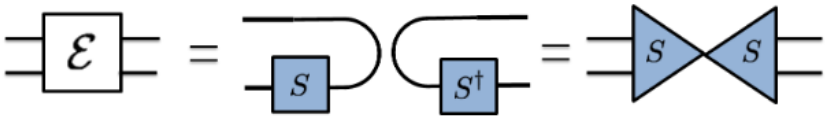
Celebrating the Choi-Jamiołkowski Isomorphism



Celebrating the
Choi-Jamiołkowski Isomorphism

Online Event

March 1-2, 2023

(Endorsed by the National Center for Quantum Informatics (KCIK), Gdańsk)

Report of Contributions

Contribution ID: **1** Type: **not specified**

The Operational Choi-Jamio lkowski Isomorphism

Thursday 2 March 2023 15:35 (30 minutes)

I use an operational formulation of the Choi-Jamio lkowski isomorphism to explore an approach to quantum mechanics in which the state is not the fundamental object. I first situate this project in the context of generalized probabilistic theories and argue that this framework may be understood as a means of drawing conclusions about the intratheoretic causal structure of quantum mechanics which are independent of any specific ontological picture. I then give an operational formulation of the Choi-Jamio lkowski isomorphism and show that, in an operational theory whichexhibits this isomorphism, several features of the theory which are usually regarded as properties of the quantum state can be derived from constraints on non-local correlations. This demonstrates that there is no need to postulate states to be the bearers of these properties, since they can be understood as consequences of a fundamental equivalence between multipartite and temporal correlations.

Primary author: ADLAM, Emily (The Rotman Institute of Philosophy,)

Presenter: ADLAM, Emily (The Rotman Institute of Philosophy,)

Contribution ID: **2** Type: **not specified**

A few puzzles in open quantum dynamics

Wednesday 1 March 2023 17:50 (30 minutes)

Despite its long history, research in open quantum dynamics still provides unexpected facets. We shall discuss some of them that are connected with entanglement generation and super-activation of back-flow of information by means of tensor products of dynamical maps.

Primary author: BENATTI, Fabio (Dipartimento di Fisica, Universit'a degli Studi di Trieste,)

Presenter: BENATTI, Fabio (Dipartimento di Fisica, Universit'a degli Studi di Trieste,)

Contribution ID: **3** Type: **not specified**

The Heisenberg groups and the dimensions of Hilbert spaces

Wednesday 1 March 2023 18:25 (30 minutes)

Finite Heisenberg groups have a certain universal status. In every finite dimensional Hilbert space there is at least one Heisenberg group that acts irreducibly in this dimension, and in no other. I will describe some dimension dependent structures that arise in this way, and some connections between seemingly different dimensions that arise from them.

Primary author: BENGTSSON, Ingemar (Stockholms Universitet, Fysikum)

Presenter: BENGTSSON, Ingemar (Stockholms Universitet, Fysikum)

Contribution ID: **4** Type: **not specified**

Higher-order quantum processes and quantum causal structures

Wednesday 1 March 2023 15:45 (30 minutes)

One of the most profound insights of the Choi-Jamio lkowski isomorphism is that quantum processes can be treated as quantum states. Following this idea, it is natural to consider a kind of super-processes that transform quantum processes into quantum processes, in a similar way as ordinary processes transform quantum states into quantum states. This construction can be iterated recursively, generating an infinite hierarchy of processes of increasingly higher orders. Physically, this hierarchy corresponds to an extension of the framework of quantum circuits, including the ordinary acyclic circuits considered in quantum computing, as well as a new type of quantum circuits with cycles. In this talk I will present the main notions in the study of higher order quantum processes, discussing their application to quantum information and their connection with the study of causal structure in quantum mechanics.

Primary author: CHIRIBELLA, Giulio (QICI Quantum Information and Computation Initiative, Department of Computer Science, The University of Hong Kong, Pokfulam Road, Hong Kong)

Presenter: CHIRIBELLA, Giulio (QICI Quantum Information and Computation Initiative, Department of Computer Science, The University of Hong Kong, Pokfulam Road, Hong Kong)

Contribution ID: **5** Type: **not specified**

A generic quantum Wielandt's inequality

Thursday 2 March 2023 15:00 (30 minutes)

In this talk, I will provide a generic version of quantum Wielandt's inequality, which gives an optimal upper bound on the minimal length such that products of that length of n-dimensional matrices in a generating system span the whole matrix algebra with probability one. I will show that this length generically is of order Θ(log n), as opposed to the general case, in which the best bound to the date is O(n2log n). We will discuss the implications of this result as a new bound on the primitivity index of a random quantum channel, as well as to show that almost any translation-invariant (with periodic boundary conditions) matrix product state with length of order Ω(log n) is the unique ground state of a local Hamiltonian. Finally, we will comment on the possibility of extending these results to Lie algebras. This is based on joint work with Yifan Jia.

Primary author: CUEVAS, Angela Capel (Fachbereich Mathematik, Universit¨at T¨ubingen, 72076 T¨ubingen, Germany)

Presenter: CUEVAS, Angela Capel (Fachbereich Mathematik, Universit¨at T¨ubingen, 72076 T¨ubingen, Germany)

Contribution ID: **6** Type: **not specified**

Emergent entanglement structures and self-similarity in quantum spin chains

Thursday 2 March 2023 17:00 (30 minutes)

We introduce an experimentally accessible network representation for many-body quantum states based on entanglement between all pairs of its constituents. We illustrate the power of this representation by applying it to a paradigmatic spin chain model, the XX model, and showing that it brings to light new phenomena. The analysis of these entanglement networks reveals that the gradual establishment of quasi-long range order is accompanied by a symmetry regarding single-spin concurrence distributions, as well as by instabilities in the network topology. Moreover, we identify the existence of emergent entanglement structures, spatially localised communities enforced by the global symmetry of the system that can be revealed by model-agnostic community detection algorithms. The network representation further unveils the existence of structural classes and a cyclic self-similarity in the state, which we conjecture to be intimately linked to the community structure. Our results demonstrate that the use of tools and concepts from complex network theory enables the discovery, understanding, and description of new physical phenomena even in models studied for decades.

Primary author: MANISCALCO, Sabrina (QTF Centre of Excellence, Department of Physics, University of Helsinki, Finland)

Presenter: MANISCALCO, Sabrina (QTF Centre of Excellence, Department of Physics, University of Helsinki, Finland)

Contribution ID: **7** Type: **not specified**

Non-decomposable positive maps from tensor products

Thursday 2 March 2023 16:10 (30 minutes)

Understanding how positivity of maps behaves under tensor products is linked to several open problems in quantum information theory. In my talk, I will present some recent results on how non-decomposable positive maps can arise from tensor products and tensor powers of decomposable maps. The Choi-Jamio lkowski isomorphism is an indispensable tool in this line of research.

Primary author: M¨ULLER-HERMES, Alexander (Department of Mathematics, University of Oslo, 0316 Oslo, Norway)

Presenter: M¨ULLER-HERMES, Alexander (Department of Mathematics, University of Oslo, 0316 Oslo, Norway)

Contribution ID: **8** Type: **not specified**

The Choi-Jamio lkowski Isomorphism: when Maths meets Physics

Wednesday 1 March 2023 16:20 (30 minutes)

I discuss the interplay between Physics and Mathematics, from a personal perspective, in the light of the celebrated Choi-Jamio lkowski Isomorphism. I argue that it is desirable that a physical law, when expressed in terms of a differential equation, should admit any initial conditions. Choi-Jamio lkowski isomorphism, complete positivity, correlations and entanglement form a facet pattern that defines the correct formulation of the dynamics of open quantum systems. A formulation that requires coordination and teamwork if all its ingredients are to be kept in perfect alignment.

Primary author: PASCAZIO, Saverio (Dipartimento di Fisica, Universit'a di Bari, Italy)

Presenter: PASCAZIO, Saverio (Dipartimento di Fisica, Universit'a di Bari, Italy)

Contribution ID: **9** Type: **not specified**

Positive Maps and Entanglement in Real Hilbert Spaces

Thursday 2 March 2023 17:35 (30 minutes)

Partially motivated by recent research in quantum physics, we take a closer look at the similarities and differences between the study of positive maps, separability, and entanglement in the real and complex case. It is possible for real matrices to be entangled as operators on a real Hilbert space and yet separable when regarded as acting on a complex space. These two distinct theories of entanglement in the real case correspond to two different theories of entanglement breaking maps in the real case. Finally, we see what these differences have to say about real versions of the PPT-squared conjecture. Based on joint research with G. Chiribella, K.R. Davidson, and M. Rahaman.

Primary author: PAULSEN, Vern (Institute for Quantum Computing and Department of Pure Mathematics, University of Waterloo, Waterloo, Waterloo, ON, Canada N2L 3G1)

Presenter: PAULSEN, Vern (Institute for Quantum Computing and Department of Pure Mathematics, University of Waterloo, Waterloo, Waterloo, ON, Canada N2L 3G1)

Contribution ID: **10** Type: **not specified**

Generalizations of the Choi matrix

Wednesday 1 March 2023 17:15 (30 minutes)

We first study generalizations of Choi matrices for linear maps of the n×n matrices into themselves. Then we generalize this to certain maps of Von Neumann algebras into themselves.

Primary author: STØRMER, Erling (Department of Mathematics, University of Oslo, 0316 Oslo, Norway)

Presenter: STØRMER, Erling (Department of Mathematics, University of Oslo, 0316 Oslo, Norway)

Contribution ID: **11** Type: **not specified**

Opening Address : Karol Zyczkowski (Krakow)

Wednesday 1 March 2023 15:00 (10 minutes)

Contribution ID: **12** Type: **not specified**

Guest of Honor : Prof. Man-Duen Choi (Toronto)

Thursday 2 March 2023 18:10 (30 minutes)

Contribution ID: **13** Type: **not specified**

Guest of Honor : Prof. Andrzej Jamiolkowski (Toru´n)

Wednesday 1 March 2023 15:10 (30 minutes)

Contribution ID: **14** Type: **not specified**

Closing Remarks: Francesco Petruccione (Stellenbosch)

Thursday 2 March 2023 18:45 (15 minutes)