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**Title:** Equivariance and $\sigma$-functions

**Abstract:** We discuss the role of equivariance in the theory of functions on Jacobians of algebraic curves, in particular in relation to Hamiltonian operators occuring in heat equations defining the $\sigma$-function.

Vincent Caudrelier
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**Title:** New integrable boundary conditions for the Ablowitz-Ladik chain: from Hamiltonian formulation to nonlinear mirror image method

**Abstract:** One of the biggest successes in the theory of (classical) integrable systems is that models that possess a Lax pair and are amenable to the inverse scattering method turn out to also possess a Hamiltonian description (several in fact). The connection between these two aspects is at the core of the theory and is well documented. The question of nontrivial boundary conditions and the construction of solutions in such models was first considered as early as 1975 by Ablowitz and Segur but only from Lax pair point of view. In 1987, Sklyanin's seminal work laid the foundations to define and study integrable boundary conditions from both the Hamiltonian and Lax pair point of views. Both aspects seem to have developed independently though and the following points were never addressed properly: 1) Can one derive the Lax pair point of view from the Hamiltonian one in a way similar to what is known in the case without boundary conditions? 2) How can one understand the apparent gap between the two approaches that predict different integrable boundary conditions?

In a recent work with J. Avan and N. Crampé, we addressed these 30 year-old problems. More recently, with N. Crampé, we used the example of the Ablowitz-Ladik model to illustrate the construction and obtained new integrable boundary conditions. The explicit construction of soliton solutions for the problem on the half-line with these new boundary conditions was also obtained using the nonlinear mirror image method.

Oleg Chalykh
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**Title:** Hamiltonian formulation of the trigonometric spin Ruijsenaars–Schneider system

**Abstract:** Abstract of the talk. The spin Ruijsenaars–Schneider (RS) system was introduced by Krichever and Zabrodin in connection with the multicomponent 2D Toda lattice. We suggest a Hamiltonian formulation for the system in the trigonometric case. Within this interpretation, the phase space is obtained by a quasi-Hamiltonian reduction performed on a representation space of a framed Jordan quiver. Using the theory of multiplicative quiver varieties developed by Crawley-Boevey–Shaw and Van den Bergh, we construct a degenerately integrable Hamiltonian system on the phase space and identify one of the flows with the trigonometric spin RS system. We calculate all the Poisson brackets in coordinates and so are able to prove an old conjecture of Arutyunov and Frolov. We also complement the principal Hamiltonians to form a completely integrable system of Gelfand–Tsetlin type. We show that all the commuting flows of this system are complete, by integrating them explicitly. Thus, our construction produces a completed phase space for the (complexified) trigonometric spin RS system. This is joint work with Maxime Fairon (Leeds), arXiv:1811.08727.

Robert Conte
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École normale supérieure de Cachan and The university of Hong Kong.

**Title:** Persistence and Bonnet surfaces

**Abstract:** The probability ("persistence") that a real stochastic variable retains its initial sign up to time t is proven to be represented by the Chazy tau-function of a particular sixth Painlevé equation, identical to the tau-function of the mean curvature of Bonnet surfaces. https://arxiv.org/abs/1810.06957 Joint result with Ivan Dornic (CEA).

Yuri Fedorov
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**Title:** From Lax representation to separation of variables

**Abstract:** This talk is a brief survey of some recent methods and algorithms of algebraic geometry which allow to make an effective separation of variables for an ample class of algebraic integrable systems, starting from their Lax representation and the corresponding spectral curve.

This approach will be illustrated in the cases of the generalized Henón–Heiles systems, the Somos 6 recurrence relation, and an autonomous limit of the matrix Painlevé II equation.

Evgeny Ferapontov
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Loughborough University, UK

**Title:** On integrability of dispersionless Hirota type equations

**Abstract:** I will review two recent results on integrability dispersionless Hirota type equations: 1. Generic integrable Hirota type equation in 3D coincides with the equation of the genus 3 hyperelliptic divisor. 2. Every integrable Hirota type equation in 4D is necessarily of Monge-Ampere type, and reduces to one of the 6 know canonical forms of heavenly type equations governing self-dual Ricci flat metrics.

Allan P. Fordy
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**Title:** First Integrals from Conformal Symmetries: Darboux-Koenigs Metrics and Beyond

**Abstract:**

On spaces of constant curvature, the geodesic equations automatically have higher order integrals, which are just built out of first order integrals, corresponding to the abundance of Killing vectors. This is no longer true for general conformally flat spaces, but in this case there is a large algebra of *conformal* symmetries.

In this talk I introduce method which uses these conformal symmetries to build higher order integrals for the geodesic equations. In 2 degrees of freedom this approach gives a new derivation of the Darboux-Koenigs metrics, which have only *one* Killing vector, but two quadratic integrals.

In 3 degrees of freedom, the method is used to construct super-integrable Hamiltonians, depending on 3 parameters and having a single first order integral (Killing vector). Specialising the parameters introduces a higher degree of symmetry, with the resulting Hamiltonians possessing 3 first order integrals. This allows the full Poisson algebra of integrals to be constructed. These Hamiltonians are a natural generalisation of the Darboux-Koenigs systems. The first order integrals are used to reduce to 2 degrees of freedom, giving Darboux-Koenigs kinetic energies with the addition of potential functions, still super-integrable, but now in 2 degrees of freedom.

This talk is based on the two papers

Allan P. Fordy,
First Integrals from Conformal Symmetries: Darboux-Koenigs Metrics and Beyond,
arXiv:1804.06904

Allan P. Fordy and Qing Huang,
Generalised Darboux-Koenigs Metrics and 3 Dimensional Super-Integrable Systems,
arXiv:1810.13368.

Jing Kang
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**Title:** Liouville correspondences between multi-component integrable hierarchies

**Abstract:** This is a joint result with Xiaochuan Liu, Peter J. Olver and Changzheng Qu. We study explicit correspondences between some multi-component integrable hierarchies. We show how the Liouville transformations between the isospectral problems of the multi-component systems relate the corresponding hierarchies, in both positive and negative directions, as well as their associated conservation laws. This extends previous results on the scalar hierarchies to the multi-component case.

Pavlos Kassotakis
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**Title:** Invariants in separated variables: Yang-Baxter, entwining and transfer maps.

**Abstract:** We present the explicit form of a family of Liouville integrable maps in 3 variables, the so-called *triad family of maps* and we propose a multi-field generalisation of the latter. We show that by imposing separability of variables to the invariants of this family of maps, the $H_I, H_{II}$ and $H^A_{III}$ Yang-Baxter maps in general position of singularities emerge. Two different methods to obtain entwining Yang-Baxter maps are also presented. The outcomes of the first method are entwining maps associated with the $H_I, H_{II}$ and $H^A_{III}$ Yang-Baxter maps, whereas by the second method we obtain non-periodic entwining maps associated with the whole $F$ and $H-$list of quadrirational Yang-Baxter maps. Finally, we show how the transfer maps associated with the $F$ and the $H$ lists of Yang-Baxter maps can be considered as the $(k^{th}-1)$-iteration of some maps of simpler form. We refer to these maps as *extended transfer maps* and in turn they lead to $k-$point alternating recurrences which can be considered as the autonomous versions of some hierarchies of discrete Painlevé equations.

Yuji Kodama
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**Title:** The Painlevé divisors and the Schur expansions of the $\tau$-functions for the full Kostant-Toda hierarchy

**Abstract:** The Painlevé divisor is the zero set of the $\tau$-function of finite nonperiodic Toda hierarchy. It is also known that the $\tau$-function has the Schur function expansion about the Painlevé divisor. In this talk, we discuss some details of the geometric structure of the Painlevé divisor for the full Kostant-Toda hierarchy.

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**Title:** On an integrable multi-dimensionally consistent $2n+2n$-dimensional heavenly-type equation

**Abstract:** This is a joint result with W.K. Schief (School of Mathematics and Statistics, The University of New South Wales, Sydney). Based on the commutativity of scalar vector fields, an algebraic scheme is developed which leads to a privileged multi-dimensionally consistent 2n + 2ndimensional integrable partial differential equation with the associated eigenfunction constituting an infnitesimal symmetry. The "universal" character of this novel equation of vanishing Pfaffian type is demonstrated by retrieving and generalising to higher dimensions a great variety of well-known integrable equations such as the dispersionless KP and Hirota equations and various avatars of the heavenly equation governing self-dual Einstein spaces.

Ting-Jung Kuo
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**Title:** Monodromy aspect of generalized Lame equation with eliiptic KdV potential

**Abstract:** In this talk, I will review some basic results of KdV theory and then introduce a second order complex ODE so called the generalized Lame equation (GLE) with elliptic KdV potential. Firstly, I will talk about the monodromy representation of this GLE. For this GLE, there associates a hyperelliptic curve to this GLE. I will focus on the geometry of this hyperelliptic curve from monodromy aspect and introduce a relevant problem which plays a role in our study. As an application, We can give a criterion to the existence or non-existence problem to a special nonlinear PDE. This is a joint work with Z. Chen and C. S. Lin.

S. Y. Lou
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Ningbo University

**Title:** Multi-place nonlocal systems

**Abstract:** Two-place nonlocal systems have attracted many scientists' attentions. In this talk, two-place non-localities are extended to multi-place non-localities. Especially, various two-place and four-place nonlocal nonlinear Schrodinger (NLS) systems and Kadomtsev-Petviashvili (KP) equations are systematically obtained from the discrete symmetry reductions of the coupled local systems. The Lax pairs for the two-place and four-place nonlocal NLS and KP equations are explicitly given. Some types of exact solutions especially the multiple soliton solutions for two-place and four-place KP equations are investigated by means of the nonlocal operator related symmetric-antisymmetric separation approach.

Ian Marshall
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**Title:** Action-Angle Duality for a Poisson-Lie Deformation of the Trigonometric BCn Sutherland System

**Abstract:** The interesting property of action-angle duality was first brought to light in a systematic way by Ruijsenaars. The method of Hamiltonain reduction reveals a natural mechanism for how such a phenomenon can arise. I will give a general overview of this and present as a special case the new result, obtained together with Laszlo Feher, referred to in the title of my talk.

Alexander V. Mikhailov
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**Title:** Polynomial integrable Hamiltonian systems on symmetric powers of plane curves

**Abstract:** We have found quite general construction of $k$ commuting vector fields on $k$–th symmetric power of $\mathbb{C}^m$ and also of $k$ commuting tangent vector fields to the $k$–th symmetric power of an affine variety $V \subset \mathbb{C}^m$. Application of this construction to $k$–th symmetric power of a plane algebraic curve $V_g$ of genus $g$ leads to $k$ integrable Hamiltonian systems on $\mathbb{C}^{2k}$ (or on $\mathbb{R}^{2k}$, if the base field is $\mathbb{R}$). In the case of a hyperelliptic curve $V_g$ of genus $g$ and $k = g$ our system is equivalent to the well known Dubrovin system which has been derived and studied in the theory of finite gap solutions (algebra-geometric integration) of the Korteweg-de-Vrise equation. We have found the coordinates in which the systems obtained and their Hamiltonians are polynomial. For $k = 2, 3$ and $g = 1, 2, 3$ we present these systems explicitly as well as we discuss the problem of their integration.

Frank Nijhoff
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**Title:** KP Hierarchies from a Direct Linearization perspective: old and some new results

**Abstract:** Probably the most popular derivation of the KP hierarchy is the one formulated by M. Sato using pseudo-differential operators. However, an alternative formulation exists on the basis of the direct linearization (DL) approach pioneered by researchers in the 1980s. The latter has some distinct advantages over the Sato approach, e.g. that it doesn't need to refer to a specific singled-out variable in terms of which the hierarchy is defined, and that it makes the multidimensional consistency more manifest. The talk provides a short review of the DL formulation of KP type hierarchies and highlights the fundamental features, in particular the presentation of a 'universal' integrable system. (This is work in collaboration with Wei Fu.)

Maxim Pavlov
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**Title:** A new class of exact solutions for three-dimensional quasilinear systems of first order

**Abstract:** Well-known Lin–Reissner–Tsien equation in aerodynamics (1948) will be considered. This equation also is known as the Khokhlov–Zabolotskaya equation in nonlinear acoustics, and is known as a dispersionless limit of the Kadomtsev–Petviashvili equation in hydrodynamics. New ansatz for construction of infinitely many two-dimensional reductions is found for this three-dimensional equation. They are generalisations of two-dimensional hydrodynamic reductions. In one-component case, a corresponding particular solution is found with five arbitrary functions of a single variable. Also some other three-dimensional integrable quasilinear systems of first order will be considered.

Andrew Pickering
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**Title:** On the symmetries of a sequence of evolution equations

**Abstract:** Joint work with P.R.Gordoa (Universidad Rey Juan Carlos, Madrid).

We consider the symmetries of a sequence of evolution equations, of orders $n = 3, 4, 5, \ldots$, which includes several well-known partial differential equations at lower orders. We seek nonclassical symmetries using a method based on compatibility, and find that no symmetries additional to classical symmetries can be obtained in the case $\tau \neq 0$. In the case $\tau = 0$ we discuss the relationship between $\phi$ and the corresponding solutions of the evolution equations that can or cannot be obtained.

Ziemowit Popowicz
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**Title:** Supercomplexification of the Korteweg-de Vries, Sawada-Kotera and Kaup-Kupershmidt Equations.

**Abstract:** The supercomplexification is a special method of $N = 2$ supersymmetrization of the integrable equations in which the bosonic sector can be reduced to the complex version of these equations. The $N = 2$ supercomplex Korteweg-de Vries, Sawada-Kotera and Kaup-Kupershmidt equations are defined and investigated. The common attribute of the supercomplex equations is appearance of the odd Hamiltonian structures and superfermionic conservation laws.

Changzheng Qu
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**Title:** Stability of peakons for nonlocal Camassa-Holm-type equations

**Abstract:** It is well-known that the Camassa-Holm-type equations possess a number of remarkable properties. One of them is the existence of peaked solitons. Several nonlocal Camassa-Holm-type equations have been proposed in the literature, which also exhibit some nontrivial properties like the Camassa-Holm equation. In this talk, we shall prove orbital stability of the nonlocal Camassa-Holm-type equations, including the modified Camassa-Holm equation, Fokas's equation and their higher-order generalizations.

Matthew Randall
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ShanghaiTech University

**Title:** Flat (2,3,5)-distributions and Chazy's equations

**Abstract:** In the theory of generic 2-plane fields on 5-manifolds, or (2,3,5)-distributions, the local equivalence problem was solved by Élie Cartan who also constructed the fundamental curvature invariant. For these distributions described by a single function of the form $F(q)$, the vanishing condition for the curvature invariant is given by a 6th order nonlinear ODE. Furthermore, Daniel An and Paweł Nurowski have shown that this ODE is the Legendre transform of the nonlinear ODE that appeared in Gottfried Noth's thesis in 1904. We show that the 6th order ODE can be reduced to a 3rd order nonlinear ODE that is a generalised Chazy equation with Chazy parameter 2/3. The ODE in Noth's thesis can similarly be reduced to another generalised Chazy equation, which has its Chazy parameter given by the reciprocal 3/2. As a consequence of solving the related generalised Chazy equations, we obtain additional examples of flat (2,3,5)-distributions. This talk is based on work available at arXiv:1506.02473 and arXiv:1607.04961.

Jing Ping Wang
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**Title:** PreHamiltonian, Hamiltonian and Nijenhuis difference operators

**Abstract:** A difference operator is called preHamiltonian if its image is a Lie subalgebra with respect to the Lie bracket of evolutionary vector fields on a difference field. Two preHamiltonian operators form a preHamiltonian pair if any linear combination of them is preHamiltonian. In this talk we explore the connections of preHamiltonian operators with Hamiltonian and Nijenhuis operators. We then illustrate these theoretic results to integrable differential-difference equations including the Toda, the Ablowitz-Ladik and the Kaup-Newell equations and a discrete Sawada-Kotera equation proposed by Adler & Postnikov in 2011. This is the joint work with S. Carpentier and A.V. Mikhailov.

Chao-Zhong Wu
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Sun Yat-Sen University, Guangzhou, China

**Title:** On solutions of Drinfeld-Sokolov hierarchies

**Abstract:** For the Drinfeld-Sokolov hierarchy associated to any affine Kac-Moody algebra, we propose a procedure to compute its formal series solution with arbitrary initial values given. In particular, a class of solutions are shown to be characterized by certain ODEs of Painlevé type, on which there are affine Weyl group actions discovered by Noumi and Yamada. This is a joint work with Si-Qi Liu and Youjin Zhang.

Pavlos Xenitidis
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Liverpool Hope University, UK

**Title:** Integrability aspects of consistent systems of difference equations

**Abstract:** Consistent systems of difference equations constitute an interesting and delicate generalization of quad equations: They involve only one dependent variable and are composed of two or more higher order equations which are compatible with each other. In this talk we will present two hierarchies of such systems and describe a nice and simple method for their construction which employs lattice paths connecting the origin with certain lattice points. Their integrability will be established by the derivation of the lowest order symmetries which are related to the Bogoyavlensky and the Sawada-Kotera lattices. Finally we will discuss how these hierarchies generalise two well-known quad equations and how one hierarchy can be viewed as a degeneration of the other.

Yiru Ye
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**Title:** Chaos and integrability in $SL(2,R)$ geometry

**Abstract:** The talk is about the integrability problem for the geodesic flow on the three-folds admitting $SL(2,R)$-geometry in Thurston's sense.

The main examples are the unit tangent bundles of surfaces with hyperbolic metric.We show that the corresponding phase space contains two open regions with integrable and chaotic behaviour respectively.

The talk is based on a joint work with A.V. Bolsinov and A.P. Veselov

Cheng Zhang
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**Title:** Integrable mappings arising from discrete initial-boundary-value problems

**Abstract:** In the study of Cauchy problems for two-dimensional discrete integrable equations on $\mathbb{Z}^2$ lattices, integrable mappings can be obtained through the so-called periodic reductions. In this talk, based on a recent study of initial-boundary-value problems for integrable lattice equations by Caudrelier, Crampé & **CZ** (SIGMA 10(2014):014), another type of reductions in the presence of boundaries is provided. Naturally, integrable initial-boundary problems give rise to classes of integrable mappings. This work is in collaboration with Peter van der Kamp and Vincent Caudrelier.

Da-jun Zhang
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**Title:** On squared eigenfunction symmetries of discrete KP and mKP

**Abstract:** We introduce a Lax triad approach to construct the scalar differential-difference Kadomtsev-Petviashvili (KP) hierarchy from a quasi-difference operator. Hamiltonian structures and symmetries of the hierarchy are discussed. The squared-eigenfunction symmetry of this hierarchy as a constraint leads the Lax triad and adjoint Lax triad of the hierarchy to a discretized AKNS spectral problem in bidirection and a semidiscrete AKNS hierarchy. In a similar manner, it is shown that the squared-eigenfunction symmetry leads the modified differential-difference KP stuff to the relativistic Toda systems. Some new relations and reductions are found.

Youjin Zhang
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**Title:** The topological tau function of the Fractional Volterra hierarchy

**Abstract:** The fractional Volterra hierarchy is a certain generalization of the Volterra hierarchy which possesses a Hamiltonian structure and a tau structure. We show the existence of a special tau function, called the topological tau function, of the integrable hierarchy which satisfies the Virasoro constraints, and show its application to the study of Hodge integrals. This is a joint work with Si-Qi Liu (Tsinghua), Di Yang and Chunhui Zhou (USTC).

Jian Zhou
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**Title:** Integrable hierarchies, spectral curves, topological recursions, and intersection numbers

**Abstract:** One can associate spectral curves to tau-functions of various integrable hierarchies. One can use the spectral curves to carry out Eynard-Orantin toplogical recursions. The latter are related to intersection numbers on the moduli spaces of curves. In this way we relate various tau-functions to intersection numbers. This is a sort of generalization of Witten Conjecture/Kontsevich Theorem.

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**Title:** Extended affine Weyl groups of BCD-type: their Frobenius manifolds and Landau–Ginzburg superpotentials

**Abstract:** This is a joint work with B.Dubrovin, Ian Strachan and Y-J. Zhang. For the root systems of type $B_l, C_l$ and $D_l$, we generalize the result of [DZ1998] by showing the existence of Frobenius manifold structures on the orbit spaces of the extended affine Weyl groups that correspond to any vertex of the Dynkin diagram instead of a particular choice made in [DZ1998]. It also depends on certain additional data. We also construct Landau–Ginzburg superpotentials for these Frobenius manifold structures.