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Project position in mathematical aspects of quantum mechanics

Position Title: Postdoc or Praedoc
Position Type: FWF-supported project
Location: Linz, Austria
Possible subject areas: Operator algebras, ordered algebraic structures, categorical quantum mechanics
Application Deadline: 31st January 2025
Position Description: Research position

The Institute for Mathematical Methods in Medicine and Data Based Modeling at the Johannes Kepler University in Linz (Austria) invites applicants for a position in the framework of the Czech-Austrian cooperative project

Orthogonality and symmetry,

which will be supported by the FWF (Austrian Science Fund) and GAČR (Czech Science Foundation) over a period of three years. The abstract can be found below.

The position is initially available for one year, with a possible extension up to the end of the project duration. The earliest starting date is 1 March 2025. We invite applicants who hold, or expect to receive, a PhD in mathematics. Alternatively, the position is available for the acquisition of a PhD in mathematics.

We are searching for somebody who is interested in the foundations of quantum mechanics and has a background in a relevant field of mathematics. A background in operator algebra is particularly desirable; an interest in ordered algebraic structures and/or categorical quantum mechanics is welcome as well. The candidate should be highly motivated and willing to contribute with own creative ideas. There is no teaching load.

Application materials required: Submit the following items to `thomas.vetterlein@jku.at` to complete your application:

- a short CV;
- a list of publications (if applicable),
- a statement about your research interests.

The deadline for applications is 31st January 2025, but later applications may also be considered.

For further information, feel free to contact Thomas Vetterlein, the coordinator of the project, by e-mail.

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Austrian-Czech cooperative Research project "Orthogonality and Symmetry"

Wider research context

More than 100 years after its emergence, the principles on which quantum physics is based are still not straightforward to understand. In the spirit of the probably oldest approach, which goes back to Birkhoff and von Neumann, algebraic, relational, or categorical structures abstracted from the basic quantum-physical model have been proposed for investigation. Considerations concern, for instance, the inner structure of physically testable properties or quantum physical states, described by orthomodular lattices or orthosets.

Objectives

Our research aims at an improved understanding of the basic mathematical formalism on which quantum physics is based. We proceed on three different levels. First, we intend to improve our knowledge about algebraic structures closely linked to the quantum physical model, most notably orthomodular lattices and their state spaces. Second, we focus on the reconstruction of the Hilbert space model of quantum mechanics, at first place by means of orthosets and their symmetries. Third, we consider operator algebras, where the aim is to establish their properties in relation to derived structures like the orthoset of their states.

Approach

The notion of orthogonality is in the centre of our interest. Based solely on this structural feature, quite a number of common structures can be described, among them the Hilbert spaces. Accordingly, our main tool are orthosets, which are solely based on a symmetric, irreflexive binary relation. The mutual relation between orthosets and the underlying structure – which can be an algebraic structure, an inner-product space, or an operator algebra – is to be investigated. A particular focus lies on the mutual relationship between the respective symmetry groups. Moreover, research is supposed to be done on a categorical level, to which end we consider dagger categories as appropriate.

Level of originality

Orthogonality is a notion that occurs in abundance in mathematics. In recent years, it has turned out that orthogonality need not be seen as a derived relation; numerous structures can rather be identified with certain orthosets. The idea of restricting attention to this sole binary relation has not yet been exploited to a large extent. Our research aims at elucidating its nature and role, particularly in the context of quantum physical modelling, where orthogonality can be transcribed into the mutual exclusivity of outcomes.

Primary researchers involved

The research group consists both of mathematicians and physicists: Thomas Vetterlein and Bert Lindenhovius (Linz), Mirko Navara and Milan Matoušek (Prague), Jan Paseka and David Kruml (Brno), Jan Kühr, Ivan Chajda, and Dominik Lachman (Olomouc), as well as Karl Svozil, Mike Behrisch, and Helmut Länger (Vienna). The tasks are supposed to be dealt with in different constellations, depending on whether single or interdisciplinary aspects are concerned.