Summary of „Emergence and nonlocality of Majorana Bound States in nanoscopic systems" PhD thesis by Aksel Kobiałka:

Topological superconductors, originating from the interplay between magnetism, spin-orbit coupling, and superconductivity, can host zero energy quasiparticle excitations at the system's edges known as Majorana bound states. These states have a peculiar property of being identical with their own antiparticle. Majorana modes, due to their non-Abelian statistics, were proposed to be able to perform "braiding", a protocol of quantum computation where one quasiparticle revolves in real space around another, allowing to store quantum information. In this thesis, I present an overview of theoretical concepts concerning emergence and nonlocality of Majorana bound states, relying on Bogoliubov - de Gennes formalism. I also focus on experimental development investigating one and two dimensional topological superconductors capable of hosting Majorana states.Additionally, I present methods used for obtaining the results presented in the main part of thesis.

Essential part of my thesis has a form of cumulative work - Chapter 4, consists of an aggregate of papers that I coauthored during my PhD, which discuss the mentioned phenomena related to Majorana physics: its emergence and nonlocality. Emergence of Majorana bound states is a fundamental concept that has to be meticulously studied as an aggregate of possible ways in which Majoranas can be hosted in the system, which increase chances for successful application. In regard to nonlocality, it is a crucial element of braiding, which allows for performing the quantum computation by employing the degenerate states that are spatially separated. It also allows for nontrivial phenomena, like quantum teleportation and nonlocal conductance.

Both of these phenomena constitute a fertile ground for theoretical research, not only during my PhD studies but hopefully also in the future to come.

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