Integrable Systems and Algebraic Geometry

dedicated to the memory of Igor Krichever (1950–2022)

北京雁栖湖
应用数学研究院

Beijing Institute
of Mathematical
Sciences and Applications

BMPSW-24: Beijing Summer Workshop in Mathematics and Mathematical Physics

(June 24 – July 5, 2024)

Conference Program (Times slots are in the Beijing Time Zone; UTC+8)

Monday, June 24

8:45-9:00	*Shing-Tung YAU*	**Welcome address**
9:00–10:30	*Samuel GRUSHEVSKY*	**Integrable systems approach to the Schottky problem and related questions (1/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Pavel ETINGOF*	**The Hitchin System and its Quantization (1/5)**
12:30–14:00	Lunch	
14:00–15:00	*Mikhail BERSHTEIN*	**Chiralization of cluster structures**
15:00–16:00	*Thomas BOTHNER*	**What is . . . a Riemann–Hilbert problem? (online)**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
17:30–18:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Tuesday, June 25

9:00–10:30	*Samuel GRUSHEVSKY*	**Integrable systems approach to the Schottky problem and related questions (2/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Pavel ETINGOF*	**The Hitchin System and its Quantization (2/5)**
12:30–14:00	Lunch	
14:00–15:00	*Anton ZABRODIN*	**Deformed Ruijsenaars–Schneider model: integrability and time discretization**
15:00–16:00	*Henry LIU*	**Invariance of elliptic genus under wall-crossing**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
17:30–18:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Wednesday, June 26

9:00–10:30	*Samuel GRUSHEVSKY*	**Integrable systems approach to the Schottky problem and related questions (3/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Pavel ETINGOF*	**The Hitchin System and its Quantization (3/5)**
12:30–14:00	Lunch	
14:00–18:30	Excursion	**Mutianyu Great Wall**
18:30–19:30	Dinner	

Thursday, June 27

9:00–10:30	*Samuel GRUSHEVSKY*	**Integrable systems approach to the Schottky problem and related questions (4/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Pavel ETINGOF*	**The Hitchin System and its Quantization (4/5)**
12:30–14:00	Lunch	
14:00–15:00	*Alexei BORODIN*	**Geometry of dimer models**
15:00–16:00	*Alexander BOBENKO*	**Dimers and M-curves (online)**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
17:30–18:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Friday, June 28

9:00–10:30	*Samuel GRUSHEVSKY*	**Integrable systems approach to the Schottky problem and related questions (5/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Pavel ETINGOF*	**The Hitchin System and its Quantization (5/5)**
12:30–14:00	Lunch	
14:00–15:00	*Youjin ZHANG*	**Bihamiltonian integrable systems and their classification**
15:00–16:00	*Ekaterina EREMENKO*	**Movie: Solving the Bonnet Problem**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
17:30–18:30	A6-1(SG) and A7-1(PE)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Saturday, June 29

Free day. Talk to the organizers about possible sightseeing and other activities.

Sunday, June 30

9:00–10:30	*Andrei OKOUNKOV*	**From elliptic genera to elliptic quantum groups (1/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Nikita NEKRASOV*	**Integrable many-body systems and gauge theories (1/5)**
12:30–14:00	Lunch	
14:00–15:00	*Sergei LANDO*	**Weight systems associated to Lie algebras**
15:00–16:00	*Senya SHLOSMAN*	**Pedestals matrices: Polynomial matrices with polynomial eigenvalues**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
17:30–18:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Monday, July 1

9:00–10:30	*Andrei OKOUNKOV*	**From elliptic genera to elliptic quantum groups (2/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Nikita NEKRASOV*	**Integrable many-body systems and gauge theories (2/5)**
12:30–14:00	Lunch	
14:00–15:00	*Ivan CHEREDNIK*	**Q-zeta revisited**
15:00–16:00	*Alexander BRAVERMAN*	**Introduction to symplectic duality and Coulomb branches of $3d$ quantum field theories (online)**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
17:30–18:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Tuesday, July 2 *(Igor Krichever's Day)*

9:00–9:30		**Opening Remarks**
9:30–10:30	*Paul WIEGMANN*	**Peierls phenomenon via Bethe Ansatz: reflection of Krichever's works on Peierls model**
10:30–11:00	Coffee Break	
11:00–12:30	*Andrei MARSHAKOV*	**Krichever tau-function: basics and perspectives**
12:30–14:00	Lunch	
14:00–15:00	*Alexander VESELOV*	**Harmonic locus and Calogero–Moser spaces**
15:00–16:00	*Stanislav SMIRNOV*	**Coulomb gas and lattice models**
16:00–16:30	Coffee Break	
16:30–17:30	*Grigori OLSHANSKI*	**Macdonald-level extension of beta ensembles and multivariate hypergeometric polynomials (online)**
18:00–20:00	Banquet	***Celebrating Igor Krichever's Legacy***

Wednesday, July 3

9:00–10:30	*Andrei OKOUNKOV*	**From elliptic genera to elliptic quantum groups (3/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Nikita NEKRASOV*	**Integrable many-body systems and gauge theories (3/5)**
12:30–14:00	Lunch	
14:00–15:00	*Da-jun ZHANG*	**Elliptic solitons related to the Lamé functions**
15:00–16:00	*Anton DZHAMAY*	**Geometry and Symmetry of Painlevé Equations**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
17:30–18:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Thursday, July 4

9:00–10:30	*Andrei OKOUNKOV*	**From elliptic genera to elliptic quantum groups (4/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Nikita NEKRASOV*	**Integrable many-body systems and gauge theories (4/5)**
12:30–14:00	Lunch	
14:00–16:00	*Ekaterina EREMENKO*	**Movie: Colors of Math. Q&A with the director**
16:00–16:30	Coffee Break	
16:30–17:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
17:30–18:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
18:30–19:30	Dinner	

Friday, July 5

9:00–10:30	*Andrei OKOUNKOV*	**From elliptic genera to elliptic quantum groups (5/5)**
10:30–11:00	Coffee Break	
11:00–12:30	*Nikita NEKRASOV*	**Integrable many-body systems and gauge theories (5/5)**
12:30–14:00	Lunch	
14:30–15:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
15:30–16:30	A6-1(AO) and A7-1(NN)	**Exercise and discussion sessions**
16:00–16:30	Coffee Break	
16:30–17:00		**Closing Remarks**
17:00–18:30		**Free Time**
18:30–19:30	Dinner	

Description of Mini-Courses

(1) *Pavel ETINGOF* (Massachusetts Institute of Technology, USA)

Title: The Hitchin System and its Quantization

Abstract: Let G be a simple complex Lie group. I will review the classical Hitchin integrable system on the cotangent bundle to the moduli space $\mathrm{Bun}_G(X)$ of principal G-bundles on a smooth complex projective curve X (possibly with punctures), as well as its quantization by Beilinson and Drinfeld using the loop group LG. I will explain how this system unifies many important integrable systems, such as Toda, Calogero–Moser, and Gaudin systems. Then I'll discuss opers (for the dual group $G^\vee$), which parametrize the (algebraic) spectrum of the quantum Hitchin system. Finally, I will discuss the analytic problem of defining and computing the spectrum of the quantum Hitchin system on the Hilbert space $L^2(\mathrm{Bun}_G(X))$, and will show that (modulo some conjectures, known in genus 0 and 1) this spectrum is discrete and parametrized by opers with real monodromy. Moreover, we will see that the quantum Hitchin system commutes with certain mutually commuting compact integral operators $H_{x,V}$ called Hecke operators (depending on a point $x \in X$ and a representation V of $G^\vee$), whose eigenvalues on the quantum Hitchin eigenfunction ψ_L corresponding to a real oper L are real analytic solutions $\beta(x, \overline{x})$ of certain differential equations $D\beta = 0$, $\overline{D}\beta = 0$ associated to L and V. This constitutes the analytic Langlands correspondence, developed in my papers with E. Frenkel and Kazhdan following previous work by Braverman-Kazhdan, Kontsevich, Langlands, Nekrasov, Teschner, and others. I will review the analytic Langlands correspondence and explain how it is connected with arithmetic and geometric Langlands correspondence.

(2) *Samuel GRUSHEVSKY* (Simons Center for Geometry and Physics, Stony Brook University, USA)

Title: Integrable systems approach to the Schottky problem and related questions

Abstract: We will review the integrable systems approach to the classical Schottky problem of characterizing Jacobians of Riemann surfaces among all principally polarized complex abelian varieties. Starting with the Krichever's construction of the spectral curve from a pair of commuting differential operators, we will proceed to show that theta functions of Jacobians satisfy the KP hierarchy, and will review Novikov's conjecture (proven by Shiota) solving the Schottky problem by the KP equation. We will finally discuss some of the motivation for Krichever's proof of Welters' trisecant conjecture, and related characterizations for Prym varieties.

(3) *Nikita NEKRASOV* (Simons Center for Geometry and Physics, Stony Brook University, USA)

Title: Integrable many-body systems and gauge theories

Abstract: Elliptic Calogero–Moser and Toda systems, Gaudin and other spin chains are algebraic integrable systems which have intimate connections to gauge theories in two, three, and four dimensions. I will explain two such connections: first, classical, through Hamiltonian reduction and second, quantum, through dualities of supersymmetric gauge theories.

(4) *Andrei OKOUNKOV* (Columbia University, USA)

Title: From elliptic genera to elliptic quantum groups

Abstract: This course will be an example-based introduction to elliptic cohomology, Krichever elliptic genera, rigidity, and related topics. We will work our way towards the geometric construction of elliptic quantum groups.

Research Talk Abstracts

(1) *Mikhail BERSHTEIN* (The University of Edinburgh, UK)

Title: Chiralization of cluster structures

Abstract: The chiralization in the title denotes a certain procedure which turns cluster X-varieties into q-W algebras. Many important notions from cluster and q-W worlds, such as mutations, global functions, screening operators, R-matrices, etc. emerge naturally in this context. In particular, we discover new bosonizations of q-W algebras and establish connections between previously known bosonizations. If time permits, I will discuss potential applications of our approach to the study of 3d topological theories and local systems with affine gauge groups. This talk is based on a joint project with J. Shiraishi, J.E. Bourgine, B. Feigin, A. Shapiro, and G. Schrader.

(2) *Alexander BOBENKO* (Technische Universität Berlin, Germany)

Title: Dimers and M-curves (*online*)

Abstract: We develop a general approach to dimer models analogous to Krichever's scheme in the theory of integrable systems. This leads to dimer models on doubly periodic bipartite graphs with quasiperiodic positive weights. Dimer models with periodic weights and Harnack curves are recovered as a special case. This generalization from Harnack curves to general M-curves, which are in the focus of our approach, leads to transparent algebro-geometric structures. In particular, the Ronkin function and surface tension are expressed as integrals of meromorphic differentials on M-curves. Based on Schottky uniformization of Riemann surfaces, we compute the weights and dimer configurations. The computational results are in complete agreement with the theoretical predictions. The talk is based on joint works with N. Bobenko and Yu. Suris.

(3) *Alexei BORODIN* (Massachusetts Institute of Technology, USA)

Title: Geometry of dimer models

Abstract: Random dimer coverings of large planar graphs are known to exhibit unusual and visually apparent asymptotic phenomena that include formation of frozen regions and various phases in the unfrozen ones. For a specific family of subgraphs of the (periodically weighted) square lattice known as the Aztec diamonds, the asymptotic behavior of dimers admits a precise description in terms of geometry of underlying Riemann surfaces. The goal of the talk is to explain how the surface structure manifests itself through the statistics of dimers. Based on joint works with T. Berggren and M. Duits.

(4) *Thomas BOTHNER* (University of Bristol, UK)

Title: What is . . . a Riemann–Hilbert problem? (*online*)

Abstract: In its classical setting, the Riemann–Hilbert problem refers to Hilbert's 21st problem of constructing a Fuchsian ODE system with prescribed poles and a given monodromy group. Using singular integral equation techniques, Plemelj presented a solution to this problem in 1908 which became widely accepted. However, Kohn, Arnold and Il'yashenko noticed in the mid 1980s that Plemelj had actually worked on a problem similar to Hilbert's 21st for so-called regular ODE systems rather than Fuchsian ones. These new investigations resulted eventually in a negative answer to Hilbert's original problem given by Bolibruch in 1989 with further developments by Bolibruch and Kostov soon after.

Tangentially to the solution of Hilbert's classical problem, the singular integral equation techniques used therein, a.k.a. analytic factorizations of given functions defined on curves, gave rise to a class of modern Riemann–Hilbert factorization problems. In fact nowadays we view such problems as part of a broad analytical toolbox that is useful in the analysis of problems in mathematics and physics, for instance the Wiener-Hopf methods in hydrodynamics and diffraction. The goal of this talk is to first review some facts of the classical Riemann–Hilbert theory and then present a few recent developments of its modern counterpart. Special attention in the second part will be given to matrix- and operator-valued Riemann–Hilbert problems that arise in random matrix theory and integrable probability.

(5) *Alexander BRAVERMAN* (University of Toronto, Canada)

Title: Mathematical introduction to Coulomb branches of 3d $N = 4$ SUSY quantum field theories (*online*)

Abstract: I will give a survey of the series of my joint works with Finkelberg and Nakajima giving a mathematical construction of the so called Coulomb branches of 3D $N = 4$ super-symmetric gauge theories (no knowledge of any of these words will be needed). I will also explain its connection with the (purely mathematical subject) of symplectic duality.

(6) *Ivan CHEREDNIK* (University of North Carolina, USA)

Title: Q-zeta revisited

Abstract:The fundamental feature of practically all zeta-functions and L-functions is that their meromorphic continuations to complex s provide a lot of information about the corresponding objects. However, complex values of s have generally no direct arithmetic/geometric meaning, and occur as a powerful technical tool. We will discuss the refined theory, which is basically the replacement of the terms $1/n^s$ by the invariants of lens space $L(n, 1)$, certain q, t, a-series. One of their key properties is the super-duality $q \leftrightarrow t^{-1}$, which is related to the functional equation of the Hasse–Weil zetas for curves, the symmetry $\epsilon_1 \leftrightarrow \epsilon_2$ of Nekrasov's instantons and to other refined theories in mathematics and physics. These invariants have various specializations, including Rogers–Ramanujan identities and the topological vertex. We will begin the talk with the Riemann q-hypothesis in type A_1, in full detail.

(7) *Anton DZHAMAY* (BIMSA, China and The University of Northern Colorado, USA)

Title: Geometry and Symmetry of Painlevé Equations

Abstract: We begin by an overview of how geometric ideas entered the theory of differential Painlevé equations in the work of of K. Okamoto, which led to the better understanding of their symmetries (Bäcklund transformations) in terms of affine Weyl groups. These ideas were then extended by H. Sakai to the discrete (elliptic, multiplicative, and additive) Painlevé equations and resulted in the beautiful Sakai classification scheme for both differential and discrete Painlevé equations. In the latter case, it is the symmetry group that is the source of a discrete dynamics.

In the second part of the talk we discuss the notion of an abstract discrete Painlevé equation and its various concrete realizations. This leads to the study of a refined identification problem, which is a classification of different orbits for the same abstract discrete Painlevé dynamic, and results in the appearance of special symmetry groups that are not a part of the general (i.e., generic) Sakai classification scheme. We illustrate this by an example of a discrete Painlevé-II equation and its symmetry group. This is based on a joint work with Yang Shi, Alex Stokes, and Ralph Willox.

(8) *Sergei LANDO* (HSE University and Krichever Center for Advanced Studies, Russia)

Title: Weight systems associated to Lie algebras

Abstract: V. A. Vassiliev's theory of finite type knot invariants allows one to associate to such an invariant a function on chord diagrams, which are simple combinatorial objects, consisting of an oriented circle and a tuple of chords with pairwise distinct ends in it. Such functions are called "weight systems". According to a Kontsevich theorem, such a correspondence is essentially one-to-one: each weight system determines a certain knot invariant.

In particular, a weight system can be associated to any semi-simple Lie algebra. However, already in the simplest nontrivial case, the one for the Lie algebra $\mathrm{sl}(2)$, computation of the values of the corresponding weight system is a computationally complicated task. This weight system is of great importance, however, since it corresponds to a famous knot invariant known as the colored Jones polynomial.

Last few years was a period of significant progress in understanding and computing Lie algebra weight systems, both for $\mathrm{sl}(2)$- and $\mathrm{gl}(N)$-weight system, for arbitrary N. These methods are based on an idea, due to M. Kazarian, which suggests a recurrence for $\mathrm{gl}(N)$-weight system extended to permutations. The recurrence immediately leads to a construction of a universal gl-weight system taking values in the ring of polynomials $\mathbf{C}[N, C_1, C_2, C_3, \dots]$ in infinitely many variables and allowing for a specialization to $\mathrm{gl}(N)$- and $\mathrm{sl}(N)$-weight systems for any given value of N. A lot of new explicit formulas were obtained.

Simultaneously, Zhuoke Yang extended the construction to the Lie superalgebras $\mathrm{gl}(N|M)$, and, together with M. Kazarian, to other classical series of Lie algebras. It happened that certain specializations of the universal gl-weight system lead to well-known combinatorial invariants of graphs, allowing thus to extend these invariants to permutations.

Certain integrability properties of the Lie algebra weight systems will be discussed.

The talk is based on work of M. Kazarian, the speaker, and N. Kodaneva, P. Zakorko, Zhuoke Yang, and P. Zinova.

(9) *Henry LIU* (Kavli IPMU, Japan)

Title: Invariance of elliptic genus under wall-crossing

Abstract: Elliptic genus, and its various generalizations, is one of the simplest numerical invariants of a scheme that one can consider in elliptic cohomology. I will present a topological condition which implies that elliptic genus is invariant under wall-crossing. It is related to Krichever–Höhn's elliptic rigidity. Many applications are possible; I will focus on elliptic Donaldson–Thomas theory for this talk.

(10) *Andrei MARSHAKOV* (Krichever Center for Advanced Studies, Russia)

Title: Krichever tau-function: basics and perspectives

Abstract: I plan to start with the definition of quasiclassical tau-function, introduced by Igor Krichever in 1992, formulate its main properties with some simple proofs, and discuss certain particular cases, which include the Seiberg–Witten prepotentials, matrix models etc. Then I am going to turn to certain modern developments, related with this object, which include the relation with instanton partition functions, isomonodromic tau-dunctions and even some unexpected relations with other famous relations in mathematical physics.

(11) *Grigori OLSHANSKI* (Krichever Center for Advanced Studies and HSE University, Russia)

Title: Macdonald-level extension of beta ensembles and multivariate hypergeometric polynomials (*online*)

Abstract: A beta ensemble (or log-gas system) on the real line is a random collection of N point particles $x_1, \dots, x_N$ whose joint probability distribution has a special form containing the Vandermonde raised to the power $\beta > 0$. I will survey results related to some discrete analogs of beta ensembles, which live on q-lattices, and large-N limit transitions.

(12) *Senya SHLOSMAN* (Krichever Center for Advanced Studies, Russia and BIMSA, China)

Title: Pedestals matrices: Polynomial matrices with polynomial eigenvalues

Abstract: I will explain a construction which for every finite poset X (such as a Young diagram) produces a square matrix M^X . Its matrix elements are indexed by pairs P, Q of linear orders on X (pairs of standard tableaux in case of Young diagrams). The entries of M^X are monomials in variables x_i . Our main result is that the eigenvalues of M^X are polynimials in x_i with integer coefficients. Joint work with Richard Kenyon, Maxim Kontsevich, Oleg Ogievetsky, Cosmin Pohoata and Will Sawin.

(13) *Alexander VESELOV* (Loughborough University, UK)

Title: Harmonic locus and Calogero–Moser spaces

Abstract: The harmonic locus consists of the monodromy-free Schroedinger operators with rational potential quadratically growing at infinity. It is known after Duistermaat and Grünbaum that in the multiplicity-free case the poles $z_1, \dots, z_N$ of such potentials satisfy the following algebraic system

$$\sum_{j\neq i}^{N} \frac{2}{(z_i - z_j)^3} - z_i = 0,\ i = 1, \dots, N,$$

describing the complex equilibriums of the corresponding Calogero–Moser system. Oblomkov proved that the harmonic locus can be identified with the set of all partitions via Wronskian map for Hermite polynomials.

We show that the harmonic locus can also be identified with the subset of the Calogero–Moser spaces introduced by Wilson, which is invariant under a natural symplectic action of $\mathbb{C}^\times$. As a corollary, for the multiplicity-free part of the locus we effectively solve the inverse problem for the Wronskian map by proving that the spectrum of Moser's matrix coincides with the set of contents of the corresponding Young diagram. We also compute the characters of the $\mathbb{C}^\times$-action at the fixed points, proving a conjecture of Conti and Masoero.

The talk is based on a joint work with Giovanni Felder.

(14) *Paul WIEGMANN* ((University of Chicago, USA and BIMSA, China)

Title: Peierls phenomenon via Bethe Ansatz: reflection of Krichever's works on Peierls model

Abstract: In the 1930s Rudolf Peierls argued that the one-dimensional electrons interacting with phonons undergo an instability, leading to the formation of a periodic structure known as an electronic crystal. Peierls's instability stands in a short list of major phenomena of condensed matter physics.

From a mathematical perspective, a comprehensive solution to the Peierls problem was given in papers by Igor Krichever and co-authored by Natasha Kirova, Sergei Brazovski, and Igor Dzyaloshinsky In the early 80's. It was found that electronic crystals are periodic solutions of soliton equations, falling within the framework of Krichever-Novikov's theory of finite-gap potentials.

The Peierls phenomenon also emerges as a limiting case of models of interacting fermions, such as Gross–Neveu models with a large rank symmetry group when the rank of the group tends to infinity. These models are solvable by the Bethe Ansatz for finite rank groups. The talk presents the result of a recent paper co-authored by Konstantin Zarembo, Valdemar Melin, and Yoko Sekiguchi, where Krichever's finite-gaps solutions of soliton equations were obtained as a singular large rank limit of the Bethe Ansatz solution of models with Lie group symmetry.

(15) *Anton ZABRODIN* (Krichever Center for Advanced Studies, Russia)

Title: Deformed Ruijsenaars–Schneider model: integrability and time discretization

Abstract: We will discuss the recently introduced deformed Ruijsenaars–Schneider (RS) many-body system. One the one hand, it is the dynamical system for poles of elliptic solutions to the Toda lattice with constraint of type B. On the other hand, equations of motion for this system coincide with those for pairs of RS particles which stick together preserving a special fixed distance between the particles. We prove integrability of the deformed RS system by finding the integrals of motion explicitly. We also obtain Backlund transformations and integrable time discretization of the deformed RS system.

(16) *Da-jun ZHANG* (Shanghai University, China)

Title: Elliptic solitons related to the Lamé functions

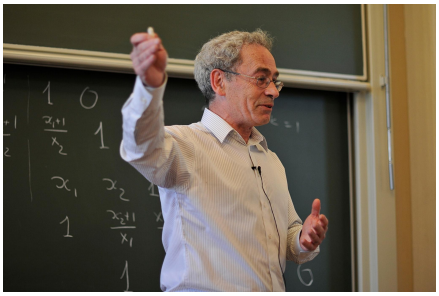
Abstract: In this talk I will report recent progress on the elliptic solitons related to the Lamé functions. Apart from the classical solitons that are composed by usual exponential type plane wave factors, there exist "elliptic solitons" which are composed by the Lamé-type plane wave factors and expressed using Weierstrass functions. Recently, we found vertex operators to generate tau functions for such type of solitons. We also established an elliptic scheme of direct linearization approach.

(17) *Youjin ZHANG* (Tsinghua University, China)

Title: Bihamiltonian integrable systems and their classification

Abstract: Bihamiltonian structure plays an important role in the theory of integrable systems. For a system of evolutionary PDEs with one spatial variable which possesses a bihamiltonian structure, one is able to find, under a certain appropriate condition, infinitely many conservation laws of the system from the bihamiltonian recursion relation and to arrive at its integrability. In the case when the bihamiltonian structure of the system of evolutionary PDEs possesses a hydrodynamic limit, one can further obtain from it a flat pencil of metrics, and relate it to Frobenius manifold structures or their generalizations under a certain condition, such a relationship may help one to find applications of the integrable system in different research areas of mathematical physics. In this talk, we will recall the notion of bihamiltonian integrable systems, explain their relationship with Frobenius manifold structures or their generalizations, and review the results on the classification of bihamiltonian integrable hierarchies which possess semisimple hydrodynamic limits.

Igor Krichever (October 15, 1950 – December 1, 2022)



Igor Krichever was a leading researcher in Mathematics and Mathematical Physics with many profound contributions to algebraic geometry, quantum integrable models, statistical physics, condensed matter theory, string theory, and especially to the theory of soliton equations and the interaction between the theory of integrable systems and algebraic geometry. Igor's work has been recognized by the prize of the Mathematical Section of USSR Academy of Sciences in 1990. Igor was a Speaker at the 1990 and 2022 International Congresses of Mathematicians and gave a Plenary Talk at the ICMP-2003 in Lisbon.

Igor was a talented administrator. He contributed to the development of the Department of Mathematics at Columbia University and served as its Chair in 2008–2011. Igor founded the Center of Advanced Studies at Skoltech. This Center now bears his name. But above all, Igor was a wonderful human being who is greatly missed.

Among Igor's main scientific achievements are

(1) General algebraic-geometrical construction of exact periodic and quasi-periodic solutions of non-linear integrable systems of the soliton theory.
(2) Solution of the classification problem of commuting ordinary differential operators. Effectivization of the results of twenties on the classification of such operators of co-prime orders.
(3) Application of the algebraic-geometrical methods of soliton theory for the problems of the solid state physics. Solution of the Peierls model and investigation of its perturbation.
(4) Construction of Floque spectral theory of periodic two-dimensional operators. The proof with its help the density of finite-gap solutions of the KP-2 equation in the space of all periodic solutions.
(5) Construction of the algebraic-geometrical perturbation theory for two-dimensional integrable systems. Construction of the exact solutions of the Whitham equations.
(6) Construction (with S.P.Novikov) theory of operator quantization of closed bosonic strings; Fourier–Laurent theory on Riemann surfaces of arbitrary genus; generalization of the Virasoro, Heisenberg and Kac–Moody algebras.
(7) Application of the Baker–Akhiezer functions for Atiyah–Hirzerbruch rigidity problem for multiplicative genera of manifolds. The proof with the help of methods of formal groups the rigidity property for the generalized elliptic genus for manifolds with zero first Chern class.
(8) The introduction of the tau-function for the universal Whitham hierarchy and a proof that this function coincides with the partition function of the topological field theory models. A proof that the tau-function of the dispersionless 2D Toda hierarchy is a generating function for conformal map of a simply-connected domain bounded bounded by smoooth curve.
(9) A construction of universal Hamiltonian approach to the soliton equations and construction of the action-angle variables.
(10) A theory of zero-curvature and isomonodromy equations on algebraic curves.
(11) Proof of Welter's trisecant conjecture, and solution of characterization problem for Prym varieties.

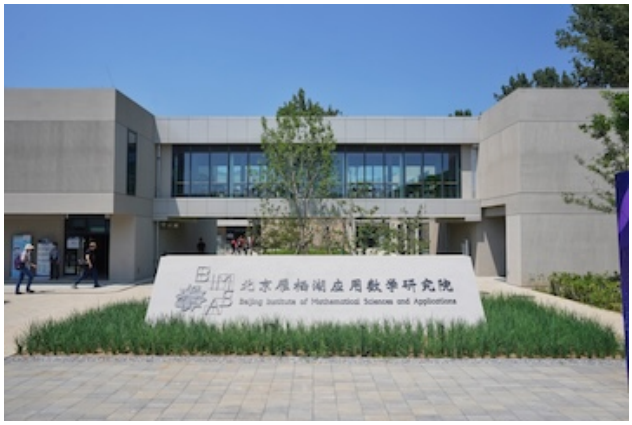
You can read more about Igor's life path and his contributions to mathematics in the tribute paper Igor Mosiseevich Krichever (on his 70th birthday)", Uspekhi Matematichekikh Nauk, 76:4 (2021), 183–193.1.

April 2024 Issue of AMS Notices contains recollections about Igor by his colleagues and friends.

About BIMSA

(Excpert from the ICBS-2024 Brochure, used with permission)

Address: 北京市怀柔区河防口村544号(No. 544, Hefangkou Village, Huairou District, Beijing)



The front entrance to BIMSA

Under the guidance and support of the Beijing Municipal Party Committee, the Beijing Municipal Government, and the Ministry of Science and Technology, Beijing Institute of Mathematical Sciences and Applications was officially established on June 12, 2020, spearheaded by the Beijing Municipal Science and Technology Commission and the Huairou District Party Committee and District Government. Leveraging the relevant advantageous disciplines of Tsinghua University, such as mathematics, BIMSA follows a development model of “75% applied mathematics and 25% fundamental mathematics" and has been continuously advancing the construction of its research teams. Currently, it has successfully recruited 136 full-time research personnel, with foreign staff accounting for 36%. Fifteen members have been selected for national talent programs, and eight have been selected for provincial talent programs. BIMSA actively attracts top global scientists and promising young scholars, having formed 12 specialized research teams, with the future scale of research personnel expected to exceed 300 people.

Study space

BIMSA has built a platform for communication in the field of mathematics and its applications, strengthening fundamental scientific research and addressing mathematical problems in major national and corporate development needs. It has opened 327 public courses, hosted 76 international seminars, organized 64 workshops, held 1,672 academic lectures, and published renowned journals such as “The Advances in Theoretical and Mathematical Physics” and “ICCM Notices”. Up to June 2024 a total of 731 publications have been published or accepted, where 7 of them are books and 365 of them are indexed in SCI, among which 46.85% are in Q1 and 28.77% are in Q2.

BIMSA engages in multifaceted educational collaborations, cultivating outstanding research talents with innovative spirits and practical abilities. Currently, it jointly offers doctoral programs with Tsinghua University, the University of Chinese Academy of Sciences, and Renmin University of China, with the first cohort of students having officially enrolled in September 2023. Additionally, BIMSA collaborates with the Yau Mathematical Sciences Center at Tsinghua University, leveraging its resources and faculty to support the Tsinghua University Qiu Zhen Academy’s “3+2+3” integrated bachelor’s, master’s, and doctoral training program, working together on student training.

BIMSA Research Groups

The research group at BIMSA is dedicated to exploring a broad spectrum of mathematical sciences, including pure mathematics, applied mathematics, theoretical computer science, and mathematical physics. We firmly believe that the most profound discoveries often require the integration of different mathematical fields. Hence, we have selected faculty with wide-ranging interests and diverse expertise, conducting research across multiple mathematical domains simultaneously. We prefer fields that allow for deep and fundamental research as well as those poised for significant new breakthroughs.

Fall at BIMSA

In the areas of algebra/number theory, representation theory, and geometry/topology, BIMSA continues the traditional strengths established since the institute's inception. Over the years, research in these fields has shifted the direction of the discipline's development.

These mathematical fields also form the foundation for BIMSA's interaction with the natural sciences academy. Concepts in physics, such as gauge fields and strings, have played a critical role in solving topological problems, and conversely, concepts in algebra and differential geometry are also highly important for theoretical physics.

BIMSA views

BIMSA has two goals—to create new mathematical knowledge and to promote the professional development of mathematicians. To achieve the latter, the institute selects around sixty talented mathematicians and computer scientists as visiting scholars each year. They come from all over the world, bringing a variety of perspectives.

These scholars represent all stages of a mathematical career, a mix designed to foster productive interactions. Promising young mathematicians work closely with seasoned veterans. We choose members with different mathematical specialties to encourage the cross-pollination of ideas, in line with BIMSA's belief in the unity of mathematics. Each year, we focus particularly on one or more aspects of mathematics.

These special programs attract a group of visiting scholars, who may constitute a third of BIMSA's total membership. These programs extend BIMSA's mathematical reach and attract a broad membership.

BIMSA provides members with an ideal environment designed to minimize distractions, foster creativity, and focus on academic research. Here, members can explore new research findings and broaden their academic horizons through participating in seminars, interacting with faculty, and engaging with one another. We hope that in the near future, many of the world's leading scholars will benefit from their experience at BIMSA.

Brief History of BIMSA

In the summer of 2019, Shing-Tung Yau received an unexpected call from the former Mayor of Beijing. This conversation gave him the opportunity to create his ideal research institute, with ample resources. Despite already leading the Yau Mathematical Sciences Center (YMSC) at Tsinghua University, Yau accepted the offer without hesitation. Three days later, he conducted an on-site inspection and reached a verbal agreement within a week.

By 2020, the Beijing Institute of Mathematical Sciences and Applications (BIMSA) was established. Located at the foot of the northern mountains of Beijing, it offers direct views of the Great Wall. BIMSA is part of a new science city plan in Huairou. Originally an industrial area, Huairou's factories were closed to improve Beijing's air quality. Today, with its beautiful scenery and fresh air, it has become an ideal place for scientific research.

The aerial view of BIMSA

Initially, BIMSA was solely intended for applied mathematics research, but Yau persuaded the relevant departments to allocate 25% of the institute's funds to pure mathematics research, emphasizing the importance of fundamental research. BIMSA was initially temporarily housed in Maple Leaf Residence at Yanqi Hotel, which had hosted the 2014 APEC meeting and other international conferences.

BIMSA at night

On May 15, 2023, BIMSA moved to its permanent location at the former site of Xingfa Cement Factory. The new facility was co-designed by German architectural firm HPP International Planning Company and Beijing Institute of Architectural Design, with an emphasis on using eco-friendly materials and construction techniques.

Shortly after the relocation, BIMSA hosted its first international event—the International Mathematical Summer Camp, attracting over 250 participants from around the world. On July 16, 2023, the International Congress of Basic Science grandly opened at the Great Hall of the People in Beijing. The two-week congress brought together over 300 top scientists from abroad and nearly a thousand leading domestic scholars to discuss cutting-edge achievements in basic science and explore future development directions in fundamental research. Renowned scientists, including eight Fields Medal winners, four Turing Award winners, one Nobel Prize winner, and more than 50 academicians from various countries, attended and delivered high-level academic reports. Over 500 conference reports, special academic sessions, and satellite meetings provided a platform for scholars at home and abroad to exchange and share academic results.

Despite its short history, BIMSA is poised to shine on the international stage.

Program at a Glance

Week 1 Schedule: June 24 – June 29

Time	Monday, June 24	Tuesday, June 25	Wednesday, June 26	Thursday, June 27	Friday, June 28	Saturday, June 29
8:45	Opening Remarks					**Free Day**
9:00	Samuel Grushevsky (1/5)	Samuel Grushevsky (2/5)	Samuel Grushevsky (3/5)	Samuel Grushevsky (4/5)	Samuel Grushevsky (5/5)	
9:30						
10:00						
10:30	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	
11:00	Pavel Etingof (1/5)	Pavel Etingof (2/5)	Pavel Etingof (3/5)	Pavel Etingof (4/5)	Pavel Etingof (5/5)	
11:30						
12:00						
12:30	*Lunch Break*	*Lunch Break*	*Lunch Break*	*Lunch Break*	*Lunch Break*	
13:00						
13:30						
14:00	Mikhail Bershtein	Anton Zabrodin	***Excursion: Mutianyu Great Wall***	Alexei Borodin	Youjin Zhang	
14:30						
15:00	Thomas Bothner*	Henry Liu		Alexander Bobenko*	Movie: Solving the Bonnet problem	
15:30						
16:00	*Coffee Break*	*Coffee Break*		*Coffee Break*	*Coffee Break*	
16:30	Exercises/Discussions	Exercises/Discussions		Exercises/Discussions	Exercises/Discussions	
17:00						
17:30	Exercises/Discussions	Exercises/Discussions		Exercises/Discussions	Exercises/Discussions	
18:00						
18:30	*Dinner*	*Dinner*	*Dinner*	*Dinner*	*Dinner*	
19:00						
19:30	Shuttle to the Hotel	Shuttle to the Hotel	Shuttle to the Hotel	Shuttle to the Hotel	Shuttle to the Hotel	

Week 2 Schedule: June 30 – July 6

Time	Sunday, June 30	Monday, July 1	Tuesday, July 2 (I. Krichever's Day)	Wednesday, July 3	Thursday, July 4	Friday, July 5
9:00	Andrei Okounkov (1/5)	Andrei Okounkov (2/5)	Opening Remarks	Andrei Okounkov (3/5)	Andrei Okounkov (4/5)	Andrei Okounkov (5/5)
9:30			Paul Wiegmann			
10:00						
10:30	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
11:00	Nikita Nekrasov (1/5)	Nikita Nekrasov (2/5)	Andrei Marshakov	Nikita Nekrasov (3/5)	Nikita Nekrasov (4/5)	Nikita Nekrasov (5/5)
11:30						
12:00						
12:30	*Lunch Break*	*Lunch Break*	*Lunch Break*	*Lunch Break*	*Lunch Break*	*Lunch Break*
13:00						
13:30						
14:00	Sergei Lando	Ivan Cherednik	Alexander Veselov	Da-jun Zhang	Movie: Colors of Math	Exercises/Discussions
14:30						
15:00	Senya Shlosman	Alexander Braverman*	Stanislav Smirnov	Anton Dzhamay		Exercises/Discussions
15:30						
16:00	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
16:30	Exercises/Discussions	Exercises/Discussions	Grigori Olshanski*	Exercises/Discussions	Exercises/Discussions	Closing Remarks
17:00						
17:30	Exercises/Discussions	Exercises/Discussions	Shuttle to the Banquet	Exercises/Discussions	Exercises/Discussions	Free Time
18:00			Conference Banquet and Celebration of Igor Krichever's Legacy			
18:30	*Dinner*	*Dinner*		*Dinner*	*Dinner*	*Dinner*
19:00						
19:30	Shuttle to the Hotel	Shuttle to the Hotel		Shuttle to the Hotel	Shuttle to the Hotel	Shuttle to the Hotel

All talks are in room A6-1, additional Zoom stream is in room A7-1

Zoom meeting ID: 844 5165 5613 (A6 lectures and discussions) and 890 0308 0976 (A7 discussions).

The Bilibili channel online broadcast: http://live.bilibili.com/1843665999

Youtube chanel online broadcast and YouTube playlist for school meeting recordings are also avaiable.

Exercise and discussion sessions are in rooms A6-1, and A7-1, it is advised to go to one session for the first hour and then switch to another.

Shuttle bus schedule (**on Monday, June 24, morning shuttle buses depart 15 minutes early**):

8:15 (Yanqi International Community) – 8:25 (Shanshui Hotel) – 8:45 (BIMSA A6) – 19:30 (BIMSA A6) – 19:50 (Shanshui Hotel) – 20:00 (Yanqi International Community)

8:35 (Swan Lakeview Hotel) – 8:45 (BIMSA A6) – 19:30 (BIMSA A6) – 19:40 (Swan Lakeview Hotel)

June 26: 14:00 (BIMSA A4) – 14:35 (the Mutianyu Great Wall) – 18:00 (the Mutianyu Great Wall) – 18:35 (BIMSA A4)

July 2: 17:30 (BIMSA A6) – 17:40 (Sunrise Kempinski Hotel) – 21:00 (Sunrise Kempinski Hotel) – Hotels