# Combinatorics and Arithmetic for Physics
# IHES, 19-21 Nov. 2025

27-10-2025 16:39

## Abstracts.–

### Marek Bożejko

**Speaker**: Marek Bożejko (Institute of Mathematics Wroclaw University).
**Title**: Łukasiewicz multi-valued logic ,conditionally free probability with applications to Tsallis entropy.
**Abstract**: In my talk I will present the following topics:
1.Free and C-Free probability and quantum channels as the main examples.
2.Free independent projections and a model of Lukasiewicz multi-valued logic.
3.Connections with the Tsallis entropy.
4.Remarks on the free product of quantum channels.

References:
M. Bożejko, Positive definite functions on the free group and the noncommutative Riesz product,Boll.U.Mat.Ital.5-A(1986),13-21.
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**Keywords**: TBA
**Domains**: TBA

### Vladimir Dotsenko

**Speaker**: Vladimir Dotsenko (Université de Strasbourg).
**Title**: On recent conjectures concerning free Jordan algebras and free alternative algebras.
**Abstract**: In 2019, Iryna Kashuba and Olivier Mathieu proposed a beautiful conjecture on Lie algebra homology which, if true, would supply a lot of new information on the structure of free Jordan algebras, one of most mysterious algebraic

structures systematically appearing in different areas of mathematics and mathematical physics. Their construction relies on a functorial version of the celebrated Tits-Kantor-Koecher construction. Motivated by their work, Shang proposed an analogue of this conjecture, which would in turn supply new information on the structure of free alternative algebras. In this talk, I shall explain why both of these conjectures are not true, discuss new computational data concerning free Jordan algebras, and, time permitting, outline some related open problems.
This is partially based on joint work with Irvin Hentzel.
**Keywords**: TBA
**Domains**: TBA

## Arthemy Kiselev

**Speaker**: Arthemy Kiselev (University of Groningen, NL)
**Title**: The Wronskians over multidimension and homotopy Lie algebras.
**Abstract**: The Wronskian determinant of $N$ functions in one variable $x$ helps us verify that they are linearly independent on an interval $(a, b)$ in $\mathbb{R}$. Can we have an equally convenient procedure over multidimensional spaces $\mathbb{R}^d$ with Cartesian coordinates $x$, $y$, $z$, ...? Yes we can; let us study the definition of Wronskians for functions in many variables, and let us explore which differential-algebraic identities these structures satisfy.

To see why the Wronskian determinants actually do satisfy a set of quadratic, Jacobi-type identities, we observe first that the Wronskian of size $2\times2$ results from commutation of vector fields on the real line $\mathbb{R}$. From differential geometry we know that vector fields are differential operators of strict order $p = 1$. By taking the alternated composition of $N = 2p$ differential operators of strict order $p > 0$ on the affine line, we obtain the operator of same order $p$ with the Wronskian determinant for coefficient. As we had the Jacobi identity for the Lie algebra of vector fields, so we establish the (table of) quadratic, Jacobi-type identities for higher-order Wronskians of $N > 1$ arguments. (In string theory, these identities govern homotopy deformations of Lie algebras, here of vector fields.) We prove that the new Wronskians over multidimensional base with $d$ coordinates $x$, $y$, $z$,... do satisfy the (table of) identities for strongly homotopy Lie algebras.

The problem is to understand how fast the dimension grows under iterated $N$-ary brackets. We spot a countable chain of finite-dimensional homotopy Lie algebras that generalize the vector field realization of $sl(2)$ on $\mathbb{R}$; we explicitly calculate all the structure constants. Yet the four-dimensional analogue of $sl(2)$ over the plane $\mathbb{R}^2$ with Cartesian coordinates $(x, y)$, now with ternary bracket from the Wronskian, is so far the only known finite-dimensional homotopy Lie algebra of this type over base dimension $> 1$. The hunt is on; we conclude that Lie algebra $sl(2)$ is the prototype not only for semisimple complex Lie algebras encoded by root systems but also for countably many $N$-ary homotopy Lie algebras.

## Anastasia Matveeva.

**Speaker**: Anastasia Matveeva (École Polytechnique).
**Title**: On the integrality of some P-recursive sequences.
**Abstract**: I revisit the integrality criterion for Motzkin-type sequences due to Klazar and Luca, and propose a unified approach for analysing global boundedness and algebraicity within a broader class of holonomic sequences.
The central contribution is an algorithm that finds all algebraic solutions of certain second-order recurrence relations with linear polynomial coefficients. As algebraicity and global boundedness are shown to be equivalent in the special cases considered, the method detects all globally bounded solutions as well. This offers a systematic approach to deciding when a given P-recursive sequence is integral or almost integral - a question that arises naturally in combinatorics and differential algebra.
Based on joint work with Alin Bostan.
**Keywords**: TBA
**Domains**: TBA

## Hiroaki Nakamura

**Speaker**: Hiroaki Nakamura (The University of Osaka).
**Title**: Combinatorics and Arithmetic of Lissajous 3-braids.
**Abstract**: We introduce a classification of braids arising from 3-body motions along Lissajous curves on the plane and discuss illustrations through the lenses of associated continued fractions, cutting sequences of checkered Farey tesselation and/or symbolic frieze patterns.
This is a joint work with Eiko Kin and Hiroyuki Ogawa.
**Keywords**: TBA
**Domains**: TBA

## Toshiki Nakashima

**Speaker**: Toshiki Nakashima (Sophia University, Tokyo)
**Title**: Characterization of the Unit Object in Localized Quantum Unipotent Category.
**Abstract**: For the quiver Hecke algebra $R$, let $R$-gmod be the category of finite-dimensional graded $R$-modules, and let $\widetilde{R\text{-gmod}}$ be the localization of $R$-gmod, called "localized quantum unipotent category". It has been shown that the set of equivalence classes of simple objects up to grading shifts $\mathrm{Irr}(\widetilde{R\text{-gmod}})$ in $\widetilde{R\text{-gmod}}$ has a crystal structure, and $\mathrm{Irr}(\widetilde{R\text{-gmod}})$ is isomorphic to the so-called cellular crystal $\mathbb{B}_{\mathbf{i}}$ by M. Kashiwara and myself. This isomorphism induces a function $\varepsilon_i^*$ on $\mathbb{B}_{\mathbf{i}}$. We give an explicit form of $\varepsilon_i^*$, and using this, we give a characterization of the unit object of $\widetilde{R\text{-gmod}}$ for finite classical types, $A_n$, $B_n$, $C_n$ and $D_n$.

This is a joint work with Koh Matsuura.
**Keywords:** Quiver Hecke algebra, categorification, localization, cellular crystal, unit object.
**Domains:** math.RT, math.QA, math.CO.

## Lucas Pannier

**Speaker**: Lucas Pannier (Université de Versailles Saint-Quentin en Yvelines)
**Title**: An effective proof of the p-curvature conjecture for first-order differential equations with rational coefficients.
**Abstract**: In 1974, Honda proved the p-curvature conjecture for order one differential equations with rational coefficients over a number field. He demonstrated that in this setting, the p-curvature conjecture was equivalent to a theorem due to Kronecker, providing a local-global criterion for the splitting of polynomials over the rational numbers. In 1985 the Chudnovskys published another proof of Honda's theorem (and of Kronecker's theorem) by means of Padé approximation and elementary number theory, thus paving the way to an effective version of these results. Here, by "effective" we mean that we wish to obtain an explicit finite bound on the number of p-curvatures to be computed in order to decide the algebraicity of the solution of the differential equation.

In this talk, I will explain how to obtain such a bound, and report on an implementation.

This is joint work with Florian Fürnsinn (University of Vienna).
**Keywords**: TBA
**Domains**: TBA

## Kilian Raschel.

**Speaker**: Kilian Raschel (CNRS, Université d'Angers).
**Title**: Persistence probabilities for random walks and related processes.
**Abstract**: In this talk, we will discuss the persistence probabilities of various random processes, including random walks, autoregressive sequences, and moving average sequences. By studying their generating functions, we will establish connections between these persistence probabilities and several special functions, such as deformed exponential functions and generating functions of certain combinatorial polynomials.
**Keywords**:
**Domains**:

## Reiko Toriumi

**Speaker**: Reiko Toriumi (Okinawa Institute of Science and Technology Graduate University (OIST))

**Title**: Invitation to Random Tensor Models: from random geometry, enumeration of tensor invariants, to characteristic polynomials.
**Abstract**: I will introduce random tensor models by first reviewing their motivation coming from random geometric approach to quantum gravity. Then, I will selectively present some of the interesting research results, by highlighting recent results on enumerations of graphs representing tensor invariants, and reporting our recent work on a new notion of characteristic polynomials for tensors via Grassmann integrals and distributions of roots of random tensors.
The latter two are based on arXiv:2404.16404[hep-th] and
arXiv:2510.04068[math-ph]
**Keywords**: TBA
**Domains**: TBA

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