COMOTION
Your Innovation Partner

Twisted MoTe2 Bilayer Device for Qubit Technologies

In the quest to unlock the potential of quantum computing, researchers have delved into the realm of quantum materials seeking to harness their unique properties such as the quantum Hall effect. This technology demonstrates the long-predicted fractional quantum anomalous hall effect, using twisted bilayers of molybdenum ditelluride in a novel multi-gate transistor device to demonstrate the effect in practice. This technology shows vast potential as a laboratory for experimenting with the fractional quantum anomalous hall effect, and as a transformative innovation working towards realizing a topological quantum computer.

Image not found or type unknown

Technology ID
BDP 8840

Category
Hardware/Quantum Information
Selection of Available Technologies

Authors
Xiaodong Xu

Further information
CoMotion Licensing
license@uw.edu

Learn more

What is the Problem?

Efforts to harness the Quantum Hall Effect (QHE) for quantum computing have gained traction, driven by the quest for topological qubits. According to Microsoft, a quantum computer built on this type of qubit would be “faster, smaller and less prone to losing information than other types of qubits under development”. In addition, a quantum computer based on topological qubits could be run at temperatures above that of liquid helium, greatly reducing the cost to run the device. According to cutting edge theory, the construction of a topological qubit could be feasible by leveraging non-Abelian anyons, special quasi-particles predicted to be possible in the fractional quantum Hall effect.

There is an unmet need for a device serving as a platform to explore the fractional quantum Hall effect and the quantum anomalous hall effect (QAHE, where the QHE is observed without applying an energy-intensive magnetic field). However, realizing such a device requires successful demonstration of the fractional quantum anomalous Hall effect, as well as a setup capable of measuring the signature electrical conductivity (a known challenge in the field). There exists a pressing need not only for materials exhibiting the fractional QAHE, but also for devices capable of demonstrating the anticipated conductivity.

What is the Solution?

This technology creates a platform for the study of the fractional quantum Hall effect through the use of twisted molybdenum ditelluride bilayers. This MoTe2 material has all of the correct properties for showing the fractional QAHE desired, including its magnetic ordering and band structure. Through heavy hole-doping of the contact region, the device manufactured around the MoTe2 successfully makes low-resistance electrical contacts, solving an issue that has plagued the field.

With this device, electrical conductivity signatures of both the quantum anomalous Hall effect, and the fractional QAH are observed to confirm earlier predictions and signatures. The device is set up as a multi-gate transistor, showing promise as a platform for research into the fractional quantum hall effect. With further work, increasing material quality and improving electrical contacts, the system shows promise of demonstrating non-Abelian anyons.

What is the Competitive Advantage?

This technology marks a significant breakthrough in the study of fractional quantum anomalous Hall (QAH) states in MoTe2. It represents the first instance where crucial electrical resistance measurements have been successfully obtained, overcoming a significant hurdle in the realm of two-dimensional quantum materials by utilizing low contact resistance electrical contacts achieved through robust hole doping. This is done through the use of low contact resistance electrical contacts achieved through the strong hole doping, getting past a large known problem in the field of two dimensional quantum materials.

The device, structured as a multi-gate transistor, introduces an innovative application of these materials, offering avenues for both fundamental research into the mechanisms of the fractional QAH effect and advancements in computing miniaturization, including the potential development of quantum computers. Further refinement efforts aimed at enhancing material quality and optimizing electrical contacts hold promise for uncovering the elusive non-Abelian anyons, thus propelling the system towards even greater capabilities and applications.

References

1. Jiaqi Cai, Eric Anderson, Chong Wang, Xiaowei Zhang, Xiaoyu Liu, William Holtzmann, Yinong Zhang, Fengren Fan, Takashi Taniguchi, Kenji Watanabe, Ying Ran, Ting Cao, Liang Fu, Di Xiao, Wang Yao, Xiaodong Xu(2023-10-05) , https://www.nature.com/articles/s41586-023-06289-w, https://www.nature.com/, 622, 63–68
2. Heonjoon Park, Jiaqi Cai, Eric Anderson, Yinong Zhang, Jiayi Zhu, Xiaoyu Liu, Chong Wang, William Holtzmann, Chaowei Hu, Zhaoyu Liu, Takashi Taniguchi, Kenji Watanabe, Jiun-Haw Chu, Ting Cao, Liang Fu, Wang Yao, Cui-Zu Chang, David Cobden, Di Xiao, Xiaodong Xu(2023-10-05) , https://www.nature.com/articles/s41586-023-06536-0, https://www.nature.com/, 622, 74–79