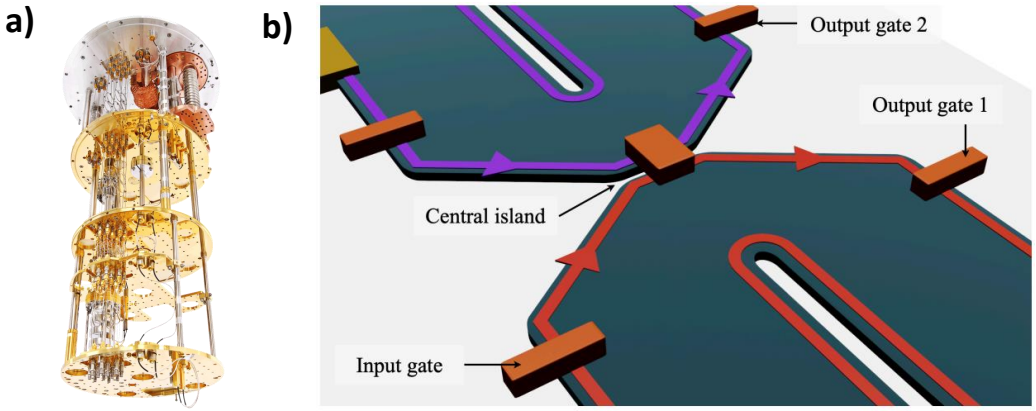

Figure 1: **Measurement setup** a) The Bluefors dilution refrigerator is used to cool the sample down to 10mK, which is necessary to observe the Quantum Anomalous hall effect. b) Device proposal for capacitively coupling two edge states via a small metallic island. Electrons would be injected via the input gate, and then coupled to the other edge state via the capacitor. The coupling can be determined by measuring the current at the output gates 1 and 2.