Linnæus University

Course syllabus

Faculty Board of Science and Engineering
School of Computer Science, Physics and Mathematics

4FY823 Geometrisk fas i kvantsystem, 7,5 högskolepoäng
Geometric phases in quantum systems, 7.5 credits

Main field of study
Physics

Subject Group
Physics

Level of classification
Second Level

Progression
A1N

Date of Ratification
Approved by the Board of the School of Computer Science, Physics and Mathematics 2011-08-17

The course syllabus is valid from spring semester 2012

Prerequisites
Physics 90 credits, mathematics 45 credits or equivalent.

Objectives

At the end of the course the students:

- should be able to account for the fundamental concept of Berry phase within the adiabatic approximation in quantum mechanics
- should have acquired a basic knowledge of appropriate mathematical concepts and tools of differential geometry, which constitute the theoretical basis of the geometric phase
- should have acquired familiarity with the concept of geometric phase for general cyclic evolution in quantum mechanics
- should have understood the connection between geometric phases and Chern numbers
- should have acquired familiarity with the ubiquitous character of the geometric phase in quantum physics and chemistry, via specific examples in molecular physics, condensed matter physics and quantum field theory
- should have become familiar with ongoing research attempts of using the geometric phase in the realization of quantum computations schemes.

Content

1. Berry adiabatic phase. The topological phase and the Aharanov-Bohm effect
2. Geometric phases for general cyclic evolution
3. Manifolds and differential forms. Fiber bundles, connections and Gauge theories.
4. Holonomy interpretations of the geometric phase. Chern classes and Chern numbers.
5. The geometric phase and the Gauge theory of molecular physics
6. Experimental detection of geometric phases
7. Manifestations and applications of the geometric phase in condensed matter systems (Bloch bands, the quantum Hall effects, spin dynamics in itinerant magnets).

Module 1 0 credits

Type of Instruction

Teaching consists of lectures, seminars, practicals and laboratory work.

Students can also register for the "distance" version of the course and follow the course via the internet. IT support and technical information: Email and web connection. Real-time and recorded lectures on course homepage.

Examination

The course is assessed with the grades Fail (U), Pass (G) or Pass with Distinction (VG).
Assessment of student performance is made through written test and/or oral examinations and/or presentation of mandatory assignments. Reexamination will be offered within six weeks under the regular semester periods. The numbers of examinations are limited to five times.

On request, students may have their credits translated to ECTS-marks. Such a request must be sent to the examiner before the grading process starts.

Course Evaluation

A course evaluation will be carried out at the end of the course in accordance with the guidelines of the University. The result of the course evaluation will be filed at the department.

Required Reading and Additional Study Material

Reference Literature

(1)A. Bohm et al., The geometric phase in quantum systems, Springer 2003 (ISSN 0172-5998).

(2)D. Churuscinski and A. Jamiolkowski, Geometric Phases in classical and quantum mechanics, Birkäuser 2004 (ISBN 0-8176-4282-X).

(3)A. Shapere and F. Wilczek eds., Geometric phases in Physics, 1989 World Scientific

(4)D. Freed, K. Uhlenbeck Instantons and Four-manifolds, Springer.

(5)J. Jost, Riemannian Geometry and Geometric Analysis, Springer ISBN 3-540-42627-2

(6)J. Jost, Partial Differential Equations, Springer ISBN 0 387 95428-7

(7)Kobayashi, S.; Nomizu, R., Foundations of differential geometry. Vol I. New York, NY 1996: John Wiley & Sons, Inc. (ISBN 0-471-15733-3).

(8)I. Madsen, J.Tornehave, From calculus to cohomology. Cambridge university press. (ISNN 0-521-58956-8)

(9)Spivak, M., A comprehensive introduction to differential geometry. Vol I-V, Wilmington, Del. 1979: Publish or Perish, Inc. (ISBN 0-914098-83-7).

(10)Nakahara, M., Geometry, topology and physics, Bristol 1990: Adam Hilger, Ltd. (ISBN 0-85274-094-8; 0-85274-095-6).

(11)Lecture compendium and selected review papers.