

# Local and nonlocal transport signatures of first- and second-order topological superconductivity with spin-polarized probes

Paweł Szumniak,<sup>1</sup> Daniel Loss,<sup>2</sup> and Jelena Klinovaja<sup>2</sup>

<sup>1</sup>*AGH University of Krakow, Faculty of Physics and Applied Computer Science,  
Al. Mickiewicza 30, 30-059 Kraków, Poland*

<sup>2</sup>*Department of Physics, University of Basel,  
Klingelbergstrasse 82, 4056 Basel, Switzerland*

Spin-dependent transport offers a powerful tool for probing topological phases in hybrid semiconductor-superconductor structures. In this presentation, we explore the spin and transport signatures of both first-order (1D) and second-order (2D) topological superconductors using spin-polarized probes.

In the 1D regime, we focus on proximitized Rashba nanowires [1]. We establish an exact correspondence between the sign of nonlocal conductance and the quasiparticle spin density. We demonstrate that this method effectively detects the spin inversion associated with the topological phase transition [2] and allows for controlled switching between Cross Andreev Reflection (CAR) and Elastic Cotunneling (ECT) processes. Moving to 2D second-order topological superconductors, we demonstrate that Majorana Corner States (MCS) exhibit characteristic electronic spin textures that enable an unambiguous labeling of individual MCS within each pair. We introduce a detection scheme in which local and nonlocal conductance features, together with two-terminal shot noise, are directly tied to the electronic spin density of the zero-energy MCS and of higher-energy spin-polarized edge modes. Moreover, we show that these characteristics can be exploited to confirm the spatial exchange of MCS, an essential operation for topological quantum computation.

Importantly, we show that in both systems these transport characteristics remain stable under moderate static disorder, thereby providing a clear pathway for experimental verification.

## References:

[1] P. Szumniak, D. Loss, and J. Klinovaja, *Phys. Rev. B* 110, 115413 (2024)

[2] P. Szumniak, D. Chevallier, D. Loss, and J. Klinovaja, *Phys. Rev. B* 96, 041401(R) (2017)