Quantum computers represent a frontier in pioneering scientific research, exploring the fascinating principles of quantum mechanics to perform complex computational tasks. At the heart of this advanced technology is the quantum bit, or qubit, which is the basic unit of quantum information processing. While quantum computers are still in the early stages of development, they hold tremendous potential. However, they also face an inherent obstacle: qubit decoherence, a phenomenon causing the loss of delicate quantum states and introducing computational inaccuracies.

One path to overcome this limitation is to identify materials that promise high error resistance. Surprisingly, the list of candidate materials is relatively short, as only few have been thoroughly investigated. Our project aims to explore the potential of a new family of materials, lead and tin chalcogenide semiconductors coupled with superconductors. These materials have not been widely studied in the field of quantum information science. We assume that their unique physical properties — strong spin-orbit interactions, high electron mobility, and effective electrostatic control — enable the reduction of qubit decoherence. Additionally, they may be used to investigate new quantum phenomena in nanoscale devices.

To embark on this scientific endeavor, we have assembled an international team of experts from Ukraine, Poland, and the United States, which includes theoreticians, experimentalists, and crystal growers representing various disciplines. Our common mission involves fabricating and characterizing nanostructures, as well as constructing and studying quantum devices using the aforementioned materials. Our efforts extend beyond laboratory work; we apply theoretical models to predict and understand unique quantum behavior. This synergy should lead to an iterative process of discovery and development.

In addition to research activities, our project emphasizes the promotion of knowledge and educational activities. We collaborate with two recognized Ukrainian institutions, Kharkiv Polytechnic Institute and V.N. Karazin Kharkiv National University, where we will organize an online course on materials and devices for quantum computations. Simultaneously, we consider the possibility of collaboration with the emerging quantum industry in technology transfer and employee training. We intend to engage in discussions with several global companies involved in quantum computing. Our project also foresees organizing a hybrid seminar to bring the scientific community together on topics related to quantum phenomena and quantum computing. As part of the project, a conference and summer school will be held to further integrate Ukrainian researchers into global efforts in this field.