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ANNOUNCED LECTURES

A. Main lectures

Ed Corrigan: *Calogero-Moser integrable systems*

Peter W. Michor: *Analysis and Geometry of Shape Spaces*

Valentin Ovsienko: *Lie antialgebras*

Claude Roger: *Gerstenhaber and BV algebras with cohomology, applications in geometry and field theory*

Konstantin Zarembo: *Spin chains and the AdS/CFT correspondence*

B. Other lectures

Teresa Arias-Marco: *Constant osculating rank vs. constant Jacobi osculating*

Klaus Bering: *A Comparative Study of Laplacians and Schroedinger-Lichnerowicz-Weitzenboeck Identities in Riemannian and Antisymplectic Geometry*

Adara-Monica Blaga: *Covariant and contravariant connections on TM and T^*M of a Poisson manifold (M, Π)*

Andreas Čap: *Affine holonomies and parabolic geometries*

Goce Chadzitaskos: *Quantization on compact spaces*

Lenka Czudková: *Lepage forms theory applied (with J. Musilova and M. Lenc)*

Jaroslav Dittrich: *On a chain of dynamical equations*

Zdeněk Dušek: *On the reparametrization of homogeneous geodesics*

Anton Galaev: *Irreducible complex skew-Berger algebras*

Matthias Hammerl: *TBA*

Jaroslav Hrdina: *Morphisms of almost complex projective geometries.*

Josef Janyška, Jan Vondra: *Natural principal connections on the principal gauge prolongation of a principal bundle*

Ivan Kolář: *Absolute contact differentiation in Cartan geometries*

Oldřich Kowalski: *On rigidity of some remarkable hypersurface in R^4*

Svatopluk Krýsl: *Symplectic Dirac operators*

Tom Lada: *A Small Example of an Open-Closed Homotopy Algebra*

Michal Lenc: *Lepage forms theory applied (with J. Musilova and M. Lenc)*

Radka Malíková: *On a Generalization of Helmholtz Conditions*

Jana Musilová: *Lepage forms theory applied (with L. Czudkova and M. Lenc)*

Katharina Neusser: *Weighted Jets and Prolongation of Overdetermined Systems*

Stana Nikčević: *Curvature Structure of Self-Dual 4-Manifolds*

Zahid Raza: *Topology of Plane Curves and Discriminants*

Jan Slovák: *TBA*

Dana Smetanová: *On Legendre Transformation for Higher Order Hamiltonian Systems*

Libor Šnobl: *Symmetries and invariant solutions of the supersymmetric sine-Gordon equation*

Petr Somberg: *Invariants for finite groups and deformations of harmonic polynomials*

Vladimír Souček: *to be announced*

Petr Vašík: *Smiholonomic jet transformations*

Lukáš Vokřínek: *String topology: cacti operad*

Ben Warhurst: *Rigidity of fundamental graded Lie algebras*

C. Abstracts

Teresa Arias-Marco: *Constant osculating rank vs. constant Jacobi osculating*

A g.o. space is a Riemannian homogeneous space on which every geodesic is an orbit of a one-parameter group of isometries. It is known that every simply connected Riemannian g.o. manifold of dimension ≤ 5 is naturally reductive. The first counter-example of a g.o. space which is not naturally reductive is six-dimensional Kaplan's example.

On the other hand, K. Tsukada pointed out on naturally reductive spaces and, the author and A. M. Naveira showed on g.o. spaces that the Jacobi operator \mathcal{J}_t has *constant osculating rank* i.e., for every fix geodesic γ there is a natural number r_γ and there are $\beta_1, \dots, \beta_{r_\gamma}$ constant such that $\beta_1 \mathcal{J}_t^{(1)} + \dots + \beta_{r_\gamma} \mathcal{J}_t^{(r_\gamma)} + \mathcal{J}_t^{(r_\gamma+1)} = 0$. Moreover, we also settled the concept of *Jacobi osculating rank of a g.o. space* as the number $\mathbf{r} = \max\{r_\gamma : \text{for all } \gamma \text{ of the g.o. space}\}$ and they established that a g.o. space has *constant Jacobi osculating rank* if there is also a relation $\beta_1 \mathcal{J}_t^{(1)} + \dots + \beta_{\mathbf{r}} \mathcal{J}_t^{(\mathbf{r})} + \mathcal{J}_t^{(\mathbf{r}+1)} = 0$ that it is the same for all γ of the g.o. space.

It is clear that $r_\gamma \leq \mathbf{r}$ for all γ of a g.o. space. Moreover, $r_\gamma = \mathbf{r} = 0$ for all γ of a symmetric space (i.e. $\nabla R = 0$). Therefore, the following question is natural: *is $r_\gamma = \mathbf{r}$ for all γ of a g.o. space with constant Jacobi osculating rank?* This question will be answered during the talk.

Joint work with A. M. Naveira.

Klaus Bering: *A Comparative Study of Laplacians and Schroedinger-Lichnerowicz-Weitzenboeck Identities in Riemannian and Antisymplectic Geometry*

We introduce an antisymplectic Dirac operator and antisymplectic gamma matrices. We explore similarities between, on one hand, the Schroedinger-Lichnerowicz formula for spinor bundles in Riemannian spin geometry, which contains a zeroth-order term proportional to the Levi-Civita scalar curvature, and, on the other hand, the nilpotent, Grassmann-odd, second-order Δ operator in antisymplectic geometry, which in general has a zeroth-order term proportional to the odd scalar curvature of an arbitrary antisymplectic and torsionfree connection that is compatible with the measure density. Finally, we discuss the close relationship with the two-loop scalar curvature term in the quantum Hamiltonian for a particle in a curved Riemannian space. For more information, see <http://arxiv.org/abs/0809.4269>

Adara-Monica Blaga: *Covariant and contravariant connections on TM and T^*M of a Poisson manifold (M, Π)*

Covariant and contravariant connections on the tangent and cotangent bundle of a Poisson manifold are defined and their properties are established. Necessary and sufficient conditions to be defined such connections on the k-tangent and k-cotangent bundles are stated and their properties are pointed out.

Andreas Čap: *Affine holonomies and parabolic geometries*

The classification of all possible irreducible holonomy groups of affine connections is a cornerstone in differential geometry. Proving existence of the possible groups was a long project with lots of case by case considerations. During the last years it has turned out that almost all the possible holonomies can be produced by two constructions starting from the canonical parabolic geometries on certain generalized flag manifolds. In my talk, I will outline these two constructions, concentrating on the (easier) case of holonomies related to $|1|$ -graded simple Lie algebras.

Goce Chadzitaskos: *Quantization on compact spaces*

For the quantization on compact spaces we need the Fourier base on this space. Having Fourier base, we define a Wigner symbols on phase space connected with our compact space. Various examples are presented - periodic chain, circle, sphere, positive reals and fundamental area of Weyl group.

Ed Corrigan: *Calogero-Moser integrable systems*

It is intended to give a short course outlining new and not so new results concerning integrable field theories with 'boundaries' or 'defects'. The idea is to be basic and analyse the simplest cases (either the sine-Gordon field theory, or its generalisations, the affine Toda field theories), investigating what kinds of boundaries or defects are allowed without destroying integrability, how they affect the spectrum, and how they affect solitons, the basic quantum states of these models. The questions are physical in character but the analysis involves interesting applications of mathematics. In particular, in the case of defects the analysis offers an alternative perspective on Backlund transformations, constructs that were originally developed in the context of differential geometry.

Lenka Czudková, Jana Musilová, Michal Lenc: *Lepage forms theory applied*

The theory of Lepage forms on jet prolongations of fibered manifolds with n-dimensional bases is applied to relativistic mechanics and string theory. Some concrete physical situations are discussed.

Jaroslav Dittrich: *On a chain of dynamical equations*

An infinite system of ordinary differential equations is solved and long-time behaviour is studied. The result supports, but not proves, the conjecture on an unlimited growth of the energy for semirelativistic quantum mechanical Fermi accelerator.

Zdeněk Dušek: *On the reparametrization of homogeneous geodesics*

A geodesic in a homogeneous pseudo-Riemannian or affine manifold is said to be homogeneous if it is an orbit of an one-parameter group of isometries, or, of affine diffeomorphisms, respectively. A homogeneous pseudo-Riemannian or affine manifold is a g.o. manifold if every geodesic is homogeneous.

On pseudo-Riemannian manifolds, the parameter of the group of isometries may be different from the affine parameter of the geodesic only for null homogeneous geodesics. Nevertheless, for all known examples of pseudo-Riemannian g.o. manifolds, these parameters are the same for all homogeneous geodesics. In the affine case, there are g.o. manifolds whose almost all geodesics must be reparametrized.

In the talk, the features of homogeneous geodesics in pseudo-Riemannian homogeneous manifolds and g.o. manifolds will be recalled, the new approach for the study of homogeneous geodesics in affine homogeneous manifold will be explained and the new phenomena which appear in the affine case will be illustrated.

Anton Galaev: *Irreducible complex skew-Berger algebras*

I will speak about a classification of irreducible skew-Berger algebras $\mathfrak{g} \subset \mathfrak{gl}(n, \mathbb{C})$, i.e. algebras spanned by the images of the linear maps $R : \odot^2 \mathbb{C}^n \rightarrow \mathfrak{g}$ satisfying the Bianchi identity. These Lie algebras can be interpreted as the irreducible complex Berger superalgebras contained in $\mathfrak{gl}(0|n, \mathbb{C})$. Then I will explain an approach to some classes of Berger superalgebras contained in $\mathfrak{gl}(m|n, \mathbb{C})$.

Jaroslav Hrdina: *Morphisms of almost complex projective geometries.*

We discuss almost complex projective geometry and the relations to a distinguished class of curves. Our approach is based on an observation that well known general techniques apply, and our goal is to illustrate the power of the general parabolic geometry theory on a quite explicit example.

Josef Janyška: *Natural principal connections on the principal gauge prolongation of a principal bundle*

Let Γ be a principal connection on a principal bundle $P \rightarrow M$ and let Λ be a linear connection on M . We describe all possible natural prolongations of Γ , with respect to Λ , to principal connections on the principal gauge prolongation $W^r P$ of P . For $r = 1, 2$ we give the full classification, for $r \geq 3$ we give a base of natural operators which generates all possible natural connections on $W^r P$. Joint work with J.Vondra

Ivan Kolář: *Absolute contact differentiation in Cartan geometries*

This is a report of joint research with Raffaele Vitolo, University of Salento in Lecce. We introduce the general concept of higher order absolute contact differentiation that is based on the idea of semiholonomic contact elements. We clarify how the moving frame method leads to the coordinate functions of the field of r -th order contact elements on a submanifold of Klein space and of the r -th absolute contact differential of a submanifold in Cartan geometry. We point out that the standard geometric objects are defined on contact elements, so that they are of universal character.

Oldřich Kowalski: *On rigidity of some remarkable hypersurface in R^4*

This is a joint work with Zdenek Dusek published recently in Mathematica Slovaca. We study the deformation properties of a remarkable hypersurface found by H. Takagi in 1972, as the first counter-example to the famous Nomizu conjecture on semi-symmetric spaces. This is a 3-dimensional hypersurface in R^4 whose second fundamental form has rank two. Deformation properties of hypersurfaces in space forms with the second fundamental form of rank two were fully described by E.Cartan in 1916. Many of them are either continuously, or discretely, deformable and many others are rigid. In 1990, Gromoll and Dajczer published a global theorem enabling to prove rigidity for a subclass of such manifolds. Yet, this Theorem cannot be applied to the Takagi example. We are using different method to prove (local) rigidity of this hypersurface. The method involves a hard computer work.

Tom Lada: *A Small Example of an Open-Closed Homotopy Algebra*

Open-closed homotopy algebras (OCHA's), recently developed by Kajiwara and Stasheff, are of interest open, closed string theory. In this joint work with T. Kadeishvili, we will present a finite dimensional example of such an algebra.

Radka Malíková: *On a Generalization of Helmholtz Conditions*

Helmholtz conditions in the calculus of variations and necessary and sufficient conditions for a system of differential equations to be variational "as it stands". It is known that this property geometrically means that the corresponding dynamical form (ie. a source form of degree $n+1$ in the variational sequence) can be completed to closed form. We study an analogous property for source forms of degree 3 in mechanics ($n=1$).

Peter W. Michor: *Analysis and Geometry of Shape Spaces*

Content:

Introduction: What are shape spaces and what are they good for. A little bit of history.

Shape spaces of plane curves: The topology of shape space. Hamiltonian background and conserved momenta. A bunch of metrics, their geodesics and curvatures: The L^2 -metric and its vanishing of geodesic distance. Almost local metrics, Immersion Sobolev metrics The scale invariant Sobolev H^1 -metric and its relation to the Grassmannian of 2-planes in an infinite dimensional space, and Neretin geodesics.

A covariant formula for curvature and its relation to O'Neill's curvature formulas.

Shape spaces as quotients of diffeomorphism groups: Right invariant metrics on diffeomorphism groups, their geodesics and curvatures. Landmark space, geodesics and curvatures. Spaces of submanifolds (plane curves and higher dimensional ones)

Abstracts of parts of the lectures: A version of shape space is the space of all smooth regular closed plane curves, i.e., the space of orbits of the action of the diffeomorphism group $Diff(S^1)$ on the space $Imm(S^1, R^2)$ of smooth mappings $c : S^1 \rightarrow R^2$ with c' never 0. The aim is to find geodesic distance functions on shape space which make sense for applications in imaging sciences. The simplest solution does not work because the L^2 or H^0 metric on the space of smooth plane regular closed curves induces vanishing geodesic distance on the quotient $Imm(S^1, R^2)/Diff(S^1)$. This is a general phenomenon and holds on all full diffeomorphism groups and spaces $Imm(M, N)/Diff(M)$ for a compact manifold M and a Riemannian manifold N . Thus we have to consider more complicated Riemannian metrics using length or curvature, and we do this in a systematic Hamiltonian way, we derive geodesic equations and split them into horizontal and vertical parts, and compute all conserved quantities via the momentum mappings of several invariance groups (Reparameterizations, motions, and even scalings). The resulting equations are relatives of well known completely integrable systems (Burgers, Camassa Holm, Hunter Saxton). A certain scale invariant geometry on $Imm(S^1, R^2)$ is diffeomorphic to the Grassmannian of 2-planes in a pre-Hilbert space. Since for the latter one can write down geodesics explicitly, following a Neretin from 2000, we have explicit solutions for the distance, geodesics, and curvature. This gives a computable distance on shape space $Imm(S^1, R^2)/Diff(S^1)$, with curvature. Some of these metrics have already found applications in computational anatomy: One can compute from the tomographic data of hearts whether the person is prone to develop cardiac rhythmic disturbances.

Landmark space $Land^N(R^n)$ consists of sets of N ordered points on R^n . More general we may consider even submanifolds of R^n , even certain currents in R^n . The group of diffeomorphisms with compact support acts transitively on shape space, and we induce Riemannian metrics on shape space induced from right invariant Sobolev metrics in the diffeomorphism groups. This offers interesting analytical difficulties. The resulting geodesic equations are well posed. Curvature can be computed in two ways: directly, or via O'Neill's formula from Arnold's curvature on the diffeomorphism group.

Stana Nikcevic: *Curvature Structure of Self-Dual 4-Manifolds*

We show the existence of a modified Cliff(1,1)-structure compatible with an Osserman 0-model of signature (2,2). Then we apply this algebraic result to certain classes of pseudo-Riemannian manifolds of signature (2,2). We obtain a new characterization of the Weyl curvature tensor of an (anti-)self-dual manifold and we prove some new results regarding (Jordan) Osserman manifolds.

Valentin Ovsienko: *Lie antialgebras*

"Lie antialgebras" is a new class of graded commutative algebras. The first examples of these algebras appeared as invariant operations in symplectic geometry. It turns out that Lie antialgebras have quite remarkable algebraic and geometric properties and relate commutative algebras to Lie algebras.

In these lectures, we describe the notions of representation and cohomology of Lie antialgebras. We present some classification results and formulate open problems.

A number of examples will be treated. In particular, we show how the classical algebra of quaternions can be viewed as a graded commutative algebra.

Zahid Raza: *Topology of Plane Curves and Discriminants*

we investigate the topology of complex polynomials in two variables. The description of the topology of the corresponding level curves is directly related to the vanishing of the leading coefficients of the discriminant of the polynomial regarded as polynomials in the level curves parameter.

Claude Roger: *Gerstenhaber and Batalin -Vilkovisky algebras; algebraic, geometric and physical aspects*

We shall give a survey of classical examples, together with algebraic methods to deal with those structures: graded algebra, cohomologies, cohomology operations. The corresponding geometric structures will be described (e.g., Lie algebroids), with particular emphasis on supergeometry, odd supersymplectic structures and their classification. Finally, we shall explain how BV structures appeared in Quantum Field Theory, as a version of functional integral quantization.

Dana Smetanová: *On Legendre Transformation for Higher Order Hamiltonian Systems*

The aim of this poster is to announce some recent results in case of second order Lagrangians corresponding to 2nd and 3rd order Euler-Lagrange form. Its related 3rd order Hamiltonian systems are found. The Legendre

transformation and geometrical correspondence between solutions of the Hamilton equations and the Euler–Lagrange equations are studied.

Libor Šnobl: *Symmetries and invariant solutions of the supersymmetric sine-Gordon equation*

A comprehensive symmetry analysis of the N=1 supersymmetric sine-Gordon equation is performed. Two different forms of the supersymmetric system are considered. We begin by studying a system of partial differential equations corresponding to the coefficients of the various powers of the fermionic independent variables. Next, we consider the super-sine-Gordon equation expressed in terms of a bosonic superfield involving fermionic independent variables. In each case, a Lie (super)algebra of symmetries is determined and the method of symmetry reduction is applied in order to derive invariant solutions.

In collaboration with A. M. Grundland, A. J. Hariton, arXiv:0812.3862.

Ben Warhurst: *Rigidity of fundamental graded Lie algebras*

I will describe simple algebraic criteria that determine when the Tanaka prolongation of a fundamental graded Lie algebra is infinite.

Konstantin Zarembo: *Spin chains and the AdS/CFT correspondence*

The AdS/CFT duality is an exact equivalence of the four-dimensional superconformal field theory, the N=4 Super-Yang-Mills (SYM), and string theory in the background of $AdS(5) \times S(5)$. I will review the circle of ideas the underlies this duality: the 't Hooft's large-N expansion; the conformal invariance in quantum field theory; and Anti-de-Sitter space. I will also describe how integrable spin chains and two-dimensional field theories arise in the AdS/CFT correspondence, and how integrability can be used to gain insight in the non-perturbative dynamics of N=4 SYM.