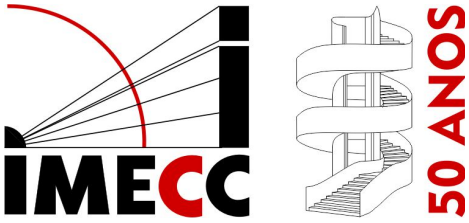
Minisymposium: Mathematics of Quantum Theory



Coordinator: Marcelo Terra Cunha, IMECC-Unicamp

We confirm the organization of the described minisymposium in the 8-talk format.

The invitees are:

- Samson Abramsky, Oxford University, UK;
- Jan-Åke Larsson, Linköping University, Sweden;
- Bárbara Amaral, UFSJ, Brazil;
- Shane Mansfield, *Université Paris Diderot - Paris 7*, France;
- Ernesto Galvão, UFF, Brazil;
- Leonardo Guerini, IFT-Unesp / ICTP-SAIFR, Brazil;
- Roberto Imbuzeiro Oliveira, IMPA, Brazil; and
- Jacques Pienaar, IIP-UFRN, Brazil

The minisymposium is open to any topic of quantum theory with a mathematical taste. The specific flavour will be given by the speakers and the organizer. It is somehow biased to foundations and contextuality, but not completely.

It will be spread into two sessions, with dates yet to be confirmed. We propose the following program:

Session 1:

- Shane Mansfield;
- Bárbara Amaral;
- Samson Abramsky;
- Jan-Åke Larsson.

Session 2:

- Leonardo Guerini;
- Jacques Pienaar;
- Ernesto Galvão;
- Roberto Imbuzeiro Oliveira.

Titles and abstracts:

Shane Mansfield
Quantum advantage and contextuality of transformations

Abstract:
I will introduce a notion of contextuality for transformations in sequential contexts, distinct from the Bell-Kochen-Specker and Spekkens notions of contextuality, which can arise even in a single qubit system. Within a transformation-based model for quantum computation it will be shown that strong sequential transformation contextuality is necessary for deterministic computation of non-linear functions. For probabilistic computation, sequential transformation contextuality is necessary for obtaining advantage over classical implementations and the degree of advantage quantifiably relates to the degree of contextuality.

Bárbara Amaral
Resource Theory of Contextuality and Nonlocality

Abstract:
Contextuality and Non-locality are two of the most fascinating features of Quantum Theory. Besides the role of these properties in the understanding of the fundamental aspects of the theory, technologies that exploit these phenomena promise a transforming revolution for science, industry and society. These characteristics were identified as essential resources in various information and computation protocols, and for this reason, it is important to study them from the point of view of Resource Theories, which provide a powerful framework for the formal treatment of a physical property as an resource, adequate for it's characterization, quantification and manipulation. In this talk I present some recent developments in the search of a unified Resource Theory for Contextuality and Non-locality in their most general forms.

Samson Abramsky
The Mathematics of Contextuality

Abstract:
We shall describe some elements of a mathematical theory of contextuality which can be applied to understanding contextuality as a resource, and its applications to quantum advantage. On the quantitative side, we shall discuss the contextual fraction, a measure of the amount of contextuality in a quantum resource, and inequalities which relate the degree of quantum advantage to the contextual fraction.
On the qualitative side, we shall expose the topological structure of contextuality,, and how cohomological obstructions can be used to witness it.

Jan-Åke Larsson
Efficient simulation of some quantum computer algorithms

Jan-Åke Larsson and Niklas Johansson

Abstract:

A long-standing aim of quantum information research is to understand what gives quantum computers their advantage. Such an understanding would be of great benefit when attempting to build a quantum computer. Here we present a framework that uses classical resources but still is able to efficiently run, for example, Deutsch-Jozsa and Simon's algorithms, and also can run Shor's factoring algorithm and Grover search with some systematic errors. The framework has been realized in classical pass-transistor logic, for example factoring 15 using Shor's algorithm with smaller systematic errors than any former experimental implementation, and the same amount of resources in time and space as a scalable quantum computer. The device will be demonstrated separately, after the talk. Our results give further insight into the resources needed for quantum computation, aiming for a true understanding of the subject.

Leonardo Guerini
Simulability properties of quantum measurements

Abstract:
In the context of quantum measurements, the idea of joint measurability captures the notion of simultaneity, meaning that a set of jointly measurable observables can be implemented as one. This is a central concept for many of the non-classical features presented by quantum theory, and can also be seen as a particular simulability property of such a set. In this talk we are motivated by the simulability scenario to present connections of joint measurability to other important concepts, such as extremality and boundary in the set of quantum measurements, uniqueness of the joint observable, and projective simulability.

Jacques Pienaar
Time symmetry in quantum causal models

Abstract:
Causality is a time-asymmetric concept. Historically, the time-asymmetry of causality has been tied to the thermodynamic arrow of time.
However, this approach would seem to work only for macroscopic systems. Recently, causal models have been applied to microscopic quantum systems.
This raises the question of how to reconcile the time symmetry of the laws of quantum mechanics with the manifest asymmetry of cause and effect.
I will discuss some ideas about how this can be achieved in an explicit model of quantum causality.

Ernesto Galvão
Photonic identity testing

Abstract:
In quantum theory, it is possible to test whether two states are the same or not using the SWAP test. More generally, permutation tests make it possible to characterize the degree of indistinguishability between N systems in unknown states. We describe how to define and characterize genuine indistinguishability between N photons, using simple linear interferometers. Our approach combines tests of two-photon indistinguishability to infer the degree of N-photon indistinguishability. Underlying these tests we found an interesting set of inequalities for probabilities of identity of subsets of photons, which I'll describe.

This talk is based on joint work with Daniel J. Brod, Niko Viggianiello, Fulvio Flamini, Nicolò Spagnolo and Fabio Sciarrino.

Related preprint:
https://arxiv.org/abs/1804.01334

Roberto Imbuzeiro Oliveira

Small violations of Bell inequalities for multipartite pure random states

Abstract: We the typical behaviour of optimal violations for a large class of Bell inequalities in any given correlation scenario for pure states with many parts. Roughly speaking, for any finite number of parts, measurements and outcomes we estimate the probability of random -qu it pure states violating a representative class of Bell inequalities. In addition, we also discuss the effect that the local dimension has on the probability of finding partite dimensional quantum systems which violate that considered class of Bell inequalities in any given scenario. We prove that under some conditions on the local dimension the probability to find any significant amount of violation goes to zero exponentially fast, as the number of parts goes to infinity.
Joint work with Raphael Drumond and Cristhiano Duarte.