Superconductors and similar to them in many respects superfluids are extraordinary states of matter in which properties of micro-world can be observed in macroscopic scale. In this case, flow whether of current carriers or fluid itself, takes place without energy loss. Thanks to that phenomenon, movement, once started, can last forever. While some well known and sought after applications, like loseless energy transfer are constantly hindered by extremely low temperatures in which all known to us substances from this class retain their properties, their study constantly bringing forth new phenomena and finding other valuable applications.

One of the most often studied structures appearing in superconductors are vortices. While they share number of characteristics with vortices in normal fluids as whirlpools, whirlwinds or cyclones they exhibit also lots of other interesting properties (like quantization of the angular momentum). In scope of this project I am mostly interested by one peculiar property of one peculiar class of vortices. While usually center of the vortex is empty, in some special classes of superconductors (called topological superconductors) in the very eye of the storm one can find very peculiar excitation - so called Majorana quasiparticle. Such vortices (Majorana vortices) appear in pairs and maintain connection even when separated to macroscopic distances. Moreover they show one more interesting property: upon swapping their positions - in contrary to other known types of particles - in their wavefunction not only information about swaps but also their order is encoded. Because of this feature they were proposed to be building block of fault-tolerant quantum computers.

This field of research is relatively young but it developed quickly over last decade. Despite many theoretical descriptions, ideas of experimental realization and several reports of observation in laboratories, many topics are still unexplored. Aim of my research is theoretical description of dynamical properties of Majorana vortices and similar excitations. Specifically, examining how they react upon external force, or what is their behavior in systems with many vortices, important question is also whether they are stable in presence of disorder, noise and other perturbations of this kind appearing in real life physical systems.

My research should give us better understanding of what type of behavior we may expect from Majorana vortices. We can also get to know more fully the laws of physics hidden behind those fascinating structures, this knowledge can be also of use in attempts to construct quantum computer in this class of systems.