Course Title (in English)	Supersymmetric gauge theories
Course Title (in Russian)	Суперсимметричные калибровочные теории
Lead Instructor(s)	Gavrylenko, Pavlo Marshakov, Andrei Yung, Alexei

Status of this Syllabus	The syllabus is a final draft waiting for form approval
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1. Annotation

Course Description	This course is an introduction to the supersymmetry, which is one of the main basic principles, being used both in field theory and in string theory. The main emphasis will be made on the consideration of dynamics of supersymmetric gauge field theories: in particular, at the non-perturbative level. Course starts from the introduction of the main concepts: supersymmetric algebra, its representations, chiral and vector multiplets. One will consider Wess-Zumino model and introduce superpotential. Then one will consider supersymmetric quantum electrodynamics, discuss supersymmetric Higgs mechanism and Higgs branches. One will consider in detail supersymmetric quantum chromodynamics. Its vacuum structure at the classical level will be discussed. Then one will introduce instantons and explain how they change vacuum structure by generating Affleck-Dine-Seiberg superpotential. Finally we will consider Seiberg duality.
Course Prerequisites	Knowledge of quantum mechanics and classical field theory. Basic knowledge of quantum field theory.

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)
Supersymmetry algebra	Spinor representations of the Lorentz group. Super-generalization of the Poincare algebra. Supersymmetry algebras in four dimensions. Vanishing of the vacuum energy. Fermion-boson degeneration. Construction of the supermultiplets.	1	4	
Superfields	Superspace. Super-transformation of coordinates of the superspace. Representations of the supersymmetry algebra. Chiral superfields. Super-transformations of the components of the superfields.	1	4	
Supersymmetric action for the chiral supermultiplet	Rules of the Grassmannian integration. Kinetic term for the chiral superfields. Wess-Zumino model. Superpotential. Component form of the action. R-symmetry. Non-renormalization of the F-terms.	1	4	
Gauge fields	Gauge transformations. Vector superfields. Wess-Zumino gauge. Action for the Abelian vector superfield. Component form of the action. Super-transformations of components of the vector supermultiplet.	1	4	
Supersymmetric QED	N=1 supersymmetric QED. Scalar potential. F- and D-terms. Fayet-Iliopoulos term. R-symmetry.	1	4	
Spontaneous symmetry breaking	Supersymmetric Higgs mechanism. Higgs branches. Low-energy sigma-model on the Higgs branch. Kähler potential.	1	4	
Spontaneous supersymmetry breaking	O'Raifeartaigh mechanism. Fayet-Iliopoulos mechanism. Goldstino.	1	4	
Non-abelian supersymmetric gauge theories	Gauge sector. Matter sector. Supersymmetric QCD. Higgs branch at the classical level. Renormalization of the coupling constant. R-charge and anomalies. Non-anomalous U(1) symmetry. Konishi anomaly.	1	4	
Instantons in supersymmetric QCD	Instantons in SU(2) gauge sector. Fermionic zero modes. ‘t Hooft instanton. Instantons in supersymmetric QCD with single flavor. Zero modes and collective coordinates. Non-zero modes and instanton measure. Effective Lagrangian.	1	4	
Non-perturbative dynamics in N=1 supersymmetric QCD	Affleck-Dine-Seiberg superpotential. Inclusion of the quark masses. Generalization to arbitrary number of colors and flavors. Gluino condensate in the Yang-Mills theory without matter. N_f=N_c case.	1	4	
Seiberg duality	Dualities in gauge theories. Dual quarks and M-meson. Anomaly matching. Conformal window. Non-Abelian Coulomb phase.	1	4	

3. Assignments

Assignment Type	Assignment Summary
Homework	

4. Grading

Type of Assessment	Graded

Grade Structure	Activity Type	Activity weight, %
	Attendance	50
	Homework Assignments	50

A:	Grading Scale
B:	86
C:	76
D:	66
E:	56
F:	46

0

5. Basic Information

Attendance Requirements	Mandatory with Exceptions

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 Physics

Course Tags	Math Physics

6. Textbooks and Internet Resources

7. Facilities

8. Learning Outcomes

Do you want to specify outcomes in another framework?	Knowledge-Skill-Experience is good enough

9. Assessment Criteria

10. Additional Notes