



Department of Materials Science and Engineering Seminar Series 2026

Magnetic field dependence of current-phase relation in topological insulator-based Josephson junctions

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Date and time: Tuesday, 18 August 2026 10:00 am

Venue: Level 9 meeting room, NUS S9 Wet Science Building

Abstract

Josephson junctions (JJs) based on topological insulators (TIs) are predicted to support Majorana zero modes (MZMs) bound to Josephson vortices. MZMs are expected to behave as non-Abelian anyons, making topological JJs a promising platform for fault-tolerant topological quantum computing. While several experiments have reported signatures consistent with MZMs in TI-based JJs, alternative explanations based on non-topological mechanisms often cannot be conclusively ruled out. As a result, the unambiguous identification of MZMs in these systems remains an open problem.

In this work, we propose direct measurements of the current-phase relation (CPR) in the presence of an external magnetic field as a complementary approach to distinguish between trivial and topological contributions in TI-based JJs. We perform a detailed investigation of the CPR's magnetic field dependence in Bi_2Se_3 and $\text{Bi}_{1.08}\text{Sn}_{0.02}\text{Sb}_{0.9}\text{Te}_2\text{S}$ -based JJs, and find that the measured behaviour is not consistent with the fusion of MZMs. Instead, it can be explained by a combination of trivial effects, such as high kinetic inductance of a thin NbSe_2 , spatially non-uniform critical current density, and charge traps in the TI bulk.

We conclude that reliable identification of MZMs requires their strong isolation from other conductive channels, such as bulk states or non-proximitized surface states. When such isolation is achieved, CPR measurements can be used to detect parity-dependent supercurrent and establish the MZM's non-Abelian nature.

Biography

Andrei Kudriashov received his BSc from Peter the Great St. Petersburg Polytechnic University and his MSc from the Moscow Institute of Physics and Technology (MIPT) and the Skolkovo Institute of Science and Technology (Skoltech). He is currently completing his PhD at the National University of Singapore (NUS), where he conducted his research in the group of Prof. Denis Bandurin.

Please join us!

HOST: Asst Prof Ahmet Avsar