Symposium Foundations of Quantum Theory (SYQT)

jointly organised by
the Quantum Information Division (QI),
the Quantum Optics and Photonics Division (Q), and
the Working Group on Philosophy of Physics (AGPhil)

Dennis Lehmkuhl
Institut für Philosophie
Rheinische Friedrich-Wilhelms-Universität Bonn
53113 Bonn
dennis.lehmkuhl@uni-bonn.de

Matthias Kleinmann
Department Physik
Universität Siegen
57068 Siegen
matthias.kleinmann@uni-siegen.de

The foundations of quantum mechanics are still subject of intense research, even 100 years after the theory was first formulated. In foundations, the underlying concepts and structures of quantum theory are discussed, ranging from philosophical debates to novel mathematical frameworks to experimental tests of quantum theory. The aim of this symposium is to highlight recent developments in the foundations of quantum theory exploring them from both a philosophical and a physics perspective.

Overview of Invited Talks and Sessions

(Lecture hall HS 1+2)

Invited Talks

SYQT 1.1	Wed	11:00–11:30	HS 1+2	**Against 'local causality'** — •Guido Bacciagaluppi
SYQT 1.2	Wed	11:30–12:00	HS 1+2	**Philosophy of Quantum Thermodynamics** — •Carina Prunkl
SYQT 1.3	Wed	12:00–12:30	HS 1+2	**Can quantum information be the underpinning of quantum physics?** — •Paolo Perinotti
SYQT 1.4	Wed	12:30–13:00	HS 1+2	**Spin-bounded correlations: rotation boxes within and beyond quantum theory** — Albert Aloy, •Thomas Galley, Caroline Jones, Stefan Ludescher, Markus Müller

Sessions

SYQT 1.1–1.4	Wed	11:00–13:00	HS 1+2	**Foundations of Quantum Theory**

SYQT 1: Foundations of Quantum Theory

Time: Wednesday 11:00–13:00 Location: HS 1+2

Invited Talk SYQT 1.1 Wed 11:00 HS 1+2

Against 'local causality' — •Guido Bacciagaluppi — Freudenthal Institute and Descartes Centre, Utrecht University, Netherlands

In his last paper on quantum foundations, J. S. Bell suggested to characterise the causal constraints of relativity in terms of a condition he called 'local causality', to which he tentatively gave a precise mathematical form. In this form, local causality implies his famous factorisation condition and thus the Bell inequalities. This leads to the conclusion that both quantum mechanics and the experimentally verified violations of the Bell inequalities violate the causal constraints of relativity, a claim that has been defended also in parts of the philosophy literature. I argue it is mistaken, trace it to an ambiguity in the formulation of local causality, and suggest an alternative formalisation that removes the alleged incompatibility between local causality and Bell nonlocality.

Invited Talk SYQT 1.2 Wed 11:30 HS 1+2

Philosophy of Quantum Thermodynamics — •Carina Prunkl — Ethics Institute, University of Utrecht

TBA

Invited Talk SYQT 1.3 Wed 12:00 HS 1+2

Can quantum information be the underpinning of quantum physics? — •Paolo Perinotti — Pavia University, Pavia, Italy

In the early 2000s the idea that quantum mechanics could be formulated starting from informational axioms broke the ground, as an outcome of the *second quantum revolution*. Since then, the formalism of Hilbert spaces, density matrices, quantum instruments and POVMs was successfully recovered in this perspective, marking an important milestone along the path. The next question regards the reconstruction of physical laws, in a context devoid of any mechanical notion from the outset. The computational model that is closest to the physical model of a quantum field is a quantum cellular automaton. We will discuss how dynamical equations of quantum field theories can be recovered along with space-time itself, from an abstract information processing scenario where elementary quantum systems form a cellular automaton. We will discuss some key philosophical implications for the nature of quantum physics that this approach entails.

Invited Talk SYQT 1.4 Wed 12:30 HS 1+2

Spin-bounded correlations: rotation boxes within and beyond quantum theory — Albert Aloy[1,2], •Thomas Galley[1,2], Caroline Jones[1,2], Stefan Ludescher[1,2], and Markus Müller[1,2,3] — [1]Institute for Quantum Optics and Quantum Information, Vienna, Austria — [2]Vienna Center for Quantum Science and Technology, Vienna, Austria — [3]Perimeter Institute for Theoretical Physics, Waterloo, Canada

How does the structure of space-time constrain the structure of quantum theory? Namely if we assume that a probabilistic theory fits into space and time does this already imply important structural features of quantum theory?

In a simple prepare-and-measure scenario the detector click probabilities should respond to rotations of the device around a fixed axis. In an analogy to the non-local boxes arising in Bell setups I will define rotation boxes which generate rotational correlations.

The correlations generated by a rotation box carry a representation of SO(2) which will allow us to define a general notion of spin. I will show that for spins 0, 1/2 and 1 the set of general correlations admits a quantum realisation, whilst for spins 3/2 and higher I will show that this is not the case by providing an explicit Tsirelson type inequality. I will briefly outline how this framework connects to a number of topics including semi-definite programs, orbitopes and symmetric entanglement witnesses.