**Doctoral School of Information and Biomedical Technologies
Polish Academy of Sciences (TIB PAN)**

SUBJECT: Speed limits for quantum resource generation

SUPERVISOR: dr hab. Alexander Streltsov, astrel@ippt.pan.pl, Institute of Fundamental Technological Research, Polish Academy of Sciences

DESCRIPTION: Quantum coherence and entanglement are fundamental features of quantum systems, separating quantum physics from its classical counterpart. In the early days of quantum mechanics entanglement has been considered as a puzzling phenomenon, and Einstein has famously termed it "spooky action at a distance". Over the last decades the situation has changed, with the existence of entanglement being confirmed in numerous experiments. Today, quantum entanglement is considered as a resource for the emerging quantum technologies, allowing us to surpass limitations of classical devices. This has led to the development of the resource theory of entanglement, allowing us to investigate the role of entanglement for technological applications, such as quantum teleportation and quantum cryptography.

The primary goal of the research is to develop quantum speed limits-rigorous, fundamental bounds that quantify the minimal time required to generate quantum resources such as coherence and entanglement through physical evolution. These limits play a crucial role in understanding the ultimate performance limits of quantum technologies, including quantum computation, communication, and metrology. Since quantum resources serve as enablers of quantum advantage, knowing how fast they can be generated or manipulated is vital for optimizing protocols and understanding the physical constraints of quantum systems.

In more detail, the goal is to determine the fastest possible way to increase the resource content of a quantum system starting from an initial quantum state, under the constraint that the system evolves unitarily according to a given Hamiltonian. This involves quantifying how the resource quantifier-such as coherence or entanglement-changes over time and identifying tight lower bounds on the time required to achieve a specified resource level. The aim is to extend established quantum speed limits, such as the Mandelstam-Tamm and Margolus-Levitin bounds, which characterize the minimal evolution time between two quantum states, to a broader and more resource-oriented context.

Profile of the candidates: Applicants should have a master's degree in engineering, physics or related areas, and have a good understanding of quantum theory. Candidates are strongly advised to contact Alexander Streltsov before formal submission of the documents: astrel@ippt.pan.pl.