Hilbert Spaces and the Mathematics of Quantum (Information) Theory

Augmester 2024

listed under

MATH 4810/5810, Special Topics in Mathematics

Course Instructor: Dr. Markus Pflaum

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Lecture Hourse: MTWThF 9:00 a.m. – 12:00 p.m., August 5 – 22, 2024

Venue: HUMN 1B90

Targeted Audience: The course is intended for upper-division undergraduate and graduate students in mathematics, physics, chemistry, computer science or engineering with an interdisciplinary interest.

Basic knowledge of Linear Algebra and Analysis is recommended.

Course Homepage: `http://math.colorado.edu/courses/HilbertSpaces`

Course Contents: The course will provide an introduction to the theory of Hilbert spaces and their application in quantum mechanics. On the mathematical side, the notions of a hermitian inner product, Hilbert space, bounded linear operator, Hilbert basis and Fourier expansion, selfadjointness and the spectrum of a linear operator will be explained. In addition, basic concepts of classical mathematical communication theory à la Shannon will be introduced. These concepts will then be applied to describe the axioms of quantum mechanics, the spectral theorem, von Neumann entropy and fundamentals of quantum information theory.

Course Projects and Homeworrk: Each student has to write a short paper (around 5 pages) on a particular topic from the theory of Hilbert Spaces or work on an extended homework problem. In addition, a short in class presentation on the course paper or homework has to be given. The papers are due August 22, 2024. A selection of possible topics will be provided on the course page, but you can propose your own project theme.

Course Grading: Your grade will be determined from the homework or the course paper and the corresponding presentation.

Course Literature: The course will be based mainly on textbooks which are freely available for CU students as eBooks through `http://libraries.colorado.edu` or as online lecture notes under an appropriate open document license.

- HALL, *Quantum Theory for Mathematicians*, Springer Verlag

- MORETTI, *Spectral Theory and Quantum Mechanics With an Introduction to the Algebraic Formulation*, Springer Verlag

- TESCHL, *Mathematical Methods in Quantum Mechanics With Applications to Schrö-dinger Operators*, American Mathematical Society

- WILDE, *Quantum Information Theory*, 2nd edition, Cambridge University Press, online version available under `https://arxiv.org/abs/1106.1445`

The following online textbooks can be used to recall the prerequisites from Linear Algebra and Analysis and are available under an open document license.

- HEFFERON, *Linear Algebra*

- TRENCH, *Introduction to Real Analysis*

Credits: The standard number of credit hours for this course is 3.