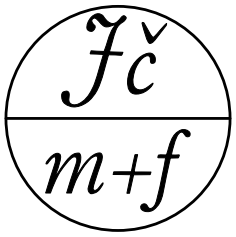
THE 40th WINTER SCHOOL
GEOMETRY AND PHYSICS

SRNÍ, CZECH REPUBLIC

JANUARY 11–18, 2020



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Alexander Zuevsky
Vojtěch Žádník

ANNOUNCED LECTURES

A. Invited lectures

Anton Alekseev: *Goldman-Turaev formality and the Kashiwara-Vergne problem*

Peter Bouwknegt: *Higher spin algebras*

Andreas Čap: *Parabolic geometries and geometric compactifications*

Theodore Erler: *String field theory*

Luca Rizzi: *An introduction to sub-Riemannian geometry and optimal transport*

Martin Roček: *Domain walls and dualities in 3 dimensions*

Christian Saemann: *Perturbative Quantum Field Theory with Homotopy Algebras*

B. Other lectures

Teresa Arias-Marco: *The inverse tomography problem on orbisurfaces*

Ľudovít Balko: *On the height of the third Stiefel-Whitney characteristic class of the canonical vector bundle of real Grassmann manifolds*

Mark Bugden: *Gauging Poisson-Lie T-duality*

Goce Chadzitaskos: *Family of orthogonal bases in* $L^2(\mathbb{R}^+)$

Maciej Dunajski: *Conformal Geodesics*

Zdeněk Dušek: *Homogeneous geodesics in homogeneous Finsler manifolds*

José Manuel Fernández-Barroso: *Can one determine symmetric-like properties from the Laplacian spectrum?*

Andrea Gagna: *Higher categorical methods in geometry*

Roman Golovko: *On holomorphic Cthulhu*

Jan Gregorovič: *On distinguished connection on Levi kernel of 2-nondegenerate CR geometries with simple model*

Leszek Hadasz: *Classification of Airy structures*

Ondřej Hulík: *TBA*

Igor Khavkine: *Initial data for closed conformal Killing-Yano 2-forms*

Svatopluk Krýsl: *Elliptic operators on homogeneous bundles*

Radoslaw Kycia: *The Poincare lemma, antiexact forms, and fermionic quantum harmonic oscillator*

Tom Lada: *TBA*

Roman Lávička: *TBA*

Hong Van Le: *The* $SL(9,\mathbb{R})$*-orbit space of trivectors on* $\mathbb{R}^9$ *and Galois cohomology*

Renann Lipinski Jusinskas: *Chiral strings, the sectorized interpretation and their integrated vertex operators*

Tibor Macko: *Cobordisms of chain complexes*

Omid Makhmali: *TBA*

Rouzbeh Mohseni: *Symmetries of twistor space of a self-dual conformal 4-fold*

Rafael Mrđen: *BGG complexes in singular blocks of category O*

Jiří Nárožný: *Simplicial principal bundles and higher connections*

Jan Novák: *Quiver mutations in string theory*

Réamonn Ó Buachalla: *A Bott–Borel–Weil theorem for the irreducible quantum flag manifolds*

Pavle Pandžić: *Dirac index and associated cycles of Harish-Chandra modules*

Lada Peksová: *BV-algebras and homological perturbation lemma*

Tomáš Procházka: *W algebras*

Tomáš Rusin: *Cohomology rings of some oriented Grassmann manifolds*

Tomasz Rybicki: *Hofer type metrics in the case of Poisson manifolds*

Tomáš Salač: *TBA*

Martin Schnabl: *Higher structures and effective field theory*

Eivind Schneider: *Differential invariants in thermodynamics*

Jan Slovák: *TBA*

Dana Smetanová: *TBA*

Vladimír Souček: *Syzygies for the Dirac operator in several variables in non-stable range*

Josef Šilhan: *TBA*

Fridrich Valach: *Ricci tensor in graded geometry*

Jiří Vanžura: *Isotropic subspaces in split-quaternions and split-octonions*

Luca Vitagliano: *Generalized Contact Bundles and Their Local Structure*

Lukáš Vokřínek: *Homotopical cocompleteness of accessible categories with enough limits*

Rikard von Unge: *$T\overline{T}$ deformations and Supersymmetry*

Jakub Vosmera: *Superstring moduli from string field theory*

Jan Vysoký: *Courant algebroid morphisms revisited*

Lenka Zalabová: *Symmetries in geometric control theory*

Václav Zatloukal: *Real spinors and real Dirac equation*

Alexander Zuevsky: *Genus g deformed Eisenstein series*

Vojtěch Žádník: *On conformal Killing fields and their trajectories*

ABSTRACTS

Teresa Arias-Marco: *The inverse tomography problem on orbisurfaces*
The Steklov problem has been deeply studied on compact Riemannian manifolds with boundary and it has applications in electrical impedance tomography.
During the talk, we will focus the attention in the last result obtained on 2-dimensional Riemannian manifolds with orbifold singularities, related with this problem. We will also present some other new connected results.

Ľudovít Balko: *On the height of the third Stiefel-Whitney characteristic class of the canonical vector bundle of real Grassmann manifolds*
We compute values of the third Stiefel-Whitney characteristic class of the canonical vector bundle over Grassmann manifolds of five dimensional subspaces of $(n+5)$-dimensional real vector space.

Goce Chadzitaskos: *Family of orthogonal bases in $L^2(\mathbb{R}^+)$*
One–parameter family of orthogonal bases in $L^2(\mathbb{R}^+)$ is derived. The main theorem and proof are presented.

Andreas Čap: *Parabolic geometries and geometric compactifications*
This series of talks will start with an introduction to the concept of Cartan geometries. We will describe the canonical Cartan geometry associated to a conformal structure in detail and then sketch the passage to general parabolic geometries. In the second lecture, we introduce conformally compact metrics and Poincare-Einstein metrics and show how the tools of conformal geometry can be used to obtain a highly effective description of such structures. We will briefly sketch the resulting boundary calculus and applications to invariants of hypersurfaces in conformal manifolds due to Gover-Waldron. This description admits an interpretation in terms of a holonomy reduction of the conformal Cartan connection and the general theory of such reductions will be discussed in the beginning of the third lecture. A short discussion of projective compactness and of applications of holonomy theory of Cartan connections to the study of compactifications of symmetric spaces concludes the series of lectures.

Maciej Dunajski: *Conformal Geodesics*
I shall discuss the integrability of the conformal geodesic flow (also known as the conformal circle flow) on some gravitational instantons, and provide a first example of a completely integrable conf. geodesic flow on a four-manifold which is not a symmetric space.

Zdeněk Dušek: *Homogeneous geodesics in homogeneous Finsler manifolds*
Recent results about homogeneous geodesics in homogeneous Finsler manifolds will be presented.

José Manuel Fernández-Barroso: *Can one determine symmetric-like properties from the Laplacian spectrum?*
The solutions of the classical closed eigenvalue problem of the Laplace–Beltrami operator can give us some geometrical information in a closed Riemannian manifold without boundary. There are properties which one can determine from the spectrum, for example the volume of the manifold. However, there are other properties which cannot be determined from such spectrum as the weak local symmetry or being a type $\mathcal{A}$ manifold, proved by T. Arias–Marco and D. Schueth.
Continuing the study about which properties can be determined in a closed Riemannian manifold from the spectrum of the Laplacian, we focus our attention on the symmetric-like properties.

Joint work with Teresa Arias–Marco.

Andrea Gagna: *Higher categorical methods in geometry*
Recent advances on geometric Langlands, derived geometry, unstable homotopy theory and TQFT require some higher 2-categorical tools, that are so far not developed. In this short talk I will sketch some work in progress focused on making these tools precise and prove their basic properties.

Roman Golovko: *On holomorphic Cthulhu*
In this talk we present the definition of Floer theory for Lagrangian cobordisms (Cthulhu homology) and its applications. This is joint work with Baptiste Chantraine, Georgios Dimitroglou Rizell and Paolo Ghiggini.

Jan Gregorovič: *On distinguished connection on Levi kernel of 2-nondegenerate CR geometries with simple model*
I will consider a 2-nondegenerate CR geometry that can be (at every point) modeled on a homogeneous space G/H, where G is simple Lie group. I will show that on the Levi kernel of this CR geometry, there is a distinguished (partial) connection that preserves the CR geometry along the Levi kernel and provides a structure of a Hermitian symmetric space to each leaf of the Levi kernel. This connection simplifies the construction of the absolute parallelism that is solving the equivalence problem of such CR geometries.

Leszek Hadasz: *Classification of Airy structures*
Quantum Airy structures, a set of at most quadratic differential operators spanning a Lie algebra, were introduced by Maxim Kontsevich and Yan Soibelman as a reformulation and generalization of the Chekhov-Eynard-Orantin topological recursion. In my talk I will define them, give some examples illustrating their relevance in mathematical physics and present a complete classification of Airy structures for finite dimensional, simple Lie algebras.

Igor Khavkine: *Initial data for closed conformal Killing-Yano 2-forms*
It is well-known that Killing-Yano p-forms give rise to conserved fermionic charges for a supersymmetric extension of geodesic motion, and also that the Hodge dual of a Killing-Yano p-form is a closed conformal Killing-Yano (n-p)-form (cCYK). Interestingly, the Einstein vacuum solutions with a non-degenerate cCYK 2-form are known to be exhausted by the Kerr-NUT-(A)dS family of higher dimensional rotating black holes. Using an exhaustive search, we identify a family of propagation identities for the cCYK equation on 2-forms in $n>4$ dimensions. These identities allow us to characterize Einstein equation initial data whose development admits a cCYK.

Svatopluk Krýsl: *Elliptic operators on homogeneous bundles*
We shall describe partly new results concerning elliptic operators on Hilbert bundles.

Radoslaw Kycia: *The Poincare lemma, antiexact forms, and fermionic quantum harmonic oscillator*
I will present the connection between Poincare lemma and homotopy operator defined by Edelen. This will be used to determine functional calculus (Bittner's operator calculus), which, in the case of a homotopy operator, resembles quantum fermionic oscillator algebra. I will also present a topological/chain complex version of a homotopy operator. Finally, I will show how this operator calculus looks in the setup of complex manifolds and how it 'interacts' with the Dolbeault complex. The talk is based on: Radoslaw Kycia, 'The Poincare lemma, antiexact forms, and fermionic quantum harmonic oscillator', arXiv:1908.02349 [math.DG]

Hong Van Le: *The $SL(9,\mathbb{R})$-orbit space of trivectors on $\mathbb{R}^9$ and Galois cohomology*
A classification of 3-vectors on $\mathbb{R}^9$, understood as a description of the orbit space of the standard $GL(9,\mathbb{R})$-action on $\Lambda^3\mathbb{R}^9$, is related to geometry defined by 3-forms in dimensions up to 9 and to the θ-representation of the $\mathbb{Z}_3$-graded split Lie algebra $e_{8(8)}$. In this talk I shall outline a method of classification of 3-vectors on $\mathbb{R}^9$ based on Vinberg-Elashivili classification of 3-vectors on $\mathbb{C}^9$ and on our joint work in progress with M. Borovoi and W. de Graaf, in which we utilize Galois cohomology to find real forms of a complex orbit.

Renann Lipinski Jusinskas: *Chiral strings, the sectorized interpretation and their integrated vertex operators*
A chiral string can be seen as an ordinary string in a singular gauge for the worldsheet metric and has the ambitwistor string as its tensionless limit. As proposed by Siegel, there is a one-parameter (β) gauge family interpolating between the chiral limit and the usual conformal gauge in string theory. This idea was used to compute scattering amplitudes of tensile chiral strings, which are given by standard string amplitudes with modified (β-dependent) antiholomorphic propagators. Due to the absence of a sensible definition of the integrated vertex operator, there is still no ordinary prescription for higher than 3-point amplitude computations directly from the chiral model. The exception is the tensionless limit. In this talk I will present a proposal to fill this gap. Starting with a chiral string action, I will define the integrated vertex operator, relying on the so-called sectorized interpretation. As it turns out, this construction effectively emulates a left/right factorization of the scattering amplitude and introduces a relative sign flip in the propagator for the sector-split target space coordinates. N-point tree-level amplitudes can be easily shown to coincide with the results of Siegel et al.

Tibor Macko: *Cobordisms of chain complexes*
Ranicki introduced the notion of symmetric and quadratic structures on a chain complex which generalize the notions of a symmetric bilinear and a quadratic form on a module. Moreover, he introduced the notion of a cobordism of such chain complexes and showed that the cobordism groups of quadratic chain complexes agree with Wall L-groups from surgery theory. This was utilized in the construction of the total surgery obstruction TSO (X) of a finite Poincare complex X, an element of an L-group of a certain category with the property that it is zero if and only if X is homotopy equivalent to a closed topological manifold. We present a definition of many notions of Ranicki's theory via universal constructions and some ideas about the simplification of the proof of the main theorem about the TSO.

Rouzbeh Mohseni: *Symmetries of twistor space of a self-dual conformal 4-fold*
I will review the construction of a particular type of twistor space and then discuss its symmetries.

Rafael Mrđen: *BGG complexes in singular blocks of category O*
Using translation from the regular block, we construct and analyze properties of BGG complexes in singular blocks of BGG category O. We provide criteria, in terms of the Kazhdan-Lusztig-Vogan polynomials, for such complexes to be exact. In the Koszul dual picture, exactness of BGG complexes is expressed as a certain condition on a generalized Verma flag of an indecomposable projective object in the corresponding block of parabolic category O. This is a joint work with Volodymyr Mazorchuk.

Jan Novák: *Quiver mutations in string theory*
A quiver is a finite oriented graph, when we allow multiple edges but not loops nor oriented 2-cycles. We define quiver mutation and we study urban renewal, which has applications to gauge

theory, especially Seiberg duality action on brane tillings. We prove the following theorem: let P and P' be acyclic quivers mutation equivalent to each other; Then P can be transformed into a quiver isomorphic to P' via a sequence of mutations at sources and sinks. Consequently all acyclic quivers in a given mutation equivalence class have the same underlying undirected graph.

Pavle Pandžić: *Dirac index and associated cycles of Harish-Chandra modules*
We show how, for certain Harish-Chandra modules, the polynomial giving the dimension of the Dirac index of the corresponding coherent family can be expressed as an integer linear combination of the coefficients of the characteristic cycle. This is joint work with S. Mehdi, D. Vogan and R. Zierau.

Tomáš Rusin: *Cohomology rings of some oriented Grassmann manifolds*
We first present a brief overview of cohomology rings of $\widetilde{G}_{n,3}$. Then we directly compute generators of $H^*(\widetilde{G}_{n,4};\mathbb{Z}_2)$ for $n = 8, 9, 10, 11$ along with partial information about the ring structure and compare the results.

Tomasz Rybicki: *Hofer type metrics in the case of Poisson manifolds*
Given any symplectic manifold, the Hofer metric is a bi-invariant metric on the group of compactly supported Hamiltonian symplectomorphisms. Hofer geometry constitutes a basic tool in symplectic topology. Our aim is to generalize the Hofer metric to the case of Poisson manifolds, a non-transitive counterpart of symplectic manifolds. It is a rather easy observation that there exists an analogue of the Hofer metric on the Hamiltonian group of an arbitrary Poisson manifold. We also prove more interesting facts of the existence of Hofer type metrics on infinite dimensional Lie groups integrating the Lie algebra of closed 1-forms as well as of the Lie algebra of $C^\infty(M)$. Thus, the Hofer geometry could be considered in a much more general setting.

Martin Schnabl: *Higher structures and effective field theory*
I will discuss emergence of higher structures in effective field theories.

Eivind Schneider: *Differential invariants in thermodynamics*
It is well known that the phase space of thermodynamics comes naturally equipped with both a contact and a metric structure. This geometric view of thermodynamics has received some attention in the last decades. Less studied is an action of the affine group that seems to be appearing naturally in this context. We study this group action by investigating invariant tensors and by finding generators for the algebra of scalar differential invariants. In the end, we discuss the relation between the invariants and some well-known physical quantities in thermodynamics.

Vladimír Souček: *Syzygies for the Dirac operator in several variables in non-stable range*
The resolution starting with the Dirac operator D_k in k Clifford variables in $\mathbb{R}^n$ is understood in the stable range (when k is smaller or equal to half dimension). In this case, all syzygies for the operator D_k are of the second order. There are only a few facts known for non-stable range. In the lecture, higher order syzygies will be discussed as well as explicit form of the corresponding higher order differential operators in non-stable case. The results are based on cooperation with F. Colombo, L. Krump, R. Lavicka, and I. Sabadini.

Fridrich Valach: *Ricci tensor in graded geometry*
We define the notion of the Ricci tensor for NQ symplectic manifolds of degree 2 and show that it corresponds to the standard generalized Ricci tensor on Courant algebroids. We use an appropriate notion of connections compatible with the generalized metric on the graded manifold.

Jiří Vanžura: *Isotropic subspaces in split-quaternions and split-octonions*
The composition algebra $\tilde{\mathbb{H}}$ resp. $\tilde{\mathbb{O}}$ of split-quaternions resp. split-octonions is endowed with indefinite regular quadratic form with signature $(2, 2)$ resp. $(4, 4)$. We shall describe all isotropic subspaces in these algebras, divide them into various types, and also describe the moduli of these subspaces.

Luca Vitagliano: *Generalized Contact Bundles and Their Local Structure*
Generalized Contact Bundles are the odd dimensional analogues of Generalized Complex Manifolds. I will present the basics of Generalized Contact Geometry and discuss a local normal form theorem.

Lukáš Vokřínek: *Homotopical cocompleteness of accessible categories with enough limits*
An ∞-cosmos is, roughly speaking, a category enriched in simplicial sets (quasicategories) that satisfies certain completeness axioms. We will prove that any accessible ∞-cosmos admits suitably weak colimits - these are essentially homotopy colimits, further details will be given in the talk. More generally, the conclusion holds for accessible categories with enough limits, enriched in a monoidal model category; the result follows from the "weak adjoint functor theorem" that will be also proved.
Joint work with John Bourke and Steve Lack.

Jakub Vosmera: *Superstring moduli from string field theory*
We will review the construction of effective actions from string field theory by integrating out the modes which are killed by a BPZ-even projector. We will emphasize various aspects of the gauge-fixing procedure and the homotopy-algebraic side of the story. Focusing on the zero-momentum sector of superstring backgrounds which admit a global $\mathcal{N} = 2$ worldsheet superconformal symmetry, we will show that the computation of vertices of the effective action localizes on the boundary of the worldsheet moduli space. We will demonstrate the utility of our results in deriving algebraic constraints on the spacetime moduli.

Jan Vysoký: *Courant algebroid morphisms revisited*
In recent years, Courant algebroids had become a geometrical useful tool in string theory. As for any mathematical structure, one naturally attempts to establish the notion of Courant algebroid morphism. Although this was done twenty years ago, the most general definition remains relatively unknown. Similarly to the category of symplectic manifolds, the space of morphisms is not large enough. Based on the Weinstein's idea of symplectic "category" and its Lagrangian relations, one has to allow for a more general notion. This has its cost - not all morphisms can be composed. A generalization of this approach is presented. One can show that some relevant physical problems naturally fit into this framework, e.g. Poisson-Lie T-duality, Kaluza-Klein reduction of supergravity, or generalized geometry inclusion into para-Hermitian geometry (possible geometrical framework for DFT).

Lenka Zalabová: *Symmetries in geometric control theory*
We show possible application of symmetries of control systems on Lie groups. We focus on nilpotent approximations of systems for vertical rolling disc and generalized trident snake with filtration (4,7). We present our computations in CAS system Maple.

Václav Zatloukal: *Real spinors and real Dirac equation*
The real Clifford (or, geometric) algebra is a convenient tool to handle geometric objects, and study relations among them. In this talk I draw attention to spinors, both in space and in spacetime, and advocate the approach, in which they are regarded as elements of the even

subalgebra of a real Clifford algebra. With this formalism, I will reexamine the minimal coupling procedure in the Dirac equation, and argue that it leads naturally to a non-Abelian generalization of the electromagnetic gauge potential.

Alexander Zuevsky: *Genus g deformed Eisenstein series*
Using the theory of Szegő kernel on a genus g Riemann surfaces obtained as a result of the multiple ρ-parameter formalism of sewing of g handles to the complex sphere, we establish new recurrent formulas for genus g prime forms and Szegő kernels. Using the above results, we finally introduce a definition of genus g counterpart of genus one deformed Eisenstein series.

Vojtěch Žádník: *On conformal Killing fields and their trajectories*
We approach to conformal Killing fields via the associated families of integral curves and their conformal invariants. We formulate several conditions under which the trajectories are somehow special. General statements are further investigated in particular cases. The talk reports on a joint work with J. Silhan and L. Zalabova, which is still in progress.

GENERAL INFORMATION

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`http://conference.math.muni.cz/srni/`

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