Abstract Booklet

MINI-WORKSHOP 2014

Search for Classical Analysis and Quantum Integrable Systems,
15-17 November 2014, Kyoto University, Japan

1 OUTLINE

• Title : MINI-WORKSHOP 2014 :
Search for Classical Analysis and Quantum Integrable Systems
15-17 November 2014, Kyoto University, Japan

• Scope and Topics : Classical and Quantum Integrable Models, Lie Theory and Symmetry in Physics

• Place : Graduate School of Informatics, Kyoto University, 36-1 Yoshida-Honmachi, Sakyo-ku, Kyoto 606-8501, Japan

Nov.15	Faculty of Engineering Integrated Research Bldg. Room 213
Nov.16	Faculty of Engineering Integrated Research Bldg.Room 213
Nov.17	Faculty of Engineering Research Bldg. No.8 Room 3

• Timetable :

Nov.15	Talks begin at AM 10:30. Workshop dinner
Nov.16	Group photo
Nov.17	Talks end in the noon.

• Accommodation : Guest House of Kyoto University "Seifu-Kaikan"

• Workshop Dinner : Japanese style bar "Momojiro-Hyakumanben"

• Web : http://kojima.yz.yamagata-u.ac.jp/workshop2014.html

• Organizing Committee :
Takeo Kojima(Yamagata University), Satoshi Tsujimoto(Kyoto University)

2 PROGRAM

• List of Invited Speakers :

	Name	Affiliation and E-mail
1	**Prof. Naruhiko Aizawa**	**Osaka Prefecture University** aizawa@mi.s.osakafu-u.ac.jp
2	**Prof. Veljko Dmitrasinovic**	**Osaka University, Institute of Physics Belgrade** dmitrasin@yahoo.com
3	**Prof. Masashi Hamanaka**	**Nagoya University** hamanaka@math.nagoya-u.ac.jp
4	**Prof. Shuhei Kamioka**	**Kyoto University** kamioka.shuhei.3w@kyoto-u.ac.jp
5	**Prof. Takeo Kojima**	**Yamagata University** kojima@yz.yamagata-u.ac.jp
6	**Prof. Satoru Odake**	**Shinshu University** odake@azusa.shinshu-u.ac.jp
7	**Prof. Dimitri Polyakov**	**Sogang University, Sichuan University** twistorstring@gmail.com
8	**Prof. Yas-Hiro Quano**	**Suzuka University of Medical Science** quanoy@suzuka-u.ac.jp
9	**Prof. Igor Salom**	**University of Belgrade** isalom@ipb.ac.rs
10	**Prof. Hiroto Sekido**	**Kyoto University** sekido@amp.i.kyoto-u.ac.jp
11	**Prof. Fumihiko Sugino**	**Okayama Institute for Quantum Physics** fumihiko_sugino@pref.okayama.lg.jp
12	**Prof. Kouichi Takemura**	**Chuo University** takemura@math.chuo-u.ac.jp
13	**Prof. Satoshi Tsujimoto**	**Kyoto University** tujimoto@i.kyoto-u.ac.jp

	Name	Affiliation and E-mail
14	**Prof. Hiroshi Miki**	**Doshisha University** hmiki@mail.doshisha.ac.jp
15	**Prof. Hiroyuki Yamane**	**Toyama University** hiroyukikcoe25@yahoo.co.jp

• **Program :**

	November 15	November 16	November 17
9:30-10:30			MIKI
10:30-11:30	TSUJIMOTO	YAMANE	SUGINO
11:30-12:30	ODAKE	KAMIOKA	KOJIMA
12:30-14:00	**lunch**	**lunch**	**departure**
14:00-15:00	AIZAWA	DMITRASINOVIC	
15:00-16:00	SEKIDO	SALOM	
16:00-16:15	**coffee**	**coffee**	
16:15-17:15	QUANO	TAKEMURA	
17:15-18:15	POLYAKOV	HAMANAKA	
18:30-	**dinner**		

No. 53：Faculty of Engineering Integrated Research Bldg.

No. 59：Faculty of Engineering Research Bldg. No.8

3 ABSTRACT

• Professor Naruhiko Aizawa (Osaka Prefecture University)

Title : Recent developments in representation theory of nonrelativistic conformal algebras.

Abstract : Nonrelativistic conformal algebra (NRCA) is a particular class of non-semisimple Lie algebras. The member of the class is a finite or an infinite dimensional Lie algebra. The semisimple part of the finite dimensional algebras is the direct sum of sl(2) and so(d), while the Virasoro algebra is the semisimple part of the infinite dimensional algebras. This class of Lie algebra appears in various kind of problems in theoretical and mathematical physics. For instance, one can find them in connection with fluid dynamics, gravity theory, AdS/CFT correspondence and vertex operator algebras. This motivate us to study representations of NRCA. The first part of this talk is an overview on NRCA. Various members of NRCA are introduced and their structure, extensions are discussed. We also give a brief summary on what has been done on representations of NRCA. In the second part, we pick up the simplest members of finite dimensional NRCA and discuss a classification of irreducible representations of the lowest weight type. As an application of the representation theory, we construct partial differential equations with the symmetries generated by NRCA.

• Professor Veljko Dmitrasinovic (Osaka University and Institute of Physics, University of Belgrade (Serbia))

Title : Dynamical Symmetry of quantum and classical motion of three quarks tethered to the Torricelli point.

Abstract : Abstract: The motivation for a search for a three-body dynamical symmetry comes from the quantum dynamics of three quarks confined by the so- called Y- and Delta strings. After a brief review of the Y- and Delta strings, their spectra and the degeneracies within, we introduce a set of three-body kinematic variables that are permutation symmetric and expose the underlying dynamical O(2) symmetry of the Y-string. This symmetry exists also as an approximate symmetry of other permutation symmetric

three-body systems, such as the Newtonian gravity one. We illustrate the role of the symmetric variables by displaying the classical Newtonian periodic three-body orbits of Euler, Lagrange and Moore in these terms. Subsequently: a) we show that the above string systems also have the same classical solutions; b) we found new classical periodic orbits of three quarks in the Y-string potential; and c) we found several new periodic orbits of three bodies in the Newtonian gravity.

- **Professor Masashi Hamanaka (Nagoya University)**

Title : Noncommutative ADHM constructions and duality.

Abstract : Abstract: Atiyah-Drinfeld-Hitchin-Manin (ADHM) construction is a powerful construction method of instantons which are finite-action solutions of anti-self-dual Yang-Mills (ASDYM) equations in four-dimensional Euclidean space. This is based on a beautiful duality between moduli space of the instantons and moduli space of the ADHM data. In this talk, we discuss the ADHM construction of U(N) instantons in noncommutative (NC) space and prove the duality. This is based on collaboration with Toshio Nakatsu (Setsunan University).

- **Professor Shuhei Kamioka (Kyoto University)**

Title : Different approaches to the Aztec diamond theorem.

Abstract : Abstract: The Aztec diamond theorem by Elkies, Kuperberg and Larsen and Propp (1992) concerns a nice product formula for a combinatorial problem of domino tilings. The theorem is so beauty that many different proofs have been given in different approaches. In this talk three of those different proofs are reviewed which are based on: (i) "urban renewal" trick by Kuperberg; (ii) determinant calculation by Kamioka; and (iii) vertex operator method by Bouttier, Chapuy and Corteel.

- **Professor Takeo Kojima (Yamagata University)**

Title : Vertex operator approach to semi-infinite lattice model: recent progress.

Abstract : Vertex operator approach is a powerful method to study exactly solvable models directly in the thermodynamic limit. In this talk we review recent progresses of vertex operator approach to semi-infinite lattice models.

(1) The first progress is a generalization of the boundary condition. We study the XXZ spin chain with a triangular boundary. Bosonizations of the boundary vacuum states are realized. Integral representations of correlation functions and form factors are proposed using bosonizations. As an application, $q-$series formulae of the boundary expectation values $< \sigma_1^{\pm} >$ are derived. Exploiting the spin reversal property, relations between n-fold integrals of elliptic theta functions are conjectured.

(2) The second progress is a generalization of the symmetry. We study the elliptic $U_{q,p}(\widehat{sl_N})$ lattice model with diagonal boundary condition, which gives an elliptic deformation of the higher-rank XXZ spin chain. Bosonizations of the boundary vacuum states are realized. Integral representations of correlation functions are proposed using bosonizations. Exploiting the spin reversal property, relations between n-fold integrals of double-infinite products are conjectured. References :

[1] T.Kojima, Diagonalization of infinite transfer matrix of boundary $U_{q,p}(A_{N-1}^{(1)})$ face model, *J.Math.Phys.***52** 01351 (26pages) (2011)

[2] P.Baseilhac, T.Kojima, Correlation functions of the half-infinite XXZ spin chain with a triangular boundary, *Nucl.Phys.***B880** 378-413 (2014)

[3] P.Baseilhac, T.Kojima, Form factors of the half-infinite XXZ spin chain with a triangular boundary, accepted for publication in *J.Stat.Mech.* (2014)

- **Professor Satoru Odake (Shinshu University)**

Title : Solvable discrete quantum mechanics: q-orthogonal polynomials with $|q| = 1$ and quantum dilogarithm.

Abstract : Several kinds of q-orthogonal polynomials with —q—=1 are constructed as the main parts of the eigenfunctions of new solvable discrete quantum mechanical systems. Their orthogonality weight functions consist of quantum dilogarithm functions, which are a natural extension of the Euler gamma functions and the q-gamma functions (q-shifted factorials). The dimensions of the orthogonal spaces are finite. These q-orthogonal polynomials are expressed in terms of the Askey-Wilson polynomials and their certain limit forms. This talk is based on the collaboration with R.Sasaki, arXiv:1406.2768.

- **Professor Yas-Hiro Quano (Suzuka University of Medical Science)**

Title : Form factors of spin 1 analogue of the eight-vertex model.

Abstract : The spin 1 analogue of the eight-vertex model (21-vertex model) is considered on the basis of free field representations of vertex operators in the 2×2-fold fusion SOS model and vertex-face transformation. Correlation functions and form factors in the 21-vertex model can be expressed in terms of type I and type II vertex operators of the corresponding fused SOS model and so-called tail operators. We need the tail operators in order to translate correlation functions and form factors in SOS model into those of elliptic vertex model. For correlation functions we use the tail operators for diagonal matrix elements with respect to the ground state sectors, and for form factors we use the ones for off diagonal matrix elements. In this talk we will construct the free field representations of the tail operators for off diagonal matrix elements with respect to the ground state sectors. As a result, integral formulae for form factors of any local operators in the 21-vertex model can be obtained, in principle.

• **Professor Igor Salom (Institute of Physics, University of Belgrade (Serbia))**

Title : Permutation-symmetric three-particle hyper-spherical harmonics.
Abstract : We consider the non-relativistic three-body body problem in quantum mechanics. Following the approach from the two-body case, the goal is to split the problem into radial and angular parts. To this end, the key element is to obtain three-body equivalent of the standard spherical harmonics (which are used for solving the two-body problem). We demonstrate the construction of the three-body permutation symmetric hyperspherical harmonics, both in the case of planar motion (2D case) and in the case of general motion (3D case).

• **Professor Hiroto Sekido (Kyoto University)**

Title : Polynomial regression with time evolution of discrete integrable systems and its applications.
Abstract : Abstract: In this talk, D-optimal designs are considered. D-optimal designs for polynomial regression models correspond to the discrete Toda equation through canonical moments and the Hankel determinant expression. We show that polynomial regression models and its D-optimal designs are generalized by using the time evolution of the discrete Toda equation. Then we introduce some applications of the generalized models.

• **Professor Fumihiko Sugino (Okayama Institute for Quantum Physics)**

Title : A SUSY double-well matrix model for 2D type IIA superstring theory.
Abstract : After a review of matrix models for bosonic string theories, we consider a double-well supersymmetric matrix model and its interpretation as a nonperturbative definition of two-dimensional type IIA superstring theory. The interpretation is confirmed by direct comparison of symmetries and amplitudes in both sides of the matrix model

and the IIA superstring theory. Next, we obtain the full nonperturbative free energy of the matrix model in terms of the Tracy-Widom distribution in random matrix theory. Its weak coupling expansion implies spontaneous supersymmetry breaking due to instantons, and strong coupling behavior suggests the existence of a well-defined S-dual theory. Furthermore, from the expression of the free energy, we see a smooth connection between a non-supersymmetric string theory and the IIA superstring theory.

• **Professor Kouichi Takemura (Chuo University)**

Title : Ultradiscrete Painlevé equations with parity variables.
Abstract : We introduce a ultradiscretization with parity variables of the q- difference Painlevé VI system of equations. We investigate solutions of ultradiscrete Painlevé equations and give a conjecture. This tale is based on a joint work with Terumitsu Tsutsui.

• **Professor Satoshi Tsujimoto (Kyoto University)**

Title : Spectral coincidence of transition operators, automata groups and box-ball systems.
Abstract : We give the automata which describe time evolution rules of the box-ball systems with a carrier. It can be shown by use of tropical geometry, such systems are ultradiscrete analogues of KdV equation. We discuss their relation with the lamplighter group generated by an automaton. We present spectral analysis of the stochastic matrices induced by these automata, and verify their spectral coincidence.

• **Professor Hiroshi Miki (Doshisha University)**

Title : Two-variable orthogonal polynomials and quantum state transfer model.
Abstract : In this talk, we show that a two-dimensional spin lattice could be solvable where an exact solution of the one excitation dynamics is provided in terms of 2-variable orthogonal polynomials. Then the perfect state transfer, the quantum state transfer with

the probability 1, is shown to take place on the lattice.

• **Professor Hiroyuki Yamane (Toyama University)**

Title : Representation theory of generalized quantum groups via Weyl groupoids.

Abstract : To any bi-homomorphism χ from a free abelian group to a field K, we can associate a generalized quantum group $U(\chi)$ in a standard way. $U(\chi)$ can be: (a) a quantum group, (b) a Lusztig's small quantum group at a root of unity, (c) a multi-parameter quantum group, (d) a quantum group associated with a basic classical Lie superalgebra, and (e) the Drinfeld quantum doubles of ta Nichols algebras of diagonal type. Let $R(\chi)$ be a generalized roo system of $U(\chi)$. Let $W(\chi)$ be the Weyl groupoid of $R(\chi)$. We apply $W(\chi)$ to obtain the classification of finite dimensional irreducible representations of $U(\chi)$, the Shapovalov determinants of $U(\chi)$, and the classification of (skew) centers of $U(\chi)$. We emphasis that especially for χ comming from the Lie superalgebra of type $B(m,n)$, there are many finite dimensional irreducible representations of $U(\chi)$ which can not be taken $q \to 1$.