Mathematical Foundations of Quantum Mechanics

Tim Shilkin

General information

- Course title: Mathematical Foundations of Quantum Mechanics
- Lector: Prof. Dr. Tim Shilkin
- Contacts: by e-mail tim dot shilkin at gmail dot com
- Course credits: 4,5 LP
- Course language: English
- Course site: http://www.pdmi.ras.ru/∼shilkin/
- Course format: on-line lectures
- Link to a zoom conference: please, send a request via e-mail in 'Contacts'
- Final attestation: oral exam
- Homework: several non-obligatory home assignments during the semester, but problems from these home assignments will be included in the final exam as additional questions

Syllabus

This course is a short mathematical introduction in the quantum mechanics. The particular attention in the course is devoted to the mathematical-friendly description of effects observed in physical experiments and their explanation in the mathematical language. Another goal of this course is to provide some insight into relations of quantum mechanics with various branches of modern mathematics emphasizing the influence of quantum mechanics on the development of mathematics.

The rough plan of the course is following: main theories of electrodynamic interactions and the place of quantum mechanics between them, experimental origins of quantum theory, mathematical apparatus of quantum mechanics, observables and states, Heisenberg's uncertainty relations, quantization, coordinate and momentum representations, quantum dynamics, Scrödinger equation, stationary states.

Possible additional topics: hydrogen atom, spin and spinor particles, Pauli equation, systems of identical particles, the symmetrization postulate and Pauli exclusion principle, helium atom, Mendeleev periodic table from the point of view of quantum mechanics.

Information about practical classes

Besides theoretical lectures these course includes several practical classes. These classes will be focused on-dimensional problems of quantum mechanics illustrating the main quantum effects. Several problem sheets will be assigned during the semester. These homework is non-obligatory, but problems from these home assignments can be included in the final exam as additional questions. Solutions (or hints to solutions) to most of homework problems will be discussed during the practical classes.

Information about attestation for this course

The attestation for this course is based on the final exam. The final exam will be held in oral form (in English) at the end of the course (approximately in April 2023). Students well be asked to give a detailed answer on one of questions on the theory covered during the semester. The list of exam questions will be announced at the course site not later than in two weeks before the exam. In the case of minor gaps in the answer on the theoretical question the partial grading is possible (i.e. 1.3, 2.7 etc).

Plan of lectures

- 27.03.23 States and observables, mathematical apparatus of quantum mechanics
- 28.03.23 Measurability of observables, Heisenberg's uncertainty relations
- 03.04.23 Quantization, coordinate and momentum representations of observables
- 04.04.23 Dynamics of quantum particles, the Schrödinger equation, stationary states
- 10.04.23 Spectrum of the Schrödinger operator, hydrogen atom
- 11.04.23 Spinor particles and spin operator, the Pauli equation
- 17.04.23 Multi-particle quantum systems, helium atom
- 18.04.23 Mendeleev's periodic table from the point of view of quantum mechanics