Course Announcement For Fall 2024 Special Topics

COURSE PREFIX/NUMBER:	MAT 494/598
TITLE OF COURSE:	Topics: Mathematics of Quantum Mechanics
INSTRUCTOR:	Dr. Sergei K. Suslov
TIME:	Tu Th 4:30 – 5:45 pm
LOCATION	WXLR A109
LINE #:	75771/75772

COURSE DESCRIPTION

The main purpose of this course is to help beginners explore the World of Quantum Mechanics, one of the most important scientific discoveries of the last century, and a subject that is very important in the education of student majoring in science or engineering.

This course uses mathematical methods which are not always part of the usual course sequence. It is designed as an introduction to quantum mechanics, with emphasis on the mathematical aspects of the theory. This includes the Schrodinger equation, the WKB approximation, angular momentum and spin, some applications of the theory of symmetry in quantum mechanics, motion in a magnetic field and, if time permits, the Dirac equation and/or other topics in relativistic theory.

All mathematical tools (aspects of analytic function theory, orthogonal polynomials, special functions, group representations, and asymptotic methods) will be introduced as needed.

PREREQUISITES: MAT 272 and 342.

TEXTBOOK:

Ashok Das, Lectures on Quantum Mechanics, Hindustan Book Agency, 2003; or any other similar textbook on non-relativistic quantum mechanics.

RECOMMENDED SUPPLEMENTARY BOOKS:

I. I. Gol'dman and V. D. Krivchenkov, Problems in Quantum Mechanics,
Dover, New York, 1993;
S. Flugge, Practical Quantum Mechanics, Springer, 1999
(reprint of the 1994 edition);
L. D. Landau and E. M. Lifshitz, Quantum Mechanics,
Third revised edition 1977, reprinted by Butterworth-Heinemann, 1998;
E. Merzbacher, Quantum Mechanics, Wiley, New York, 1998;
A. Messiah, Quantum Mechanics, Dover, 2001;
A. F. Nikiforov and V. B. Uvarov, Special Functions of Mathematical Physics, Birkhauser, Boston, 1988.

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SUGGESTED PROJECTS

1. The WKB approximation. Bohr-Sommerfeld's quantization rule.
2. Perturbation theory. Perturbations independent of time. The secular equation.
3. Motion in a Coulomb field (sperical coordinates and parabolic coordinates).
4. Rotational symmetry: the rotation operator, angular momentum and conservation laws.
5. The representations of the rotation group.
6. Addition of angular momenta. Clebsch-Gordan coefficients. Racah coefficients.
7. Irreducible tensor operators.
8. Hidden symmetry of the hydrogen atom.
9. Scattering. The cross section. The Born approximation.
10. Scattering in the Coulomb field.
11. The spin. The spin operator, Pauli matrices and spin angular momentum.
12. Motion in magnetic field. Schrodinger equation in a magnetic field.
13. Motion in a uniform magnetic field. Landau levels.
14. A hydrogen atom in an electric field. The Stark effect.
15. The Dirac equation: solutions of the free field Dirac equation.
16. The Dirac equation: central forces and the hydrogen atom.
17. Tree method for multi-dimensional Laplace equation.

HOMEWORK PROBLEMS

Gol'dman and Krivchenkov:

Section 1: # 1, 2, 3, 4, 5, 6, 7, 10, 11, 12

Section 3: # 1, 2, 3

Related publications:

K.Barley, J. Vega-Guzman, A Ruffing, and S.K.Suslov, *Discovery of the relativistic Schrödinger equation*, Physics-Uspekhi **65**(1) 90-103 (2022). From the history of physics.
https://iopscience.iop.org/article/10.3367/UFNe.2021.06.039000

S. I. Kryuchkov, N. A. Lanfear, and S.K. Suslov, *The role of the Pauli-Lubanski vector for the Dirac, Weyl, Proca, Maxwell, and Fierz-Pauli equations*, Physica Scripta, **91** (2016)#3, 035301
https://iopscience.iop.org/article/10.1088/0031-8949/91/3/035301

S. I. Kryuchkov, S. K. Suslov and J. M. Vega-Guzman, *The minimum-uncertainty squeezed states for atoms and photons in a cavity*, J. Phys. B: At. Mol. Opt. Phys. **46** (2013)#10, 104007 (15 pages). (IOP=Institute Of Physics SELECT and HIGHLIGHT for 2013).
https://iopscience.iop.org/article/10.1088/0953-4075/46/10/104007

(see also the reference therein).