LEEVI LEPPÄJÄRVI

Institute of Physics
Slovak Academy of
Sciences

Project number
1372/03/01

Project duration
9/2022 - 8/2025

I applied for the SASPRO 2 fellowship programme because it gives me the opportunity to pursue my own research interests in exploring the foundations of quantum theory in the best research group in the field of quantum information in Slovakia. The fellowship allows me to benefit not only from the scientific excellence of the host organisation, but also from an open international research environment. The successful realisation of the planned research will allow me to deepen my knowledge in my field and become an independent researcher in the international research scene. It is my hope that the fellowship will also help me to establish myself in my field and that it opens new doors in my scientific career after the fellowship.

S A S P R O 2

BIOGRAPHY

I was born in Rovaniemi, Lapland, Finland; the official hometown of Santa Claus. For my university studies I moved to southern Finland where I started studying theoretical physics at the University of Turku in 2013. Following my master's degree in 2017 I continued to do my PhD under the supervision of Dr. Teiko Heinosaari. During my PhD I focused on exploring different nonclassical features of measurements in quantum theory and other operational theories. After getting my PhD in the summer of 2021 I moved to Bratislava, Slovakia to work as a postdoctoral researcher at the Research Center for Quantum Information at the Institute of Physics at the Slovak Academy of Sciences where I continued to work on the topics of quantum foundations and quantum information.

PROJECT SUMMARY

Sequential measurements and incompatibility in operational theories (SeMIOpT)

The framework of operational theories provides an abstract setting for possible physical theories based on operational principles. Containing not only quantum and classical theories but also countless toy theories, the operational theories give us means to study well-known properties of quantum theory in a more general setting. This allows us to formulate and examine these properties in different theories, quantify them and compare different theories to each other based on how these properties behave within them. An important platform for comparing quantum theory to other operational theories are the prepare-and-measure scenarios. The prepare-and-measure scenarios consist of preparing a physical system in a desired state, measuring the system with some physical observable and finally registering the obtained measurement outcome. As a basis of every physical experiment and communication scheme it serves as the framework in which all information-theoretic tasks can be implemented. Studying these scenarios using the methods of operational theories helps us understand which type of communication is possible in quantum theory, what are the origins of the limitations for the different information-theoretic tasks and even what kind of theories could overcome the limits of quantum theory. An example of an important and well-studied property of quantum theory is the incompatibility of observables, i.e., the impossibility to measure some physical observables jointly and sharply with a single joint measurement device. Incompatibility has many foundational and practical consequences. It has been shown that incompatibility is not only a property of quantum theory but also all other operational theories which are not classical; hence, incompatibility is a strongly non-classical feature, which can be efficiently studied in the framework of operational theories.

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PUBLICATIONS

1. T. Heinosaari, L. Leppäjärvi and M. Plávala, No-free-information principle in general probabilistic theories, Quantum 3, 157 (2019)

2. S. N. Filippov, T. Heinosaari and L. Leppäjärvi, Simulability of observables in general probabilistic theories, Phys. Rev. A 97, 062102 (2018)

3. S. N. Filippov, S. Gudder, T. Heinosaari and L. Leppäjärvi, Operational restrictions in general probabilistic theories, Found. Phys. 50, 850-876 (2020)

4. L. Leppäjärvi and M. Sedlák, Postprocessing of quantum instruments, Phys. Rev. A 103, 022615 (2021)

5. T. Heinosaari, O. Kerppo and L. Leppäjärvi, Communication tasks in operational theories, J. Phys.A:Math. Theor. 53, 4353 (2020)

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