Description for the general public of the project: *From invariant quantum channels to long-range quantum communication*

Quantum information science is a dynamically developing branch of modern physics, which changed our view on such problems like effective transfer of information or speed of solving computational problems. A trademark of quantum information is quantum entanglement. We say that two far away objects are entangled, if the information about both of them, treated as a single object, is greater than the information about its parts treated separately. Such a paradoxical situation is impossible for any physical objects according to classical physics. Therefore entangled states involve very strong correlations between their subparts, that can be used for more effective and secure information processing.

This research project aims to advance technologies for secure long-range quantum communication. The main focus is on developing methods to average quantum channels over various symmetry transformations, a crucial aspect for quantum information processing without requiring shared reference frames. The project seeks to address several key issues:

1. **Averaging Quantum Channels**. The project aims to characterize the process of averaging quantum channels over general symmetry operations, which is essential for analyzing quantum circuits exposed to various types of noise.

2. **Finite Averaging Sets**. The researchers aim to extend techniques used for averaging quantum states to quantum channels, creating finite sets of operations that represent these averages. These sets are vital for implementing randomized quantum algorithms.

3. **Relativistic Quantum Information**. The project will explore quantum channels acting on discrete degrees of freedom (like spin) of relativistic quantum particles, focusing on their invariance under Lorentz transformations.

4. **Averaging in Quantum Optics**. There will be efforts to construct finite averaging sets for quantum states of light, relevant for quantum optics applications.

5. **General Averaging Sets Construction**. The researchers aim to develop general methods for constructing finite averaging sets for physical quantities under various symmetry groups.

This project tackles fundamental challenges in quantum communication and information processing by developing novel methods for averaging quantum channels and states, which are crucial for secure and efficient long-range quantum communication. This is particularly important in scenarios where the sender and receiver do not share reference frames, such as long-distance communication in space.