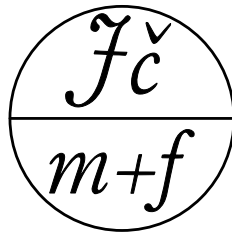


# THE 46<sup>th</sup> WINTER SCHOOL GEOMETRY AND PHYSICS

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**MUNI**

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Owen Gwilliam	Grigory Mikhalkin	Hartwig Winterroth
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Pavel Hajek	Gabriele Novelli	Martin Zika
Ondrej Hulik	Marcella Palese	Alexander Zuevsky
Goce Chadzitaskos	Pavle Pandzic	
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# ANNOUNCED LECTURES

## A. INVITED LECTURES

**Peter Albers:** *Inner and outer symplectic billiard*

**Pierre Bieliavsky:** *Symplectic and contact symmetric spaces*

**Owen Gwilliam:** *Correspondences between 6d and 2d theories: from Deligne to Witten via Beilinson and Drinfeld*

**Grigory Mikhalkin:** *Tropical trigonometry*

**Ingmar Saberi:** *Derived perspectives for the practically-minded: an introduction through examples*

**Aleksy Tralle:** *Topology of Sasakian and K-contact manifolds*

## B. OTHER LECTURES

**Spyridon Afentoulidis Almpanis:** *Tensor product decomposition for rank one spin groups*

**Julius Benner:** *Codifferential calculi on quantized flag manifolds*

**Vinicius Bernardes:** *Covariant phase space and  $L_\infty$  algebras*

**Eugenia Boffo:** *Cartan takes over BV Laplacians*

**Frederik Āalal:** *Generalized Palatini formalism*

**Antonio Del Donno:** *Lusztig differential calculi on the non-irreducible quantum flag manifolds*

**Martin Doleřal:** *Finite Lie algebra of vector fields in 3-link snake robot model*

**Martha Valentina Guarin Escudero:** *Fedosov connections and  $L$  infinity algebras associated with dg manifolds*

**Anton Galaev:** *On holonomy of contact sub-Riemannian manifolds*

**Giovanni Gava:** *First-order differential calculi over braided Hopf algebras*

**Roman Golovko:** *Non-decomposable Lagrangian cobordisms of Legendrian knots*

**Zhangwen Guo:** *Distinguished exact Weyl structures on a path geometry*

**Leszek Hadasz:** *Intersection theory and Kontsevich-type (super)matrix integrals.*

**Pavel Hajek:** *Computational experiments at Wolfram Institute*

**Ondrej Hulik:** *TBA*

**Goce Chadzitaskos:** *Parabolic cylinder functions as orthonormal bases on  $L^2(\mathbb{R}_+)$  and  $L^2(\mathbb{R})$*

**Chen-Hsu Chien:** *Double Cover  $SL(2, \mathbb{C})$  Gravity*

**Ioannis Chrysikos:** *Adapted connections with skew-torsion on metric  $f$ -manifolds*

**Lorenz Jetter:** *Generalized Ricci Solitons on the Five Dimensional Heisenberg Algebra*

**Jakub Knesel:** *Algebraic Topology and Representation Theory of Complex Flag Manifolds of the  $B, C, D$  Series*

**Hubert Kotcz:** *Lie-Poisson Geometric Criteria for Classical Optical Emulation in Measurement-Based Quantum Computing*

Daniel Komárek: *About lengths of Lagrangian cobordisms between Legendrian knots*

Oleksii Kotov: *Graded geometry: local and global approaches*

Jan Kotrbatý: *Invariant valuations on Lie groups*

Andrey Krutov: *Group valued moment maps for linear  $G$ -(super)manifolds*

Svatopluk Krysl: *Symplectic spinors – quantization and new results*

Roman Lávička: *Massless fields in Euclidean spaces*

Hong Van Le: *Minimal unital cyclic  $C_\infty$ -algebras and the real homotopy type of closed manifolds*

William Giuseppe Alessandro Luciani: *Conformal supergravity as a super Cartan connection*

Myriam Mahaman: *Rings of differential operators and Hopf algebroids*

Filip Moučka: *Courant algebroid lifts and curved Courant algebroids*

Gabriele Novelli: *The Geometry of the Yang–Mills Theory*

Marcella Palese: *Invariant variational problems and cohomology*

Pavle Pandzic: *Covariant algebra attached to four qubits*

Ana Prlić: *Unitary Highest Weight Modules with Fixed Infinitesimal Character*

Tomáš Procházka:  *$W$ -algebras and ODE/IM correspondence*

Jan Pulmann: *Graded Necklace Lie Bialgebras and Batalin–Vilkovisky Formalism*

Andrea Rivezzi: *Hopf categories associated to comonoidal functors*

Paolo Rossi: *Entanglement Entropy through Topological Defects in 2d Rational CFT*

Josef Silhan: *A compatibility complex in conformal geometry*

Rudolf Smolka: *Frobenius theorem for  $\mathbb{Z}$ -graded manifolds*

Vladimir Souček: *Integrability conditions for Grushin distributions*

Fridrich Valach: *Courant contact models and the Costello–Li conjecture*

Petr Vlachopoulos: *The Cheeger constant of curved tubes in complex space forms*

Rikard von Unge: *Gauged linear sigma models and Ricci flat metrics.*

Jan Vysoky: *Flows on Graded Manifolds*

Thomas Weber: *Vector fields in noncommutative differential geometry*

Hartwig Winterroth: *From generalized principal connections to generalized Yang–Mills theories*

Lenka Zalabová: *Conserved quantities of loxodromes*

Martin Zika: *Renormalization Group Flow and Homotopy*

Alexander Zuevsky: *Cyclic cohomology interpretation of a topological invariant in QFT*

## ABSTRACTS

**Spyridon Afentoulidis Almpanis:** *Tensor product decomposition for rank one spin groups*

Let  $G$  be a real reductive Lie group. Let  $\pi_1$  and  $\pi_2$  be unitary irreducible representations of  $G$ . The decomposition of the tensor product representation  $\pi_1 \otimes \pi_2$  is a long-standing problem in representation theory of Lie groups. In this talk, we will discuss this problem for the case when  $G = Spin(n, 1)$ , i.e. the spin double cover of  $SO_e(n, 1)$ . It turns out that the decomposition of  $\pi_1 \otimes b\pi_2$  in this case is closely related to the branching problem of unitary irreducible representations of  $G$  to some minimal parabolic subgroup  $P$ . More precisely, we will present how one can obtain an explicit decomposition of  $\pi_1 \otimes b\pi_2$  whenever  $\pi_1$  is a unitary principal series representation and  $\pi_2$  is an arbitrary unitary irreducible representation of  $G$ . If time permits, we will also discuss the case when  $\pi_1$  is a complementary series representation. Joint work with Gang Liu.

**Peter Albers:** *Inner and outer symplectic billiard*

In the first lectures, I will explain the motivation and definition of inner and outer symplectic billiard and possibly their strange new cousin: outer length billiards. The second lecture will focus on properties of inner symplectic billiards in dimension 2. I will try to make some remarks concerning higher dimensions as well. The third lecture treats outer symplectic billiards in higher dimensions. We will, in particular, focus on the behavior at infinity. This is all joint work with Sergei Tabachnikov, Ana Chavez Caliz, and Lael Costa. As a disclaimer: outer symplectic billiard in dimension 2 is known as "outer billiard", a topic with a long history and many great results. I will briefly mention this, of course, but outer billiards deserves its own lecture series by an expert!

**Julius Benner:** *Codifferential calculi on quantized flag manifolds*

Over the past few decades there has been an extensive study of covariant differential calculi on quantized flag manifolds. The latter are given by certain coideal subalgebras  $O_q(G/P)$  of quantized coordinate rings  $O_q(G)$ , but may equally well be understood from point of view of the certain quotients  $C_q(g/p)$  of the quantized universal enveloping algebra  $U_q(g)$ . These quotients are typically not algebras, but rather coalgebras, which raises the question whether there is a structure on the level of  $C_q(g/p)$ , which serves as a replacement for a differential calculus. We propose and answer to this question by introducing the notion of a codifferential calculus. In doing so, we will present various structure theorems which dualize known results for differential calculi and give explicit descriptions for codifferential calculi on quantized projective spaces, which dualize the antiholomorphic Heckenberger-Kolb calculi.

**Vinicius Bernardes:** *Covariant phase space and  $L_\infty$  algebras*

The covariant phase space is a powerful formalism to derive the symplectic structure of field theories. However it is not clear how to apply it on theories with non-local interactions. I will present a new construction of the symplectic form for any theory described with  $L_\infty$  algebras, including Wilsonian effective theories and String Field Theory. Based on arXiv:2506.20706.

**Pierre Bieliavsky:** *Symplectic and contact symmetric spaces*

**Eugenia Boffo:** *Cartan takes over BV Laplacians*

BV algebras are a special case of Gerstenhaber algebras with a second order differential, the BV Laplacian  $\Delta$ . They are important for the purpose of integration in the quantization of gauge theories. A fundamental property is that the BV Laplacian fails to derive the product and this is

measured by the bracket  $\{-, -\}$ . In this work in progress with Domenico Fiorenza, we stress that the relation of  $\{-, -\}$  and  $\Delta$  results from the existence of a Cartan calculus. Our working examples are odd symplectic supermanifolds and cyclic Hochschild cochains. In the former case, we shall exploit a result of Ševera, who showed that the BV Laplacian is a differential on a second page of a spectral sequence.

**Frederik Ďalák:** *Generalized Palatini formalism*

Palatini formalism in classical geometry is a well-known approach to obtain the equations of general relativity by considering both the metric and the connection as independent variables in the action. Recently, this formalism has been shown to transcend remarkably well into the setting of generalized geometry. Our aim here is to highlight the advantages the formalism has in the generalized setting compared to the classical one and outline the directions of research where it could be applied.

**Antonio Del Donno:** *Lusztig differential calculi on the non-irreducible quantum flag manifolds*

**Martin Doležal:** *Finite Lie algebra of vector fields in 3-link snake robot model*

The 3-link snake-robot model is described by a rank-2 bracket-generating distribution on a 5-dim configuration space and is the standard example of a  $(2, 3, 5)$ -geometry. Consequently it admits a parabolic geometry description and one can algorithmically compute its normalized Cartan connection. For a special choice of two vector fields spanning the distribution, depending on the link lengths and wheel positions as parameters, these vector fields generate a finite-dimensional Lie subalgebra of the infinite-dimensional algebra of all vector fields. This Lie algebra structure allows us to simplify the computation of the parameter-dependent normalized Cartan connection and could be used to find parameters for which it forms a homogeneous model. Moreover, it allows us to think about an extension of the model that admits a local Lie group structure.

**Martha Valentina Guarín Escudero:** *Fedosov connections and L infinity algebras associated with dg manifolds*

In this talk, we discuss the construction of L-infinity algebras on the space of vector fields of a dg-manifold. By using similar ideas of Fedosov's approach to deformation quantization, we first construct a curved L-infinity algebra. This relies on defining a "Fedosov connection," closely related to the Spencer operator on the jet bundle of vector fields. In the second part of the talk, we discuss another L infinity-algebra structure introduced by Stiénon, Xu, and Seoul, and compare it with our construction.

**Anton Galaev:** *On holonomy of contact sub-Riemannian manifolds*

Given a contact sub-Riemannian manifold  $(M, \theta, g)$ , where  $\theta$  is a contact form on  $M$ , and  $g$  is a metric on the contact distribution  $D = \ker \theta$ , there is the Schouten connection, which defines parallel transport of vectors tangent to  $D$  along curves tangent to  $D$ . The holonomy group of this connection is called the horizontal holonomy group. The adapted connection (Tanaka-Webster connection) is an extension of the horizontal connection to a connection on the vector bundle  $D$  over  $M$ . I will show that in the K-contact case (which means that the Reeb vector field is a Killing one), the holonomy of the adapted connection is the holonomy of some Riemannian manifold, and the horizontal holonomy either coincides with the holonomy of the adapted connection, or it is a codimension-one normal subgroup of the later group. I will also present the classification in the case of pseudo-Hermitian spaces. I will discuss the question of existence of parallel horizontal spinors, examples, and consequences.

**Giovanni Gava:** *First-order differential calculi over braided Hopf algebras*

Woronowicz's theory of first-order differential calculi over Hopf algebras plays a central role in noncommutative geometry. In this talk, we show that the main results of this theory extend to Hopf algebras in a generic braided monoidal category. We formulate first-order differential calculi in the braided setting and establish braided analogues of Woronowicz's theorems. The category of Yetter–Drinfeld modules serves as a guiding example throughout the presentation. Finally, we indicate applications to smashed product calculi on bosonization Hopf algebras. This is joint work with Antonio Del Donno, Emanuele Latini, and Thomas Weber.

**Roman Golovko:** *Non-decomposable Lagrangian cobordisms of Legendrian knots*

The standard way to construct Lagrangian cobordisms between Legendrian knots in the contact  $S^3$  is by concatenating elementary cobordisms, which arise as traces of three moves in the front projection: Legendrian isotopy, the isolated standard-unknot birth (inducing a Lagrangian 0-handle attachment), and Legendrian surgery – also called a pinch move in reverse – which induces a Lagrangian 1-handle attachment.

We will construct non-regular (and hence non-decomposable) Lagrangian concordances between Lagrangian fillable Legendrian knots, as well as non-decomposable Lagrangian cobordisms of arbitrary genus between (stabilized) Legendrian knots. In addition, we will show that the relation defined by Lagrangian concordance when we restrict it to Lagrangian fillable Legendrian knots is not a partial order. This talk is based on joint works with Georgios Dimitroglou Rizell and Daniel Komarek.

**Zhangwen Guo:** *Distinguished exact Weyl structures on a path geometry*

A path geometry is a smooth family  $\mathcal{F}$  of unparametrized curves on a manifold  $N$  such that given a point and a line in the tangent space at the point, there is precisely one curve through the point tangent to the line. Such a geometry encodes an equivalence class of systems of second order ODEs. Formally, a path geometry is defined as a pair  $E \oplus V$  of distributions on the projectivized tangent bundle  $\mathcal{PTN}$  in a way analogous to Lagrangian contact geometry.

We associate to every smooth parametrization of  $\mathcal{F}$  a so-called exact Weyl connection. We present it as the unique affine connection preserving the general and the chosen geometric data and, in addition, its torsion satisfies a certain collection of normalizing conditions. Thus we obtain an analog of the Webster–Tanaka connection on a CR geometry associated to a contact form.

Moreover, we say that an exact Weyl connection is distinguished if its curvature vanishes upon inserting two sections of  $E \oplus V$ . We prove that locally, there is a one-to-one correspondence between distinguished exact Weyl connections and submersions  $x_0 \in C^\infty(N)$ . The latter encodes the parametrization of the subset  $\{\gamma \in \mathcal{F} : dx_0(\dot{\gamma}) \neq 0\}$  of curves by  $dx_0(\dot{\gamma}) = 1$ .

The presentation is based on my ongoing project jointly with Andreas Cap.

**Owen Gwilliam:** *Correspondences between 6d and 2d theories: from Deligne to Witten via Beilinson and Drinfeld*

**Leszek Hadasz:** *Intersection theory and Kontsevich-type (super)matrix integrals.*

In my talk I will report on a progress in relating the intersection theory of the moduli spaces of (super)curves to Kontsevich type matrix integrals.

**Pavel Hajek:** *Computational experiments at Wolfram Institute*

The Wolfram Institute develops theory and tools for computational experiments with discrete systems, where repeated applications of simple rules and the systematic treatment of ambiguities

results in the emergence of structures interpretable in both mathematical and physical terms. I will present core paradigms of our approach, give a brief overview of our projects, and delve into a specific topic (likely an attempt to reconstruct space-time like geometry from hypergraph rewriting, or to construct higher Lie structures through surgery on hypergraphs and relate algebraic relations to confluence in multiway systems).

**Ondrej Hulik:** *TBA*

**Goce Chadzitaskos:** *Parabolic cylinder functions as orthonormal bases on  $L^2(R_+)$  and  $L^2(R)$*

In addition to orthogonal polynomials, orthogonal functions play an important role and have a wide range of applications. They are related to the solution of differential equations. In this contribution, we present the explicit form of one-parameter families of orthonormal bases in the spaces  $L^2(R_+)$  and  $L^2(R)$ . These bases are formed using the eigenvectors of the self-adjoint extension of the Schroedinger operator. For each choosing parameter, the set of eigenvectors forms an orthonormal basis. In both cases, the Hermite polynomials are obtained using special parameters.

**Chen-Hsu Chien:** *Double Cover  $SL(2, C)$  Gravity*

I formulate four-dimensional gravity with cosmological constant as a Cartan gauge theory for  $G = Spin(4, 1)$  or  $G = Spin(3, 2)$ , with Lorentz subgroup  $H = Spin(3, 1) \simeq SL(2, C)$ . The Cartan connection is written in a chiral block form combining the left/right  $SL(2, C)$  spin connections with the soldering form in the off-diagonal sector. A MacDowell–Mansouri action built from the Lorentz-projected curvature yields Einstein–Cartan gravity plus  $\Lambda$  and a topological term, while making the double-cover (spinorial) structure manifest.

**Ioannis Chrysikos:** *Adapted connections with skew-torsion on metric  $f$ -manifolds*

**Lorenz Jetter:** *Generalized Ricci Solitons on the Five Dimensional Heisenberg Algebra*

We classify all harmonic generalized Ricci solitons on the five dimensional Heisenberg algebra up to automorphisms. The talk is based on work in-progress as part of my Ph.D. project supervised by Vicente Cortés and Shubham Dwivedi.

**Jakub Knesel:** *Algebraic Topology and Representation Theory of Complex Flag Manifolds of the  $B, C, D$  Series*

We study embeddings of complex flag manifolds of the classical Lie types  $B, C, D$ . In particular, we are interested in computing the Chern classes of normal bundles of these embeddings in terms of the cohomology generators dual to the Schubert cells appearing in the CW decomposition of these manifolds. We begin the talk by briefly recalling the algebraic topology of complex flag manifolds of the  $A$  series. Namely, we recall their CW decomposition into Schubert cells and the multiplicative structure of their cohomology rings. We then use this data to equip the flag manifolds of the series  $B, C, D$  with a particularly nice CW structure, from which we can immediately deduce the additive structure of their cohomology. Finally, we use the obtained information to compute the Chern classes of the normal bundles of embeddings of the  $B, C, D$  series flag manifolds. We would like to point out that the knowledge of the cup product on the  $B, C, D$  series flag manifolds is not needed for obtaining these results.

**Hubert Kołcz:** *Lie–Poisson Geometric Criteria for Classical Optical Emulation in Measurement-Based Quantum Computing*

Measurement-Based Quantum Computing (MBQC) operates through adaptive single-qubit measurements on pre-entangled cluster states, providing a distinct paradigm from gate-based

quantum computation. Photonic MBQC, with qubits encoded in polarization states on the Poincaré sphere, leverages linear optical components and probabilistic entangling operations from the KLM paradigm to generate cluster states.

Interestingly, certain classical optical systems can emulate stabilizer-like correlations using spatial and polarization modes, replicating linear optical matrix operations without genuine multi-photon entanglement. This overlap poses a fundamental question: under what precise conditions can MBQC algorithms be reproduced using purely classical optical means?

This research proposal introduces a Lie–Poisson geometric framework aimed at systematically establishing criteria for classical emulation of MBQC algorithms. By leveraging the symplectic and Poisson geometric structures underlying quantum state evolution and error correction, the study seeks to identify mathematical boundaries between true quantum advantage and classical simulability for photonic MBQC. This approach will also clarify the connections between error correction formalism and classical emulation, enabling rigorous differentiation of quantum resources from their classical counterparts.

**Daniel Komárek:** *About lengths of Lagrangian cobordisms between Legendrian knots*

We will define basic notions in contact geometry and subsequently we define Legendrian contact homology. In addition, we provide an outline how to construct LCH capacities and show how to measure lengths of Lagrangian cobordism between Legendrian knots.

**Oleksii Kotov:** *Graded geometry: local and global approaches*

The talk will focus on manifolds graded by abelian groups or, more generally, by commutative monoids. While the categories of graded vector spaces (and algebras within these categories) can be defined unambiguously, the corresponding geometric objects admit several possible formulations. Using the examples of  $\mathbb{Z}$ -graded and  $\mathbb{Z}_2^2$ -graded manifolds, we shall discuss differences between these definitions and their resulting properties.

**Jan Kotrbatý:** *Invariant valuations on Lie groups*

The notion of valuation, that is, finitely additive measure on the space of convex bodies in a vector space, is of central importance in convex geometry. In a series of papers from the 2000s, Alesker discovered a natural product of translation-invariant valuations and extended the theory of valuations from vector spaces to manifolds. Remarkably, if the manifold is a Lie group, then the space of bi-invariant valuations carries another product, the so-called convolution. It was constructed by Bernig and Fu for vector spaces and by Alesker and Bernig for compact groups. In a joint work with Andreas Bernig and Dmitry Faifman we classify the Lie groups admitting a non-trivial space of bi-invariant valuations and then define the convolution for a general unimodular Lie group, thus unifying the two previously defined convolution operations.

**Andrey Krutov:** *Group valued moment maps for linear  $G$ -(super)manifolds*

Let  $G$  be a simple Lie group, and  $\mathfrak{g}$  its Lie algebra. It is well known that a  $G$ -module  $V$  carrying a nondegenerate invariant bilinear form gives rise to a Hamiltonian Poisson space with a quadratic moment maps  $\mu$ . We show that under condition  $\text{Hom}_{\mathfrak{g}}(\wedge^3 V, S^3 V) = 0$  this space can be viewed as a quasi-Poisson space with the same bivector, and with the group valued moment map  $\Phi = \exp \circ \mu$ . Furthermore, we show that by modifying the bivector by the standard  $r$ -matrix for  $\mathfrak{g}$  one obtains a space with a Poisson action of the Poisson-Lie group  $G$ , and with the moment map in the sense of Lu taking values in the dual Poisson-Lie group  $G^*$ .

Based on the joint work with A. Alekseev (Geneva), arXiv:2507.19434

**Svatopluk Krysl:** *Symplectic spinors – quantization and new results*

Symplectic Dirac operators are parallel to the classical Riemannian or pseudoriemannian Dirac operators, but they act on smooth fields/sections with values in a Hilbert space of infinite dimension, called the space of symplectic spinors. Symplectic spinors have relevant features concerning quantization, developed by Habermann and Klein. Besides them, we explain some new results concerning complexes of symplectic twistor operators accompanying the Dirac ops.

**Roman Lávička:** *Massless fields in Euclidean spaces*

The talk is based on joint work with F. Brackx, H. De Schepper, V. Souček and W. Wang. Classical Clifford analysis provides a rich function theory of the Dirac equation in Euclidean spaces for spin  $1/2$  fields. For any spin, as a proper analogue of the massless field equations in Euclidean spaces, the so-called generalized Cauchy–Riemann equations (GCR) have been recently considered. In this talk, we explain recent results about solutions of GCR in dimensions 4 and 6.

**Hong Van Le:** *Minimal unital cyclic  $C_\infty$ -algebras and the real homotopy type of closed manifolds*

We show that the minimal unital  $C_\infty$ -algebra obtained from a Poincaré graded commutative algebra admitting a Hodge homotopy in our previous work with Domenico Fiorenza is cyclic. As a result, we give a new proof of a theorem due to Crowley–Nordström that a  $(r - 1)$  connected closed manifold  $M$  of dimension  $4r - 1$  with  $b_r(M) \leq 3$  is intrinsically formal, if there is a  $\varphi \in H^{2r-1}(M)$  such that  $H^n(M) \rightarrow H^{3n-1}(M), x \mapsto \varphi(x)$ , is an isomorphism. This result is a strengthening of a result by Cavalcanti stating that under the same condition, all the Massey products vanish uniformly. We give a new proof and an extension of Cavalcanti’s result that a  $(r - 1)$  connected closed manifold  $M$  of dimension  $4r$  with  $b_r(M) \leq 2$  is intrinsically formal, if there is a  $\varphi \in H^{2r-1}(M)$  such that  $H^r(M) \rightarrow H^{3r-1}(M), x \mapsto \varphi(x)$ , is an isomorphism. Finally, we give a classification of real homotopy types of closed connected, simply connected smooth manifolds  $M$  with the same cohomology algebra  $H^*(M, \mathbb{R})$  in terms of a sequence of obstruction classes. This is a joint work with Domenico Fiorenza.

**William Giuseppe Alessandro Luciani:** *Conformal supergravity as a super Cartan connection*

This is the subject of an ongoing project of Ingmar Saberi, Fabian Hahner and myself. Recently, a general formalism has appeared in the literature for describing the conformal supergravity multiplet in various dimensions. In particular, in the formalism the field content is given by an  $L_\infty$  algebra related to the formal moduli problem of deformations of a superconformal structure. In the bosonic case, the field content of gravity is given by a metric which is equivalent to a Cartan connection of a certain type. One thus anticipates a description of the conformal supergravity multiplet as a super Cartan connection. I’ll start by briefly describing the use of  $L_\infty$  algebras for field theories, I then define the necessary geometric structures and illustrate the bosonic equivalence.

**Myriam Mahaman:** *Rings of differential operators and Hopf algebroids*

Let  $A$  be an algebra over a commutative ring  $k$ . It is well-known that the ring of differential operators over  $A$  is a Hopf algebroid when  $A$  is smooth over  $k$ . We would like to investigate what happens when  $A$  is not smooth. In this talk, I will introduce a sufficient condition for the existence of a Hopf algebroid structure on the ring of differential operators and provide some explicit examples to illustrate the condition.

**Grigory Mikhalkin:** *Tropical trigonometry*

**Filip Moučka:** *Courant algebroid lifts and curved Courant algebroids*

Given a Courant algebroid on a bundle of the form  $TM+E$ , we describe a natural construction

of a pairing, an anchor, and a bracket on  $TE$  using a vector bundle connection on  $E$ . In general, this resulting structure on  $TE$  fails to satisfy all Courant algebroid axioms, which leads us to introduce the notion of a curved Courant algebroid. We identify the precise obstruction to obtaining an actual Courant algebroid and provide several illustrative examples related to the Patterson–Walker metric, special complex geometry, and Poisson geometry. This talk is based on joint work with Roberto Rubio, arXiv:2511.04743.

**Gabriele Novelli:** *The Geometry of the Yang–Mills Theory*

This work focuses on the mathematical formalization of gauge theories, with a particular focus on the Yang–Mills theory. The underlying framework of gauge theories is differential geometry, including smooth manifolds, Lie groups and algebras, fiber bundles, and connections. Special attention is given to principal bundles and their associated bundles, as these provide the language for formulating gauge fields and curvature, interpreted respectively as gauge bosons and field strength tensors in physics. The work studies the necessary concepts to construct gauge theories on flat and curved spacetimes and generalizes the Maxwell Lagrangian to non-abelian  $SU(n)$  gauge groups. This approach highlights the central role of geometry in modern theoretical physics and the deep connections between mathematics and the fundamental interactions described by the Standard Model.

**Marcella Palese:** *Invariant variational problems and cohomology*

The interplay of inverse variational problems with invariance properties is exploited. We focalize on symmetries of globally defined locally variational field equations and find conditions for the variation of local Noether strong currents to be conserved and variationally equivalent to a global conserved current.

**Pavle Pandzic:** *Covariant algebra attached to four qubits*

We show how to obtain generators and relations for the algebra of  $U(2)^4$ -highest weight vectors in polynomials on  $\mathbb{C}^{\otimes 4}$ . Besides methods from representation theory, we also use a computer. This is joint work in progress with Jing-Song Huang and Soo Teck Lee.

**Ana Prlić:** *Unitary Highest Weight Modules with Fixed Infinitesimal Character*

We study unitary highest weight  $(\mathfrak{g}, K)$ -modules for a noncompact, connected, simply connected simple Lie group  $G$ , assuming  $(G, K)$  is a Hermitian symmetric pair. Each such module is determined by a highest weight  $\lambda$ , with infinitesimal character  $\Lambda = \lambda + \rho$ . We present a criterion for when a parameter  $\Lambda$ , conjugate to its  $\mathfrak{g}$ -dominant representative, corresponds to a unitary module and also provide a new, more elementary proof of the classification of unitary highest weight modules originally obtained by Enright–Howe–Wallach and independently by Jakobsen. The talk is based on joint work with Pavle Pandžić, Gordan Savin, Vladimír Souček, and Vít Tuček.

**Tomáš Procházka:** *W-algebras and ODE/IM correspondence*

I will discuss how certain aspects of integrable structure of 2d conformal field theory are captured by ordinary differential equations (ODE/IM correspondence). In particular, the WKB expansion of the corresponding ODE encodes the local integrals of motion of the 2d CFT.

**Jan Pulmann:** *Graded Necklace Lie Bialgebras and Batalin–Vilkovisky Formalism*

I will report on a joint work with N. Perry on necklace Lie bialgebras associated to a double of a quiver. These bialgebras can be encoded in a Batalin–Vilkovisky operator on shifted symmetric powers of the necklace Lie bialgebra. We construct a flat Batalin–Vilkovisky structure on the representation variety of this quiver and provide a morphism of Batalin–Vilkovisky algebras, an

infinitesimal analogue of the Wilson loop observable.

**Andrea Rivezzi:** *Hopf categories associated to comonoidal functors*

In 2016, P. Ševera (Sel. Math. 22(3), 1563–1581) provided a new construction of Hopf monoids based on the notion of  $M$ -adapted functor, leading to a new approach to the solution of the problem of finding a universal quantization of Lie bialgebras. In this talk, I present a recent extension (Appl. Cat. Struct. 34 (7), 2026) of Ševera's result, which allows us to build Hopf categories starting from a comonoidal functor.

**Paolo Rossi:** *Entanglement Entropy through Topological Defects in 2d Rational CFT*

Defects and interfaces have drawn much attention in the past decade, and appear in many applications both in high energy and condensed matter physics. One way to quantify their impact on quantum correlators is by computing Entanglement Entropy (EE) in presence of a defect network. We investigate subleading contributions (known to encode the interplay between boundaries, defects and bulk excitations) in the EE in presence of topological defects, specifically in twisted excitations. We work in the BCFT approach to EE, and extend it to when the system requires the specification of a defect network. The latter is particularly relevant in the case of non-invertible defects, such as the duality defect in the Ising model. For the 2d critical Ising model, our results show agreement with existing numerical simulations. This resolves a long-standing tension between previous theoretical analyses and numerics.

**Ingmar Saberi:** *Derived perspectives for the practically-minded: an introduction through examples*

**Josef Silhan:** *A compatibility complex in conformal geometry*

In the locally flat case, the BGG-complex is a compatibility complex for the conformal-to-Einstein operator. We consider the 'opposite' case when the Weyl tensor is (in a suitable sense) generic and construct a compatibility complex in this setting. This is a joint work with I. Khavkine.

**Rudolf Smolka:** *Frobenius theorem for  $Z$ -graded manifolds*

One of the fundamental theorems in differential geometry, the Frobenius theorem, is often stated in two parts. The so-called local Frobenius theorem states that a smooth distribution is involutive if and only if it is integrable. The so-called global Frobenius theorem then states that every integrable distribution is given by a unique regular foliation. In this talk we revisit the theorem in the category of  $Z$ -graded manifolds, though the discussion applies to other gradings as well. We will see that one needs to be careful with the definition of integrable distribution and integral submanifold. These can be given in several ways that are equivalent in non-graded geometry, but not so in graded geometry.

**Vladimir Souček:** *Integrability conditions for Grushin distributions*

**Aleksy Tralle:** *Topology of Sasakian and  $K$ -contact manifolds*

I will give a series of lectures on "Galicki-Boyer" program of studying topological properties of metric contact manifolds.

**Fridrich Valach:** *Courant contact models and the Costello-Li conjecture*

We extend the conjecture of Costello and Li on the twisting of supergravity on a Calabi-Yau 5-fold to an arbitrary supergravity background. This in particular leads to a generalisation of the Courant algebroid theory beyond the smooth or holomorphic setup. This is a joint work with J. Kupka, I. Saberi, and C. Strickland-Constable.

**Petr Vlachopoulos:** *The Cheeger constant of curved tubes in complex space forms*

**Rikard von Unge:** *Gauged linear sigma models and Ricci flat metrics.*

I will describe a new construction of Ricci flat metrics using gauged linear sigma models satisfying the Calabi–Yau condition.

**Jan Vysoky:** *Flows on Graded Manifolds*

In ordinary differential geometry, every vector field has its unique maximal flow. It is obtained as a collection of solutions of systems of ordinary differential equations. One can expect similar structures arising in theory of graded manifolds. This requires one to view flows as local actions of graded Lie groups. We prove that flows (sometimes) exist and examine their properties and possible applications. This is a work in progress.

**Thomas Weber:** *Vector fields in noncommutative differential geometry*

We give a gentle introduction to noncommutative differential geometry, an algebraic generalization of differential geometry, which develops concepts, like differential forms and principal bundles, for certain classes of algebras, e.g. Hopf algebras. Our focus is the notion of vector field in this algebraic setup. We explain that noncommutative vector field calculi are dual to differential calculi, in the sense that there is a categorical adjunction. Moreover, there is a universal vector field calculus, which is a terminal object in the category, i.e., every vector field calculus is naturally a subobject of it. To illustrate the approach, we discuss examples of vector field calculi on finite sets, the noncommutative 2-torus and quantum  $SL(2)$ . This talk is based on work in progress with Rita Fiorese and Emanuele Latini.

**Hartwig Winterroth:** *From generalized principal connections to generalized Yang–Mills theories*

Aiming at the development of an instance of generalized mathematical gauge theories, we provide a characterization of Lie group fiber bundle connections and generalized principal connections in order to obtain the local coordinate representation of all such structures. In particular, studying the curvature of generalized principal connections, we specialize the Bianchi identities obtaining a generalized version of the classical homogeneous field equations. As an application, we prove also that vector bundles are an example of generalized principal bundles, that a generalized principal connection on a vector bundle is an affine connection and that the generalized homogeneous field equations can be rephrased, in this case, in terms of basic soldering forms and torsion tensors. Finally, resorting to gauge theories and variational calculus on fiber bundles, we propose a first approach to (an instance of) generalized Yang–Mills theories. We accordingly prove that the corresponding variational field equations (i.e. Euler–Lagrange equations) generalize the usual Yang–Mills equations. While generalized Yang–Mills theories need more developments to give a full answer, we expect that the Einstein equations can be formulated ultimately as an example of generalized Yang–Mills equations. This is a joint work with Lorenzo Fatibene.

**Lenka Zalabová:** *Conserved quantities of loxodromes*

We study conserved quantities of special loxodromes. This is a joint project with Prim Plansangkate.

**Martin Zika:** *Renormalization Group Flow and Homotopy*

According to the philosophy of Kevin Costello, a perturbative quantum field theory should be understood as a family of effective theories at different energy scales related by the renormalization group flow. The renormalization group equation describes how to get an effective theory at a low energy scale from one at a higher energy scale—by averaging over high energy

fields. We will show how in Batalin–Vilkovisky formalism this can be understood as a homotopy of quantum  $L$  infinity algebras. As an application, this gives a new proof of the decomposition theorem and span construction. We will sketch how this can be interpreted using the quantum odd symplectic category.

**Alexander Zuevsky:** *Cyclic cohomology interpretation of a topological invariant in QFT*

We give a cyclic cohomology/noncommutative–geometric interpretation of an integral topological invariant related to Quantum Hall Effect. The integrand defines a cyclic 3–cocycle (a Chern character) which pairs with the  $K$ –class of the Green’s operator, producing an integer–valued topological invariant when the system is gapped. The construction generalizes the TKNN/Chern–number picture to varying magnetic fields and to the Wigner–Weyl (Moyal) star–product setting. (Joint work with M.A. Zubkov)

## GENERAL INFORMATION

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