50th Seminar "Sophus Lie"

25 September - 1 October 2016, Będlewo, Poland

Supported by:

Banach Center IM PAN

Warsaw Center of Mathematics and Computer Science

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Invited speakers

- **EMS Distinguished Speaker**: Ernest B. Vinberg (Russia)
- Anton Alekseev (Switzerland)
- Alexander Alldridge (Germany)
- Dorothea Bahns (Germany)
- Wolfgang Bertram (France)
- José F. Cariñena (Spain)
- Jacques Faraut (France)
- Alfred M. Grundland (Canada)
- Madeleine Jotz Lean (England)
- Peter W. Michor (Austria)
- Gestur Ólafsson (USA)
- Bent Ørsted (Denmark)
- Angela Pasquale (France)
- Anke Pohl (Germany)
- Hadi Salmasian (Canada)
- Henrik Schlichtkrull (Denmark)
- Karl Strambach (Germany)

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- Karl-Hermann Neeb (Erlangen)
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AIM AND SCOPE

The Seminar "Sophus Lie" is an international seminar of mathematicians interested in the theory of Lie groups and Lie algebras and their applications. Its first meeting was in January 1991. This workshop will be the 50th workshop and it will take place 25 years after the first one. On this occasion, our intention is to use the opportunity to have both, a look back on results achieved, and on future developments in the field.

To be more specific, the goal of the workshop is to bring together leading experts working in currently particularly active areas of Lie theory, thus continuing with the main stream of activities of Seminar Sophus Lie. We also want to include promising students and young researchers, and to create an open learning environment for a fruitful exchange of ideas with the goal of creating new visions and collaborations between experts and students alike. Accordingly, we prefer not to concentrate only on the newest results in a narrow area, but rather include survey lectures and comparative study of various ideas and methods.

TOPICS

The main topics of the conference are:

- Representation theory
- Microlocal techniques and dynamical systems
- Deformations of algebraic and related geometric structures
- Lie systems: generalizations and applications

HISTORICAL REMARKS

The Sophus Lie seminar was founded around 1989-90 when, during the Volkskammer Government of the German Democratic Republic in 1989, open contacts between mathematicians in East- and West-Germany became a reality for the first time since 1961. Several mathematicians located at the Technische Hochschule Darmstadt, the University of Erlangen, the University of Greifswald, and the University of Leipzig (historically, Leipzig was particularly important in Sophus Lie's life) organized informally the Seminar with financial support by the Deutsche Forschungsgemeinschaft and met for the first seminar session at the University of Leipzig in January 1991. The Seminar usually meets once a semester since that time. Over the years, the seminar was attended by participants from more and more countries. Meetings took place in Germany (Leipzig, Greifswald, Erlangen, Darmstadt, Clausthal, Bielefeld, Stuttgart, Berlin, Paderborn, Gőttingen, Marburg, Bad Honnef), Austria (Vienna), France (Metz, Nancy, Mulhouse, Reims, Lyon), Poland (Będlewo), Hungary (Budapest), Romania (Cluj-Napoca), Luxembourg (Luxembourg). Now, it is an European event with a clear international dimension. For a more detailed history of the seminar we refer to: A. Fialowski and A. Szilard, Seminar Sophus Lie, Newsletter of the EMS 69 (Sept. 2008), pp. 14-16.

PRACTICAL INFORMATION

Up-to-date information about the conference can be found on our website 50sls.impan.pl. In case of any problems you can contact the organizers by email at *50SeminarLie@gmail.com* or directly by phone:

- (+48) 61 813 51 87 Conference Center in Będlewo
- (+48) 604 579 071 Katarzyna Grabowska (in Będlewo since Sunday early afternoon)
- (+48) 516 403 968 Javier de Lucas (in Będlewo since Sunday early afternoon)

SCHEDULE

	Monday	Tuesday	Wednesday	Thursday	Friday
	morning session	**morning session**	**morning session**	**morning session**	**morning session**
09.00-10.00	J. Faraut	M. Jotz Lean	A. Pohl	A. Alldridge	A. Alekseev
10.00-11.00	A. Pasquale	W. Bertram	J. F. Cariñena	D. Bahns	B. Ørsted
	coffee	*coffee*	*coffee*	*coffee*	*coffee*
11.30-12.30	H. Schlichtkrull	P. W. Michor	E. Vinberg	H. Salmasian	G. Ólafsson
13.00-14.00	*lunch*	*lunch*	*lunch*	*lunch*	*lunch*
	afternoon session	**afternoon session**	*excursion*	**afternoon session**	**afternoon session**
15.00-16.00	K. Strambach	A. M. Grundland		J. de Lucas	A. Panasyuk
				M. Rotkiewicz	D. Beltita
	coffee	*coffee*		*coffee*	*coffee*
16.30-17.00	N. Poncin	T. Przebinda		poster session	H. Glöckner
17.00-17.30	S. Korvers	V. Tsanov			best poster talk
17.30-18.00	J. Möllers	M. van Pruijssen			
19.00	*grill, bonfire*	*diner*	*conference dinner*	*diner*	*diner*

SOCIAL EVENTS

- **Monday 26th September** from **19.00**: a special dinner with grill, beer, and bonfire
- **Wednesday 28th September 14.00-18.00**: excursion
- **Wednesday 28th September** from **19.00**: conference dinner

SCIENTIFIC PROGRAM

Saturday-Sunday $24^{th} - 25^{th}$ September	
all day	arrivals, registration
Monday 26^{th} September	
09.00-10.00	**Jacques Faraut**: *Orbital measures and spline functions*
10.00-11.00	**Angela Pasquale**: *Resonances and singular integrals*
11.30-12.30	**Henrik Schlichtkrull**: *Real spherical spaces*
15.00-16.00	**Karl Strambach**: *The origins and developments of the seminar Sophus Lie*
16.30-17.00	**Norbert Poncin**: *Higher algebra over the Leibniz operad*
17.00-17.30	**Stéphane Korvers**: *Formal and non formal deformation quantizations of bounded symmetric domains*
17.30-18.00	**Jan Möllers**: *The compact picture of symmetry breaking operators for rank one orthogonal and unitary groups*
Tuesday 27^{th} September	
09.00-10.00	**Madeleine Jotz Lean**: *On ideals in Lie algebroids*
10.00-11.00	**Wolfgang Bertram**: *Lie calculus, groupoids, and loops*
11.30-12.30	**Peter W. Michor**: *Old and new on diffeomorphism groups too*
15.00-16.00	**Alfred M. Grundland**: *On the Fokas-Gel'fand theorem for integrable systems*
16.30-17.00	**Tomasz Przebinda**: *The character and the wave front set correspondence in the stable range*
17.00-17.30	**Valdemar Tsanov**: *Variations of geometric invariant theory on flag varieties*
17.30-18.00	**Maarten van Pruijssen**: *Vector valued orthogonal polynomials*
Wednesday 28^{th} September	
09.00-10.00	**Anke Pohl**: *Sup-norm bounds for Siegel-Maass forms*
10.00-11.00	**José F. Cariñena**: *Recent advances on Lie systems and applications*
11.30-12.30	**Ernest Vinberg**: *Short $SL(3)$-structures on Lie algebras*
Thursday 29^{th} September	
09.00-10.00	**Alexander Alldridge**: *Schur Q functions and Capelli identities for the Lie supergroup $Q(n)$*
10.00-11.00	**Dorothea Bahns**: *On an infinite-dimensional Lie algebra in string theory*
11.30-12.30	**Hadi Salmasian**: *Smooth vectors, smoothing operators, and applications*
15.00-15.30	**Javier de Lucas**: *A Lie systems approach to the Riccati hierarchy and partial differential equations*
15.30-16.00	**Mikołaj Rotkiewicz**: *A note on actions of some monoids*
16.30-18.00	poster session
Friday 30^{th} September	
09.00-10.00	**Anton Alekseev**: *The Goldman-Turaev Lie algebra and the Kashiwara-Vergne problem*
10.00-11.00	**Bent Ørsted**: *Branching laws and elliptic boundary value problems*
11.30-12.30	**Gestur Ólafsson**: *Harmonic Analysis with respect to Jack Polynomials*
15.00-15.30	**Andriy Panasyuk**: *On classification of Lie pencils*
15.30-16.00	**Daniel Beltita**: *Groupoids, coadjoint dynamical systems of solvable Lie groups, and their C^*-algebras*
16.30-17.00	**Helge Glöckner**: *L^1-regularity of Banach-Lie groups and diffeomorphism groups*
17.00-17.30	**best poster talk**:

Plenary talks

Anton Alekseev (Université de Genève)
The Goldman-Turaev Lie algebra and the Kashiwara-Vergne problem

Abstract: Let S be an oriented surface of genus g with n boundary components, and let K be a field of characteristic zero. The K-linear span $A_{g,n}$ of conjugacy classes in the fundamental group of S carries a canonical Lie bialgebra structure defined in terms of intersections of curves on the surface, and it has a filtration induced by the central series in the fundamental group. Hence, one can ask whether $A_{g,n}$ is formal (that is, isomorphic to its associated graded).

We answer this question in the positive for $n > 0$. For genus 0, it reduces to the Kashiwara-Vergne problem on the properties of the Campbell-Hausdorff series. For genus 1, we define the elliptic Kashiwara-Vergne problem and solve it using the theory of elliptic associators. The general case follows by combining genus 0 and 1 results.

The formality problem has interesting applications to geometry of moduli spaces of flat connections.

The talk is based on a joint work with N. Kawazumi, Y. Kuno and F. Naef.

Alexander Alldridge (University of Cologne)
Schur Q functions and Capelli identities for the Lie supergroup $Q(n)$

Abstract: We report on joint work with Hadi Salmasian (Ottawa) and Siddhartha Sahi (Rutgers). Schur Q-functions are symmetric functions introduced by I. Schur in the study of spin representations of the symmetric group. The definition of their factorial versions was suggested by Okounkov. We show that factorial Schur Q-functions appear as eigenvalue polynomials for polynomial differential operators invariant under the Lie supergroup $Q(n)$, and the Schur Q-functions, their homogeneous top degree part, appear as spherical polynomials. These results refine the higher Capelli identities for $Q(n)$ of Nazarov.

Dorothea Bahns (Mathematisches Institut, Georg-August-Universität Göttingen)
On an infinite-dimensional Lie algebra in string theory

Abstract: When quantizing strings – or more correctly, immersed extremal surfaces – in the framework proposed by Klaus Pohlmeyer 30 years ago, a certain infinite dimensional graded Lie algebra occurs as an auxiliary tool. This Lie algebra is given in terms of generators and relations on the indecomposable elements of a certain graded commutative connected Hopf algebra, but little is known about its structure. I will report on some ongoing research and first steps towards understanding this algebra.

Wolfgang Bertram (Université de Lorraine)
Lie calculus, groupoids, and loops

Abstract: I intend to report on ongoing work having its distant roots in joint work with K.-H. Neeb and H. Glöckner on general differential calculus. My recent approach to these topics is via *groupoids*: for the purpose of this talk, I will call it "Lie calculus", since its distinctive feature is to describe calculus itself by a certain Lie groupoid (in fact, a generalized version of Connes' *tangent groupoid*). Thus foundations of calculus and of Lie theory appear to be merged with each other from the very beginning on. Seen this way, a Lie group is a group plus a groupoid structure, leading to a double groupoid (or even to a threefold groupoid when formally taking account of its manifold structure), and higher order calculus leads to n-fold groupoids. Passing from Lie groups to general affinely connected manifolds, the group structure is replaced by a family of *loop* structures, and one is lead to investigate

the interaction between groupoid and loop structures. A non-technical overview about these topics can be found on my homepage.

José F. Cariñena (Universidad de Zaragoza)
Recent advances on Lie systems and applications

Abstract: After a quick presentation of the theory of Lie systems from a geometric perspective, recent progresses on their applications when compatible geometric structures exist will be described with an special emphasis in the particular case of admissible Kähler structures, and therefore with applications in Quantum Mechanics. The more general cases of quasi-Lie systems and bundle Lie systems will also be presented.

References

[1]J.F. Cariñena, J. Grabowski and J. de Lucas, *Quasi-Lie schemes: theory and applications*, J. Phys. A **42**, 335206 (2009).
[2] J.F. Cariñena, J. Grabowski, J. de Lucas and C. Sardón, *Dirac–Lie systems and Schwarzian equations*, J. Diff. Eqns **257**, 2303–2340 (2014).
[3] J.F. Cariñena, J. Grabowski and G. Marmo, *Lie–Scheffers systems: a geometric approach,* Bibliopolis, Naples, 2000.
[4] J.F. Cariñena, J. Grabowski and G. Marmo, *Superposition rules, Lie Theorem and partial differential equations*, Rep. Math. Phys. **60**, 237–258 (2007).
[5] J.F. Cariñena, J. de Lucas and C. Sardón, *Lie–Hamilton systems: theory and applications*, Int. J. Geom. Methods Mod. Phys. **10**, 09129823 (2013).
[5] P.G. Estévez, F.J. Herranz, J. de Lucas and C. Sardón, *Lie symmetries for Lie systems: applications of ODEs and systems of PDEs*, Appl. Math. Comp. **273**, 435–452 (2016).
[7] S. Lie and G. Scheffers, *Vorlesungen uber continuierliche Gruppen mit geometrischen und anderen Anwendungen*, Teubner, Leipzig, 1893.

Jacques Faraut (Université Pierre et Marie Curie, Paris)
Orbital measures and spline functions

Abstract: Consider a Hermitian $n \times n$-matrix X with eigenvalues $\lambda_1 \le \cdots \le \lambda_n$, and the projection Y of X on the $(n-1) \times (n-1)$ upper left corner. Rayleigh Theorem says that the eigenvalues $\mu_1 \le \cdots \le \mu_{n-1}$ of Y interlace those of X:

$$\lambda_1 \le \mu_1 \le \lambda_2 \le \cdots \le \mu_{n-1} \le \lambda_n.$$

If the matrix X is distributed uniformly on a $U(n)$-orbit, then the joint distribution of the eigenvalues $\mu_1, \ldots, \mu_{n-1}$ is described by a formula due to Baryshnikov. More generally the eigenvalues of the projection of X on the $k \times k$ upper left corner $(1 \le k \le n-1)$ is distributed according to a determinantal formula due to Olshanski. This formula involves spline functions.

Recently analogous results have been obtained by Zubov in case of the action of the orthogonal group on the space of real skew-symmetric matrices. For the action of the orthogonal group on the space of real symmetric matrices much less is known.

We will also consider unbounded orbital measures for the action of the noncompact group $U(p, q)$. In this case there is an analogue of Rayleigh Theorem and Baryshnikov formula.

Alfred M. Grundland (Université du Québec, CRM Université de Montréal)
On the Fokas-Gel'fand theorem for integrable systems

Abstract: The Fokas-Gel'fand theorem on the immersion formula of 2D-surfaces is related to the study of Lie symmetries of an integrable system. A rigorous proof of this theorem is presented which

may help to better understand the immersion formula of 2D-surfaces in Lie algebras. It is shown, that even under weaker conditions, the main result of this theorem is still valid. A connection is established between three different analytic descriptions for immersion functions of 2D-surfaces, corresponding to the following three types of symmetries: gauge symmetries of the linear spectral problem, conformal transformations in the spectral parameter and generalized symmetries of the integrable system. The theoretical results are applied to the $\mathbb{C}P^{N-1}$ sigma model and several soliton surfaces associated with these symmetries are constructed. It is shown that these surfaces are linked by the gauge transformations.

Madeleine Jotz Lean (University of Sheffield)
On ideals in Lie algebroids

Abstract: I will describe a notion of ideals in Lie algebroids, named 'infinitesimal ideal systems' and motivate from several point of views why this is in my opinion the 'right' notion of symmetry in the Lie algebroid setting: I will discuss quotients by infinitesimal ideal systems, their equivalence to multiplicative foliations on Lie groupoids, and how they define sub-representations of Lie algebroids adjoint representations (up to homotopy). Then I will sketch a first obstruction to the existence of an infinitesimal ideal system structure on a Lie pair.

This is partly based on joint work with Ortiz and Drummond.

Peter W. Michor (University of Vienna)
Old and new on diffeomorphism groups too

Abstract: Groups of diffeomorphisms of a manifold M have many of the properties of finite dimensional Lie groups, but also differ in surprising ways. I will review some (or all or more) of the following properties or I do something else:

- No complexification.
- Exponential mappings are defined but are not locally surjective of injective.
- Right invariant Riemannian metrics might have vanishing geodesic distance.
- Many famous PDE's arise as geodesic equations on diffeomorphism groups.
- There are topological groups of diffeomorphisms which are smooth manifolds but only right translations are smooth.
- There are diffeomorphism groups which are smooth in a certain sense (Some Denjoy-ultradifferentiable class) but not better (not real analytic).

Gestur Ólafsson (Louisiana State University)
Harmonic Analysis with respect to Jack Polynomials

Abstract: In an influential though unpublished manuscript I. G. Macdonald developed the theory of multivariate hypergeometric functions depending on a parameter. In this talk we will discuss several conjectures formulated in by Macdonald. Among other we will discuss estimates for the exponential kernel that allow us to establish a rigorous theory of the Fourier and Laplace transforms. We then discuss some of the applications.

Bent Ørsted (Aarhus University)
Branching laws and elliptic boundary value problems

Abstract: For a unitary representation of a Lie group it is a basic problem to understand the restriction to a closed subgroup, i.e. the branching law. For the conformal group of Euclidian space and the

conformal group of a hyperplane we shall explain how branching is related to some natural elliptic boundary value problems. This lecture is based on joint work with Jan Möllers and Yoshiki Oshima.

Angela Pasquale (Université de Lorraine)
Resonances and singular integrals

Abstract: Let Δ be the Laplacian on a Riemannian symmetric space of the noncompact type $X = G/K$, and let $\sigma(\Delta)$ denote its spectrum. The resolvent $R(z) = (\Delta - z)^{-1}$ is a holomorphic function on $\mathbb{C} \setminus \sigma(\Delta)$, with values in the space of bounded operators on $L^2(X)$.If we consider R as a map from $C_c^\infty(X)$ to $(C_c^\infty(X))^*$, then a meromorphic continuation of R on a Riemann surface above $\mathbb{C} \setminus \sigma(\Delta)$ is possible. The poles of the meromorphically extended resolvent are called the resonances and the image of the residue operator at a resonance is a G-module. The main problems are the existence and the localization of the resonances as well as the study of the (spherical) representations of G so obtained.

In this talk we will consider the case of Riemannian symmetric spaces of rank > 1. The search for resonances is then connected with the analysis of certain singular integrals on the complex sphere. This talk is based on joint works with Joachim Hilgert (Universität Paderborn) and Tomasz Przebinda (University of Oklahoma).

Anke Pohl (MPIM Bonn)
Sup-norm bounds for Siegel-Maass forms

Abstract: Given a Riemannian locally symmetric space, bounds for eigenfunctions of the Laplace operator or for joint eigenfunctions of the whole algebra of isometry-invariant differential operators are of great interest in several areas. Methods from analysis allow to provide bounds (nowadays called 'generic') which are sharp for certain spaces. However, if the symmetric space and the eigenfunctions enjoy certain additional symmetries it is expected that the generic bounds can be improved. We will discuss our joint work with Valentin Blomer, which provides the first example of such a subconvexity bound for a higher rank setup.

Hadi Salmasian (University of Ottawa)
Smooth vectors, smoothing operators, and applications

Abstract: Let (π, H) be a unitary representation of a possibly infinite dimensional Lie group G. A bounded operator on H is called a smoothing operator if its image lies inside the subspace of smooth vectors of (π, H). We give various characterisations for smoothing operators and also for a more restricted class of operators called Schwartz operators. We use this characterization to obtain characterization of smooth vectors of a semibounded unitary representation of G, and to construct C^* algebras that act as host algebras for unitary representations of Lie supergroups.

This talk is based on a joint project with K.-H. Neeb, G. van Dijk, and C. Zellner.

Henrik Schlichtkrull (University of Copenhagen)
Real spherical spaces

Abstract: A homogeneous space G/H of a real reductive Lie group G is called spherical if a minimal parabolic subgroup of G admits an open orbit on G/H. All symmetric spaces are spherical, but the property is shared also by other spaces. In the talk I shall discuss the geometry of such spaces, and a recent classification for the case with G simple and H reductive. The talk is based on joint work with F. Knop, B. Krötz and T. Pecher.

Karl Strambach (FAU Erlangen-Nürnberg)
The origins and developments of the seminar Sophus Lie

EMS Distinguished Speaker:

Ernest B. Vinberg (Moscow State University)
Short $SL(3)$-structures on Lie algebras

Abstract: Let G be a connected complex algebraic group and $\mathfrak{g} = \mathrm{Lie}(G)$. A short $SL(3)$-structure on $\mathfrak{g}$ is a subgroup $L < G$ locally isomorphic to $SL(3)$ (or, equivalently, a subalgebra $\mathfrak{l} < \mathfrak{g}$ isomorphic to $\mathfrak{sl}(3)$) such that all irreducible components of its adjoint representation in $\mathfrak{g}/\mathfrak{l}$ are three- or one-dimensional. Any simple Lie algebra $\mathfrak{g}$ but C_n admits such a structure, and it is unique up to an automorphism of $\mathfrak{g}$.

For any short $SL(3)$-structure on a Lie algebra $\mathfrak{g}$, there is a "section", a subalgebra $\mathfrak{s} < \mathfrak{g}$ intersecting every minimal L-invariant subspace of $\mathfrak{g}$ in a one-dimensional subspace. Under the additional condition that $\mathfrak{s} \cap \mathfrak{l}$ consists of semisimple elements, a section is unique up to a conjugation by L. For the simple Lie algebras of types A_n, B_n, D_n, G_2, F_4, E_6, E_7, E_8 such sections are reductive Lie algebras of types $A_{n-2} + T_1$, $B_{n-2} + A_1$, $D_{n-2} + A_1$, A_1, C_3, A_5, D_6, E_7, respectively. They appear together with a "very short even $\mathfrak{sl}_2$-structure", an $\mathfrak{sl}(2)$-subalgebra such that all irreducible components of its adjoint representation in $\mathfrak{s}$ are three- or one-dimensional. These algebras can be characterized axiomatically and classified apriori. They are related to some remarkable cubic forms.

There is an inverse procedure reconstructing a simple Lie algebra from its section. This gives some models for the exceptional simple Lie algebras, in terms of which one can better understand some of their embeddings.

All this matter is closely related to previous works of Freudenthal, Tits, Rosenfeld, I.Kantor, Allison, Seligman and myself devoted to constructing exceptional simple Lie algebras in terms of some non-associative algebras (the algebra of octonions etc.) However, the approach presented in the talk permits to avoid considering non-associative algebras other than Lie algebras.

CONTRIBUTED LECTURES

Daniel Beltita (Institute of Mathematics "Simion Stoilow" of the Romanian Academy)
Groupoids, coadjoint dynamical systems of solvable Lie groups, and their C^*-algebras

Abstract: Coadjoint actions of Lie groups are natural examples of transformation groups, hence locally compact groupoids, whose spectra have a quite complicate topological structure. We show how that structure can be studied in the case of exponential solvable Lie groups, by restricting the coadjoint action to suitable invariant subsets of the corresponding Lie-Poisson spaces. As an application of our groupoid techniques we produce examples of Lie groups whose C^*-algebras admit faithful irreducible representations. By classical results in representation theory, such Lie groups can be neither reductive nor nilpotent, but it is still an open problem if they can be exponential solvable Lie groups. This talk is based on joint work with Ingrid Beltita.

Javier de Lucas (University of Warsaw)
A Lie systems approach to the Riccati hierarchy and partial differential equations

Abstract: A general change of variables is provided, allowing the mapping of the members of the Riccati hierarchy, the so-called Riccati chain equations, into projective Riccati equations. This leads us to characterize Riccati chain equations in terms of the projective vector fields of a Riemannian flat metric and to derive their associated superposition rules. Next, we give necessary and sufficient conditions under which it is possible to map second-order Riccati chain equations into conformal Riccati equations through a local diffeomorphism. This allows one to determine superposition rules for particular higher-order Riccati chain equations depending on fewer particular solutions than in the previous case. Finally, the use of nonlocal transformations enables us to apply the derived results to the study of relevant partial differential equations, such as the Kaup-Kupershmidt and Sawada-Kotera equations.

Helge Glöckner (University of Paderborn)
L^1-regularity of Banach-Lie groups and diffeomorphism groups

Abstract: A Lie group G modelled on a (sufficiently complete) locally convex space is called L^1-*regular* if each L^1-curve $\gamma\colon [0,1] \to \mathfrak{g}$ in its Lie algebra arises as the left logarithmic derivative of an absolutely continuous curve $\mathrm{Evol}(\gamma)\colon [0,1] \to G$ starting at the neutral element, and the map

$$L^1([0,1],\mathfrak{g}) \to AC([0,1],G), \quad \gamma \mapsto \mathrm{Evol}(\gamma)$$

to the Lie group of absolutely continuous G-valued curves is smooth. Many classes of Lie groups are L^1-regular, and the latter property has interesting consequences like validity of the Trotter Product Formula and Commutator Formula for one-parameter groups [1], which are important in the representation theory of infinite-dimensional Lie groups [2] (and difficult to verify by other means).

In the talk, I'll outline the general framework and then explain the L^1-regularity for two major classes of examples, namely (a) Lie groups modelled on Banach spaces and (b) Lie groups of C^∞-diffeomorphisms of finite-dimensional smooth manifolds. In contrast to other examples, the discussion of (a) and (b) is mainly based on a study of integral curves to ODEs, flows and parameter-dependence in the classical setting of Banach manifolds (albeit for right-hand sides which are merely measurable in time).

References
[1] H.G., *Measurable regularity properties of infinite-dimensional Lie groups*, preprint, arXiv:1601.02568
[2] Neeb, K.-H. and H. Salmasian, *Differentiable vectors and unitary representations of Fréchet-Lie supergroups*, Math. Z. **275** (2013) no. 1–2, 419–451.

Stéphane Korvers (University of Luxembourg)
Formal and non formal deformation quantizations of bounded symmetric domains

Abstract: We introduce an explicit construction leading to a realization of the space of all invariant deformation quantizations on an arbitrary bounded symmetric domain of $\mathbb{C}^n$. This approach unifies existing methods giving such deformation quantizations and it extends new methods initiated by Bieliavsky and his collaborators in the 2000's. The method used in this work is lying at a crossing point between Lie theory, harmonic analysis and noncommutative geometry.

Jan Möllers (FAU Erlangen-Nürnberg)
The compact picture of symmetry breaking operators for rank one orthogonal and unitary groups

Abstract: Symmetry breaking operators are intertwining operators from a representation of a group G to a representation of a subgroup G', intertwining for the subgroup. For spherical principal series of $G = O(1, n + 1)$ and $G' = O(1, n)$ such operators have been classified recently by Kobayashi-Speh in the smooth category. We study symmetry breaking operators in the category of Harish-Chandra modules, recovering the results by Kobayashi-Speh in this setting, and thus providing the compact picture of their operators. We further extend their main results to the case of unitary groups $G = U(1, n + 1)$ and $G' = U(1, n)$.

Andriy Panasyuk (University of Warmia and Mazury)
On classification of Lie pencils

Abstract: I will discuss the problem of classification of pencils of Lie algebra structures, one of which is semisimple, and the approach to it presented in my paper "Compatible Lie brackets: Towards a classification"(Journal of Lie Theory, 24(2014), 561-623). Any such pencil is determined by a linear operator which is defined up to the addition of a derivation. A special fixing of this operator is introduced to get rid of this ambiguity and the operators preserving the root decomposition with respect to a Cartan subalgebra are considered. The classification leads to two disjoint classes of pairs depending on the symmetry properties of the corresponding operator with respect to the Killing form.

Norbert Poncin (University of Luxembourg)
Higher algebra over the Leibniz operad

Abstract: The lecture would be based on the four (related) papers whose abstracts you find below.

The supergeometry of Loday algebroids (Journal of geometric mechanics, American Institute of Mathematical Sciences, Volume 5, Number 2, June 2013 - with J. Grabowski and D. Khudaverdyan)

A new concept of Loday algebroid (and its pure algebraic version – Loday pseudoalgebra) is proposed and discussed in comparison with other similar structures present in the literature. Loday algebroids are interpreted as homological vector fields on a 'supercommutative manifold' associated with a shuffle product and the corresponding Cartan calculus is introduced. Several examples, including Courant algebroids, Grassmann-Dorfman and twisted Courant-Dorfman brackets, as well as

algebroids induced by Nambu-Poisson structures, are given.
Free Courant and derived Leibniz pseudoalgebras (Journal of Geometric Mechanics (2016), 8(1), 71-97 - with B. Jubin and K. Uchino)

We introduce the category of generalized Courant pseudoalgebras and show that it admits a free object on any anchored module over 'functions'. The free generalized Courant pseudoalgebra is built from two components: the generalized Courant pseudoalgebra associated to a symmetric Leibniz pseudoalgebra and the free symmetric Leibniz pseudoalgebra on an anchored module. Our construction is thus based on the new concept of symmetric Leibniz algebroid. We compare this subclass of Leibniz algebroids with the subclass made of Loday algebroids, which were introduced by Grabowski, Khudaverdyan and Poncin, as geometric replacements of standard Leibniz algebroids. Eventually, we apply our algebro-categorical machinery to associate a differential graded Lie algebra to any symmetric Leibniz pseudoalgebra, such that the Leibniz bracket of the latter coincides with the derived bracket of the former.

On the infinity category of homotopy Leibniz algebras (Theory and Applications of Categories, Vol. 29, 2014, No. 12, pp 332-370 - with D. Khudaverdyan and J. Qiu)

We discuss various concepts of infinity-homotopies, as well as the relations between them, focusing on the Leibniz type. In particular infinity-n-homotopies appear as the n-simplices of the nerve of a complete Lie infinity-algebra. In the nilpotent case, this nerve is known to be a Kan complex. We argue that there is a quasi-category of infinity-algebras and show that for truncated infinity-algebras, i.e. categorified algebras, this infinity-categorical structure projects to a strict 2-categorical one. The paper contains a shortcut to (infinity,1)-categories, as well as a review of Getzler's proof of the Kan property. We make the latter concrete by applying it to the 2-term infinity-algebra case, thus recovering the concept of homotopy of Baez and Crans, as well as the corresponding composition rule given by Schreiber and Stasheff. We also answer a question of Shoikhet about composition of infinity-homotopies of infinity-algebras.

A Tale of Three Homotopies (Applied Categorical Structures, pp 1-29 - with V. Dotsenko)

For a Koszul operad P, there are several existing approaches to the notion of a homotopy between homotopy morphisms of homotopy P-algebras. Some of those approaches are known to give rise to the same concept. We exhibit the missing links between those notions, thus putting them all into the same framework. The main nontrivial ingredient in establishing this relationship is the homotopy transfer theorem for homotopy cooperads due to Drummond-Cole and Vallette.

Tomasz Przebinda (University of Oklahoma)
The character and the wave front set correspondence in the stable range

Abstract: *(paper attached)* We relate the distribution characters and the wave front sets of unitary representation for real reductive dual pairs of type I in the stable range.

Mikołaj Rotkiewicz (University of Warsaw, Department of Mathematics)
A note on actions of some monoids

Abstract: Smooth actions of the multiplicative monoid $(\mathbb{R}, \cdot)$ of real numbers on manifolds lead to an alternative, and for some reasons simpler, definition of a vector bundle, a double vector bundle and related structures like a graded bundle [Grabowski and Rotkiewicz, J. Geom. Phys. 2011]. For these reasons it is natural to study smooth actions of certain monoids closely related with the monoid $(\mathbb{R}, \cdot)$. Namely, we discuss geometric structures naturally related with: smooth and holomorphic actions of the monoid of multiplicative complex numbers, smooth actions of the monoid of second jets of

punctured maps $(\mathbb{R}, 0) \to (\mathbb{R}, 0)$, smooth action of the monoid of real 2 by 2 matrices and smooth actions of multiplicative reals on a supermanifold. In particular cases we recover the notions of a holomorphic vector bundle, a complex vector bundle and a non-negatively graded manifold.

The talk is based on a joint work with Michał Jóźwikowski.

Valdemar Tsanov (Universität Göttingen)
Variations of Geometric Invariant Theory on Flag Varieties

Abstract: We consider an embedding of semisimple complex Lie groups G' in G. A fundamental problem in representation theory is to understand the space of G'-invariants in a given simple G-module. We address this problem in the framework of Geometric Invariant Theory (GIT). By the Borel-Weil theorem, every simple G-module can be obtained as the space of sections of a suitable line bundle L on the flag variety G/B. The G'-nullcone N of L is the common zero locus of all G'-invariants in the homogeneous coordinate ring of L. The GIT-quotient of the complement $(G/B) \setminus N$ carries a line bundle, whose space of sections is isomorphic to the G'-invariant sections of L.

Under some hypotheses, we derive an explicit geometric description of the G'-nullcone N for an arbitrary ample line bundle L on G/B. We compute the Picard groups of the quotients, and deduce some interesting properties, e.g. being Mori dream spaces. We also prove the existence of L such that the associated GIT-quotient carries the information about the G'invariants in all G-modules, not only the one associated to L. This allows us to deduce some global properties of multiplicities of invariants.

This is joint work with Henrik Seppänen.

Maarten van Pruijssen (Universität Paderborn)
Vector valued orthogonal polynomials

Abstract: The relation between Jacobi polynomials and matrix coefficients of compact symmetric pairs is also available for vector valued functions. Indeed, if we impose a multiplicity freeness condition, then the generalized spherical functions of fixed type have the structure of a free module over the polynomial ring of zonal spherical functions. In this way we obtain families of vector valued orthogonal polynomials in several variables, that are simultaneous eigenfunctions of a commutative algebra of differential operators.

We briefly discuss this construction together with the classification of the data for which this construction is possible. We also indicate how the families of polynomials in low dimensional examples of rank one can be deformed and allow for shift operators.

Finally, we discuss some details for the symmetric pair $(SU(n+1) \times SU(n+1), diag(SU(n+1)))$: the polynomials in this case depend on n variables and take values in a $(\binom{n+k}{n} - 1)$-dimensional space, for $k \geq 1$. The weight matrix that determines the pairing for the polynomials can be made explicit by a generalization of a miraculous formula of Tom Koornwinder.

This is joint work with Erik Koelink and Pablo Román.

POSTER SESSION

Mariusz Budziński (University of Warsaw)
Quantum families of quantum group homomorphisms

Abstract: We define a quantum family of homomorphisms of Hopf algebras. Roughly speaking, we show that such a family is classical. Moreover, we show that a quantum family of homomorphisms of Hopf algebras is consistent with the counits and coinverses of the given Hopf algebras.

Antoine Caradot (Institut Camille Jordan)
Inhomogeneous Kleinian singularities and quivers

Abstract: Starting with a finite groupe of $SU_2(\mathbb{C})$, we construct the Kleinian singularities linked to the Dynkin diagrams of type A, D, E and explained some known results about them. Then, using symmetries on Dynkin diagrams, we give a definition due to P. Slodowy of singularities linked to the inhomogeneous Dynkin diagrams. The notions of deformation and resolution can be extended to the inhomogeneous Kleinian singularities. H. Cassens and P. Slodowy constructed the semi-universal deformation of a Kleinian singularity of type A, D or E using symplectic geometry and quiver theory. We will present how we can extend their construction to the inhomogeneous Kleinian singularities and the consequences of some computations.

Szymon Charzyński (University of Warsaw)
Wei-Norman equations for classical and exceptional groups

Abstract: We show, that the non-linear autonomous Wei-Norman equations, expressing the solution of a linear system of non-autonomous equations on a Lie algebra, can be reduced to the hierarchy of matrix Riccati equations in the case of all classical simple Lie algebras. The result cannot be fully extended to all simple Lie algebras, in particular to the exceptional $\mathfrak{g}_2$ algebra.

Tomasz Czyżycki (Institute of Mathematics, University of Bialystok)
Generalized discrete orbit function transforms of affine Weyl groups

Abstract: The four types of orbit functions are a generalization of the standard symmetric and anti-symmetric orbit sums. They can also be viewed as multidimensional generalizations of one-dimensional cosine and sine functions with the symmetry and periodicity determined by the affine Weyl groups. We classify two independent admissible shifts, which preserve the symmetries of the weight and the dual weight lattices and generalize the form of orbit functions. The discrete Fourier calculus and discrete orthogonality relations of the generalized orbit functions are formulated.

Diana Dziewa-Dawidczyk (Warsaw University of Life Sciences - SGGW)
Jacobi polynomials and representations of group $SU(2)$ (together with prof. Aleksander Strasburger)

Agota Figula (Institute of Mathematics, University of Debrecen)
Multiplicative loops of topological quasifields

Abstract: An interesting application of Lie theory in geometry is the area of the coordinatization of topological non-desarguesian affine planes. Locally compact connected topological non-desarguesian translation planes have been a popular subject of geometrical research since the seventies of the last century (cf. [1]). These planes are coordinatized by locally compact quasifields Q such that the kernel of Q is either the field $\mathbb{R}$ of real numbers or the field $\mathbb{C}$ of complex numbers. The multiplicative loop $Q^* = (Q\backslash\{0\}, \cdot)$ is homeomorphic to $\mathbb{R} \times S^n$, where S^n is the n-sphere with $n \in \{1, 3, 7\}$. The

group G topologically generated by the left translations λ_a, $a \in Q^*$ is a linear Lie group, namely a closed connected subgroup of the group $GL_{n+1}(\mathbb{R})$ if the kernel of Q is $\mathbb{R}$, whereas a closed connected subgroup of the group $GL_2(\mathbb{C})$ if the kernel of Q is $\mathbb{C}$. In the talk we wish to determine the algebraic structure of the multiplicative loops for topological connected quasifields and describe explicitly the quasifields which coordinatize locally compact translation planes admitting a large Lie group as collineation group.

References

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Elitza Hristova (Institute of Mathematics and Informatics, Bulgarian Academy of Sciences)

Invariants of the symplectic and the orthogonal groups acting on $GL(n)$-modules

Abstract: Let W be a polynomial $GL(n,\mathbb{C})$-module. Then W can be written as a direct sum $W = \oplus_\lambda k(\lambda)V^n_\lambda$, where $\lambda = (\lambda_1 0,\dots,\lambda_n) \in \mathbb{Z}^n_{\geq 0}$ is a partition and V^n_λ is the irreducible $GL(n,\mathbb{C})$-module with highest weight λ. We consider the algebra of polynomial functions $\mathbb{C}[W]$ and the algebras of invariants $\mathbb{C}[W]^G$ where G is one of $SL(n,\mathbb{C})$, $O(n,\mathbb{C})$, and $Sp(2k,\mathbb{C})$ (in the case $n = 2k$). In the paper [BBDGK] the authors develop a method for computing the Hilbert series $H(\mathbb{C}[W]^{SL(n,\mathbb{C})}, t)$ of the algebra of invariants $\mathbb{C}[W]^{SL(n,\mathbb{C})}$. Instead of the Molien-Weyl integral formula, this method uses the theory of rational symmetric functions. In our poster we discuss the method from [BBDGK] and show how to extend it to compute also the Hilbert series of the algebras of invariants $\mathbb{C}[W]^G$ for $G = O(n,\mathbb{C})$ and $G = Sp(2k,\mathbb{C})$. We give explicit examples for computing $H(\mathbb{C}[W]^G, t)$, some of which were known and some of which were not known before. We discuss also further generalizations and applications of this method. The poster is based on a joint work with Vesselin Drensky.

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Katarzyna Karnas (Center for Theoretical Physics, Polish Academy of Sciences)

Criterions for quantum gates unversality

Abstract: The conditions for a set of quantum k-mode unitary and orthogonal gates to be universal are presented. It is shown that if the spectra of considered gates do not belong to a finite list of exceptional spectra, the problem of deciding universality boils down to solving a set of linear equations. We also present how the exceptional spectra are determined and prove that their number grows exponentially with the number of modes. Finally, for 2- and 3-mode gates it turns out that the exceptional spectra correspond to either finite subgroups of $SU(2)$ ($SO(3)$), or give universality. This way we classify all universal pairs of one qubit gates.

These are the results of the joint work with Adam Sawicki.

Anna Kimaczyńska (Lodz University)

Elliptic boundary conditions in the symmetric bundle

Abstract: A complete set of elliptic boundary conditiobs for second order $O(n)$-invariant differntial operators in the bundle of symmetric tensors will be presented.

Arthemy Kiselev (University of Groningen)
Deformation approach to quantisation of field models

Abstract: *(based on the IHES/M/15/13)* Associativity-preserving deformation quantisation $x \to \star$ via the Kontsevich summation over weighted graphs is lifted from the algebras of functions on finite-dimensional Poisson manifolds to the algebras of local functionals within the variational Poisson geometry of gauge fields over the space-time.

Wasyl Kowalczuk, Barbara Gołubowska, Ewa Eliza Rożko (Institute of Fundamental Technological Research of the Polish Academy of Sciences)
Towards affine dynamical symmetry in mechanics of deformable bodies

Abstract: Certain dynamical models of deformable bodies, including problems of partial separability and integrability, are discussed. There are some reasons to expect that the suggested models are dynamically viable and that on the fundamental level of physical phenomena the "large" affine symmetry of dynamical laws is more justified and desirable than the restricted invariance under isometries.

Abdelmalek Mohammed (Abubker Belkaid University, Tlemcen)
Transversality of special manifolds in arbitary codimensions

Giovanni Moreno (Institute of Mathematics, Polish Academy of Sciences)
A representation-theoretic characterisation of completely exceptional second-order PDEs

Abstract: The class of "completely exceptional PDEs" was introduced by Peter Lax in 1954. He studied the phenomenon of development of shock waves out of discontinuity waves, realising that, for the solutions of certain equations, such a transition never occur after a finite time. He called these equations "completely exceptional", since they behave like linear PDEs, though being genuinely non-linear. In 1991 Guy Boillat proved that, by integrating Lax's conditions of complete exceptionality, one obtains precisely the Monge-Ampere equations. In this talk, based on a joint publication with J. Gutt and G. Manno (doi:10.1016/j.geomphys.2016.04.021) I will show that completely exceptional second-order PDEs can be parametrised by the elements of the kernel of a natural differential operator. In order to prove the existence such an operator, I will introduce a suitable geometric framework for nonlinear second-order PDEs, and use some elementary representation-theoretic techniques. Our operator allows to describe intrinsically the original "completely exceptionality conditions" found by Lax, but also to introduce more general (quadratic, cubic, etc.) Monge-Ampere equations.

Natalie Nikitin (University of Paderborn)
Exponential laws for weighted function spaces and regularity of weighted mapping

Abstract: Let $U \subseteq \mathbb{R}^n$, $V \subseteq \mathbb{R}^m$ be open subsets and E be a locally convex topological vector space. For $k, l \in \mathbb{N}_0 \cup \{\infty\}$ a function $\gamma : U \times V \to E$ is called $C^{k,l}$ if the maps $\frac{\partial^\alpha}{\partial x^\alpha}\frac{\partial^\beta}{\partial y^\beta}\gamma : U \times V \to E, (x, y) \mapsto \frac{\partial^\alpha}{\partial x^\alpha}\frac{\partial^\beta}{\partial y^\beta}\gamma(x, y)$ $\frac{\partial^\alpha}{\partial x^\alpha}\frac{\partial^\beta}{\partial y^\beta}\gamma : U \times V \to E, (x, y) \mapsto \frac{\partial^\alpha}{\partial x^\alpha}\frac{\partial^\beta}{\partial x^\beta}\gamma(x, y)$ are defined and continuous for all $\alpha \in \mathbb{N}_0^n$, $\beta \in \mathbb{N}_0^m$ with $|\alpha| \leq k$, $|\beta| \leq l$. For natural topologies on the function spaces, an exponential law of the form $C^{k,l}(U \times V, E) \cong C^k(U, C^l(V, E))$ was shown by H. Alzaareer and A. Schmeding ([1]). We prove analogous exponential laws for weighted spaces of $C^{k,l}$-maps ([2]), and also for spaces of $C^{k,l}$-maps on suitable topological groups, like metrizable or locally compact groups ([3]). As an application, certain Lie groups of weighted mappings are shown to be C^k-regular. Exponential laws for function spaces related to infinite-dimensional Lie groups have also been established by A. Kriegl, P. W. Michor and A. Rainer ([4]) in a special case of Schwartz spaces of vector-valued

rapidly decreasing smooth functions. Our results concerning topological groups improve findings by D. Beltiţă and M. Nicolae ([5]).

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Antoni Pierzchalski (Lodz University)
Natural elliptic boundary conditions for different geometries

Abstract: A short review of complete lists of natural boundary conditions for different geometries like Riemannian, Hermitaian, symplectic etc. will be given. The problem of their ellipticity in the sense of Gilkey-Smith will be mentioned. The significance of the branching rule for subgroups of suitable Lie groups will be noticed.

Xavier Rivas (Polytechnic University of Catalonia)
A constraint algorithm for k-precosympletic field theories and some applications

Farshid Saeedi (Islamic Azad University, Mashhad, Iran)
On the dimension of the Schur multiplier of n-Lie algebras

Abstract: For an n-Lie algebra A of dimension d, we find the upper bound $\dim \mathcal{M}(A) \leq \binom{n}{d}$, where $\mathcal{M}(A)$ denotes the multiplier of A and that the equality holds if and only if A is Abelian. Finally, we give a formula for dimension of the multiplier of direct sum of two n-Lie algebras.

Daniel Wysocki (University of Warsaw)
Structure and classification of Lie bialgebras

Abstract: We study the problem of determination and classification of non-equivalent Lie bialgebra structures on a fixed Lie algebra. We introduce invariants on classes of Lie bialgebras giving the same Lie algebra structure on the dual Lie algebra. This is employed to simplify the differentiation of non-equivalent Lie bialgebra structures. Special attention is paid to coboundary Lie bialgebras. The classification of Lie bialgebras on $\mathfrak{sl}(2,\mathbb{R})$ and $\mathfrak{su}(2)$ is studied in detail.

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