Skoltech
Skolkovo Institute of Science and Technology

Course Syllabus

Course Title (in English)	Research seminar "Supersymmetric Gauge Theories and Integrable Systems"
Course Title (in Russian)	Научно-исследовательский семинар "Суперсимметричные калибровочные теории и интегрируемые системы"
Lead Instructor(s)	Gavrylenko, Pavlo Marshakov, Andrey

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1. Annotation

Course Description

This research seminar will be devoted to the study of N=2 supersymmetric gauge theories and related topics. It turns out that comparing to the N=1 theories, N=2 supersymmetry allows to compute much more quantities. In particular, low-energy effective action can be described in terms of single function, prepotential. Seiberg-Witten solution of the N=2 theory gives explicit description of the prepotential in terms of periods of some meromorphic differential on algebraic curve. It turns out that this description is deeply related to classical integrable systems.

This seminar is a continuation of the last year course on Seiberg-Witten theory. It will be devoted to some advanced topics based on Seiberg-Witten exact solution and on Nekrasov instanton computation in the 4D theory. We hope to cover such topics as 5D theories, qq-characters, exact quantization, etc.

There will be both lectures and talks given by the seminar participants.

Course Prerequisites / Recommendations	Seiberg-Witten exact solution, Nekrasov partition functions

Аннотация

Этот научно-исследовательский семинар будет посвящён изучению N=2 суперсимметричных калибровочных теорий и связанных сюжетов. Оказывается, что по сравнению с N=1 теориями, N=2 суперсимметрия позволяет значительно больше величин. В частности, низкоэнергетическое действие может быть выражено в терминах одной функции, препотенциала. Решение Заберга-Виттена N=2 теории даёт явное описание препотенциала в терминах периодов некоторого мероморфного дифференциала на алгебраической кривой. Оказывается, что это решение глубоко связано с классическими интегрируемыми системами.

Этот семинар является продолжением прошлогоднего курса по теории Зайберга-Виттена. Он будет посвящён некоторым продвинутым темам, основывающимся на точном решении Зайберга-Виттена и Некрасовском инстантонном вычислении в четырёхмерной теории. Мы надеемся рассмотреть такие темы как пятимерные теории, qq-характеры, точное квантование, и т.д.

Планируются как лекции, так и доклады участников семинара.

2. Structure and Content

Course Academic Level	Master-level course suitable for PhD students
Number of ECTS credits	6

Topic	Summary of Topic	Lectures (# of hours)	Seminars (# of hours)	Labs (# of hours)
AGT correspondence	Formulation of the AGT correspondence, identification of matrix elements in CFT with Nekrasov partition functions.			
Localization formulas and instanton partition functions	Various computations of integrals by localization. Instanton moduli spaces and Nekrasov partition functions, qq-characters.			

3. Assignments

Assignment Type	Assignment Summary
Presentation	To give a talk on some topic related to Seiberg-Witten theory
Other	To participate in the discussions during seminars, to understand what is going on

4. Grading

Type of Assessment Graded

Grade Structure

Activity Type	Activity weight, %
Attendance	70
Presentation	30

Grading Scale

A:	86
B:	76
C:	66
D:	56
E:	46
F:	0
Attendance Requirements	Mandatory with Exceptions

5. Basic Information

Course Stream Science, Technology and Engineering (STE)

Course Term (in context of Academic Year)
Term 1
Term 2

Students of Which Programs do You Recommend to Consider this Course as an Elective?

Masters Programs	PhD Programs
Mathematical and Theoretical Physics	Mathematics and Mechanics

Course Tags	Math Physics

6. Textbooks and Internet Resources

Papers	DOI or URL
L. Alvarez-Gaume, S.F. Hassan, Introduction to S-Duality in N=2 Supersymmetric Gauge Theory. (A pedagogical review of the work of Seiberg and Witten)	https://arxiv.org/abs/hep-th/9701069
Adel Bilal, Duality in N=2 SUSY SU(2) Yang-Mills Theory: A pedagogical introduction to the work of Seiberg and Witten	https://arxiv.org/abs/hep-th/9601007
Nikita A. Nekrasov, Seiberg-Witten Prepotential From Instanton Counting	https://arxiv.org/abs/hep-th/0206161
Nikita Nekrasov, Vasily Pestun, Seiberg-Witten geometry of four dimensional N=2 quiver gauge theories	https://arxiv.org/abs/1211.2240

7. Facilities

8. Learning Outcomes

Knowledge
Localization formulas, derivation of instanton partition functions, AGT correspondence

Skill
Ability to compute integrals over the instanton moduli spaces. Ability to perform free-field computations with screenings.

Experience
To prepare talks and to participate in the discussions

9. Assessment Criteria

Input or Upload Example(s) of Assigment 1:	
Select Assignment 1 Type	Presentation
Input Example(s) of Assignment 1 (preferable)	To give a talk on some topic related to Seiberg-Witten theory
Assessment Criteria for Assignment 1	At least one talk
Input or Upload Example(s) of Assigment 2:	
Select Assignment 2 Type	Other
Input Example(s) of Assignment 2 (preferable)	To participate in the discussions during seminars, to understand what is going on
Input or Upload Example(s) of Assigment 3:	
Input or Upload Example(s) of Assigment 4:	
Input or Upload Example(s) of Assigment 5:	

10. Additional Notes