VII School on Geometry and Physics

25 June — 29 June 2018

1. **Alexander HELEMSKII** — *Moscow State University, Russia*

   Amenability, Flatness and Measure Algebras

   One of most known applications of the homological algebra to functional analysis is the positive answer to the following old conjecture: is it true that for an amenable measure algebra $M(G)$ the respective group G must be discrete? We shall formulate such a theorem, explain its ingredients, discuss it, compare it with some other results, and give its detailed proof. We hope that the argument, being an interplay of various ideas and methods of algebra and analysis, will be interesting and instructive to young researchers. It involves the basic homological algebra in its functional-analytic version (notably the notion of a flat Banach module), classical functional analysis (in particular, properties of the weak* topology in the second dual of a Banach space) and, finally, the presence of some exotic measurable subsets in a given non-discrete locally compact group.

2. **Gabriel LAROTONDA** — *Consejo Nacional de Investigaciones Cientificas y Técnicas (CONICET), Argentina*

   Functional Analysis techniques in Optimization and Metrization problems

   In the context of infinite dimensional Lie groups (and their homogeneous spaces, such as Grassmannians or positive operators) it is not uncommon to find natural optimization problems posed in terms of tangent metrics, or Lagrangians, that are not necessarily Riemannian. Therefore the task of finding and characterizing optimal paths (minimizers of the Lagrangian) must be approached using functional analysis techniques that include -but are not limited to- convex analysis, operator inequalities, and representation theory. In this short course we will give an introduction to this rich subject that intertwines functional analysis, differential geometry and operator theory. We will go through some general tools of the theory and explore relevant examples of the literature.

3. **Bogdan MIELNIK** — *CINVESTAV, Mexico*

   The unreasonable effectiveness of mathematics (E. Wigner), blessing or disaster?

4. **Armen SERGEEV** — *Steklov Mathematical Institute, Russia*

   Twistor Geometry and Gauge Fields

   The main goal of this course is to present the basics of twistor theory and its applications to the solution of equations of gauge theory such as selfdual Yang–Mills equations. The first part of the course, devoted to the twistor theory, starts from the construction of the twistor model of Minkowsky space. Then we turn to the study of the twistor correspondence between geometric objects in Minkowsky space and their twistor counterparts. We pay attention also to the Klein model of Minkowsky space in which this space is identified with a quadric in the 5-dimensional complex projective space $\mathbb{CP}^5$. In the second part of the course we apply twistor theory to the study of gauge field equations. As a first example we consider the Yang-Mills duality equations in the Euclidean space $\mathbb{R}^4$ and their solutions called instantons. Atiyah–Ward theorem gives a twistor interpretation of instantons and ADHM (Atiyah–Drinfeld–Hitchin–Manin) construction, based on this theorem, yields a complete description of the moduli space of instantons. The

next example is provided by the monopole equations in $\mathbb{R}^3$ otherwise called the Bogomolny-Prasad equations. Their twistor interpretation was proposed by Nahm. At last we turn to the 2-dimensional models which are represented by the Yang–Mills–Higgs equations in $\mathbb{R}^2$ and Hitchin equations on Riemann surfaces. The moduli space of solutions of selfdual Yang–Mills–Higgs equations is completely described by the theorem of Taubes. All considered equations have a deep physical meaning and their study is important both for mathematicians and physicists.

5. **Adam SKALSKI** — *Polish Academy of Sciences, Poland*

   Quantum Dirichlet forms and their recent applications

   We will discuss the notion of classical Dirichlet forms, quadratic forms giving rise to Markov semigroups on the spaces of the form $L^2(X, \mu)$, and its quantum generalizations, defined in terms of von Neumann algebras. Some very recent applications of such quantum Dirichlet forms will be presented and further directions of research outlined.

   Plan of the lectures:

Lecture 1 **C_0-semigroups of operators and classical Dirichlet forms**: C_0-semigroups of operators and their generators; quadratic forms; Choquet–Deny conditions; some examples.

Lecture 2 **Quantum Dirichlet forms**: noncommutative L^p-spaces (tracial and nontracial case); quantum Markov semigroups; noncommutative Choquet–Deny conditions.

Lecture 3 **Recent applications and perspectives**: Haagerup property for von Neumann algebras; quantum convolution semigroups; open problems.

The lectures should be accessible to the audience having a general functional analytic background and some knowledge of operator algebras.

6. **Nikolai TYURIN** — *Bogoliubov Laboratory of Theoretical Physics / High School of Economics, Russia*

   Lagrangian approach in Geometric Quantization

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Monday, June 25

LECTURES 09:30–12:40

09:30–10:20 *Amenability, Flatness and Measure Algebras*
Alexander HELEMSKII, Moscow State University, Russia

10:20–10:50 Coffee break

10:50–11:40 *Quantum Dirichlet forms and their recent applications*
Adam SKALSKI, Polish Academy of Sciences, Poland

11:50–12:40 *Functional Analysis techniques in Optimization and Metrization problems*
Gabriel LAROTONDA, Consejo Nacional de Investigaciones Cientificas y Técnicas (CONICET), Argentina

Tuesday, June 26

LECTURES 09:30–12:40

09:30–10:20 *Functional Analysis techniques in Optimization and Metrization problems*
Gabriel LAROTONDA, Consejo Nacional de Investigaciones Cientificas y Técnicas (CONICET), Argentina

10:20–10:50 Coffee break

10:50–11:40 *Amenability, Flatness and Measure Algebras*
Alexander HELEMSKII, Moscow State University, Russia

11:50–12:40 *Quantum Dirichlet forms and their recent applications*
Adam SKALSKI, Polish Academy of Sciences, Poland

Wednesday, June 27

LECTURES 09:30–12:40

09:30–10:20 *Twistor Geometry and Gauge Fields*
Armen SERGEEV, Steklov Mathematical Institute, Russia

10:20–10:50 Coffee break

10:50–11:40 *Lagrangian approach in Geometric Quantization*
Nikolai TYURIN, Bogoliubov Laboratory of Theoretical Physics / High School of Economics, Russia

11:50–12:40 *Amenability, Flatness and Measure Algebras*
Alexander HELEMSKII, Moscow State University, Russia

Thursday, June 28

LECTURES 09:00–13:10

09:00–09:50 *Twistor Geometry and Gauge Fields*
Armen SERGEEV, Steklov Mathematical Institute, Russia

10:00–10:50 *Quantum Dirichlet forms and their recent applications*
Adam SKALSKI, Polish Academy of Sciences, Poland

10:50–11:20 Coffee break

11:20–12:10 *Lagrangian approach in Geometric Quantization*
Nikolai TYURIN, Bogoliubov Laboratory of Theoretical Physics / High School of Economics, Russia

12:20–13:10 *The unreasonable effectiveness of mathematics (E. Wigner), blessing or disaster?*
Bogdan MIELNIK, CINVESTAV, Mexico

Friday, June 29

LECTURES 09:30–12:40

09:30–10:20 *Lagrangian approach in Geometric Quantization*
Nikolai TYURIN, Bogoliubov Laboratory of Theoretical Physics / High School of Economics, Russia

10:20–10:50 Coffee break

10:50–11:40 *Functional Analysis techniques in Optimization and Metrization problems*
Gabriel LAROTONDA, Consejo Nacional de Investigaciones Cientificas y Técnicas (CONICET), Argentina

11:50–12:40 *Twistor Geometry and Gauge Fields*
Armen SERGEEV, Steklov Mathematical Institute, Russia