Faculty of Health, Science and Technology
Physics

Syllabus

Connections between number theory, algebra and physics

Course Code: 2FYS015
Course Title: Connections between number theory, algebra and physics
Samband mellan talteori, algebra och fysik
Credits: 7,5 ECTS
Degree Level: Doctoral

Course Approval
The syllabus was approved by the Faculty of Health, Science and Technology, 11 November 2015 and is valid from the spring semester 2016.

Language of instruction
Teaching is mainly in Scandinavian languages and English, depending on the lecturer´s natural language. If there are participants unfamiliar with Scandinavian languages English is used as the course language.

Prerequisites
Admission to doctoral studies in physics or mathematics, or a Master's degree in physics or mathematics, or equivalent.

Learning Outcomes
The goal of the course is to introduce advanced methods and concepts which connect various areas of modern mathematics and modern quantum physics, in a way that makes them accessible to PhD students both in mathematics and in physics.

After completion of the course the student is expected to be able to

- give a detailed account of advanced aspects of the representation theory of finite groups;

- give an account of notions from the theory of vertex operator algebras, modular forms and Calabi-Yau manifolds;

- give an account of number theoretic aspects of conformal field theory;

- perform standard calculations on modular forms, representations of finite groups and integrable representations of Kac-Moody algebras;

- give an outline of the connections between the monster group, modular functions and structures in conformal field theory, as well as between Mathieu groups and K3 surfaves;

- interpret and critically scrutinize considerations in favor of such connections.

Course Content
The course is taught in the form of lectures, which are complemented by self-studies, together with a minor project.

The lectures treat the following topics, partially in a cursory manner:

- simple finite groups, in particular the sporadic groups, and their representation theory;

- Kac-Moody algebras and the Virasoro algebra and their integrable representations;

- vertex operator algebras;

- modular functions, modular forms, automorphic forms;

- superconformal field theory and elleiptic genus;

- Calabi-Yau manifolds, in particular K3 surfaves;

- "Monstrous moonshine": connections between the monster group, modular functions and conformal field theory;

- "Mathieu moonshine": connections between Mathieu groups and K3 surfaces.

Reading List
See separate document.

Examination
The examination of the course is done in the form of an oral exam, individual homework problems, as well as through a project and its oral presentation.

Grades
One of the grades Fail (U) or Pass (G) is awarded in the examination of the course.

Quality Assurance
The course convenor has a duty to encourage a continuous dialogue on learning processes and goal fulfilment. A written evaluation is carried out at the conclusion of the course combined with a joint student-teacher discussion of all aspects commented

on. The result of the evaluation is collated and made available in accordance with *The Higher Education* Ordinance, Chapter 1, § 14.

Course Certificate
Course certificate is issued on request.