

BELGIAN MATHEMATICAL SOCIETY

Comité National de Mathématique CNM $C \underset{N}{W} M$ NCW Nationaal Comité voor Wiskunde

Newsletter of the Belgian Mathematical Society and the National Committee for Mathematics

Belgian Mathematical Society ASBL/VZW ULB Campus Plaine, C.P. 218/01, Bld du Triomphe, B-1050 Brussels, Belgium

Website: bms.ulb.ac.be Newsletter: wendy.goemans@kuleuven.be **# 150**, November 15, 2024



By Andreas Weiermann

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The next edition of this newsletter appears on 15 January. Send your content (on PhD defenses, seminars, conferences, workshops, meetings, interaction with other sciences or companies, popular lectures, school initiatives, math exhibitions, job opportunities, ...) to wendy.goemans@kuleuven.be.

Foreword by the president of the BMS

Dear colleagues and friends,

One could wonder at which point something can be rightfully called a tradition. I asked myself this question, when I recently listened to a podcast where it was said that "as the tradition demands, we will answer the question of one of our listeners". Only, this was only the third or fourth episode of the podcast, maybe a bit early for a "tradition", was my impression. But who am I, to make such a judgement ? Instead, let me see the opportunity in this: also at the Belgian Mathematical Society we have the very nice tradition of awarding yearly a prize to a promising young mathematician. This prize was established in 2021 to commemorate the centenary of our society. The initial plan of our Society was to celebrate our 100 years of existence with a big conference. But, as those of you that are old enough might remember, in those times at the beginning of the third decade of the century, it was somewhat complicated to organize meetings. That is why we opted for the prize. And now comes the time to announce the fourth winner of this traditional Young Scholar Award: **Jozefien D'haeseleer**.

Jozefien obtained her PhD in Mathematics from Ghent University in 2021, under the supervision of Maarten De Boeck (University of Memphis, USA), Leo Storme (Ghent University) and Geertrui Van de Voorde (University of Canterbury, Christchurch, New Zealand). Currently, she is working as a post-doctoral researcher within the Department of Mathematics: Analysis, Logic and Discrete Mathematics at Ghent University. The research of Jozefien D'haeseleer is situated within Finite Geometry, but she also performs research in adjacent fields, such as algebraic and extremal combinatorics, graph theory, coding theory and other types of incidence geometries. Already during her Bachelor and Master studies, she obtained original results that have led to publication. The work she did in her Master thesis resulted in a significant improvement of the so-called sunflower bound for (k, 1)-SCIDs. This is the minimal size that a set of *k*-dimensional vector subspaces, pairwise intersecting in 1-dimensional vector subspaces, should have to guarantee that it becomes a sunflower, i.e. a set of *k*-spaces passing through a fixed 1-space, and pairwise intersecting in this fixed 1-space.

During her PhD, she extended her expertise to the use of algebraic combinatorics for studying problems regarding substructures in Finite Geometry. Since then, she demonstrated her versatility by studying diverse topics, such as cospectral graphs, Neumaier graphs, blocking sets, minimal codes and trifferent codes, Hilton-Milner problems, Higgledy-piggledy sets, translation hyperovals and absolute points of correlations. So far, she authored and co-authored 19 research papers and has more than 20 different co-authors. We want to warmly congratulate Jozefien with this award and wish her a fruitful continuation of her career.

Furthermore, if you would like to know more about the work of Jozefien, let me recall you that the Belgian Mathematical Society organizes a "Recent Breakthroughs in Mathematics" meeting on December 18 in Brussels, where she will be one of the speakers. During the same event, there will be talks about the work of Luis Cafarelli (Abel prize 2023), Maryna Viazovska (Fields Medal 2022) and Michel Talagrand (Abel prize 2024). You can find more information about this event further in the newsletter and on our website. Please do not forget to register for this event, so that we can guarantee enough food and drinks for all participants!

I hope you will continue to enjoy your Maths and I hope to see many of you in Brussels on December 18.

Joost.

1 News from the BMS & NCM

1.1 General Assembly 2024

The Belgian Mathematical Society is happy to invite you to its "Recent breakthroughs in Mathematics" symposium which will take on Wednesday December 18 2024 at ULB, Campus Solbosch (room Somville, building S). On this occasion we will also organise the society's general assembly.

See all information further in this newsletter and on https://bms.ulb.ac.be/conferences/recent-breakthroughs-in-mathematics-and-general-assembly-2024/.

1.2 Membership dues for 2025

The basic BMS membership fee is 20€ **per year or 100**€ **for 5 years.** See Section 1.2.1 for reciprocity membership.

You can pay via bank transfer (**BIC: GEBABEBB / IBAN: BE70 0011 7447 8525**) or through the following QR codes (please mention your name as communication)



Figure 1: Left: 20 euros - basic membership fee. Middle: 45 euros - BMS + EMS fee. Right: 100 euros - 5 year basic membership fee

Our address is:

Belgian Mathematical Society Campus de la Plaine, C.P. 218/01 Boulevard du Triomphe B-1050 Brussels, BELGIUM

The new Project Euclid system for electronic access to our journal, the Bulletin of the Belgian Mathematical Society, is stricter than before and asks the Society to update our subscriber's list yearly in January. So please pay your dues as soon as possible in order to keep uninterrupted access to the Bulletin.

1.2.1 Reciprocity and combined membership

The BMS has reciprocity agreements with the AMS, EMS, DMV, LMS, RSME, SMF, SBPMef, VVWL and KWG. In case you are already member of one of these societies, your membership fee for the BMS is reduced to 18€. Details can be found on this webpage.

We summarize the most common combined memberships:

BMS	20,00€
BMS for 5 years	100,00€
BMS with reciprocity	18,00€
BMS + EMS	45,00€

Note that the EMS (European Mathematical Society) membership fee of $25,00 \in$ is allowed only to persons belonging to an EMS corporate member society, such as the BMS. The individual EMS membership fee is $50,00 \in$ otherwise.

Note that it is now preferred that you pay your EMS membership fee directly to the EMS. See http://www.euro-math-soc.eu/ems_payment_new/ems_payment_new.html for details.

1.3 Bulletin of the Belgian Mathematical Society - Simon Stevin

Starting from Volume 28 the Bulletin of the Belgian Mathematical Society - Simon Stevin only appears online and is not printed any more. As a member of the BMS you have electronic access to all electronically available issues of the bulletin, free of charge. If you have any trouble logging in or accessing the journal, please contact customer_support@projecteuclid.org.

Content Volume 31 (3) October 2024

- The Cauchy problem for the fractional nonlinear Schrödinger equation in Sobolev space **HakBom Mun, JinMyong An, JinMyong Kim** DOI: 10.36045/j.bbms.230426
- On a Poincaré-Perron problem for high order differential equations Harold Bustos, Pablo Figueroa, Manuel Pinto DOI: 10.36045/j.bbms.230615
- Harmonic functional calculi in Banach algebras with involution **Abderrahim Medbouhi** DOI: 10.36045/j.bbms.231202
- A note on two new integral representations of the Gauss hypergeometric function with an application **Wathek Chammam, Arjun K. Rathie, Mongia Khlifi** DOI: 10.36045/j.bbms.
- The properties of solutions for the coupled 4th-order parabolic equations **Bingchen Liu**, **Yang Li** DOI: 10.36045/j.bbms.240131
- Criteria for the properties (ω) and (W_E) under perturbations **Gaohuizi Feng**, **Pentong Li** DOI: 10.36045/j.bbms.240307
- Higher order differential subordinations for certain starlike functions **S. Sivaprasad Kumar, Neha Verma** DOI: 10.36045/j.bbms.240311
- The Lattice of Bornologies on a Set Gerald Beer, Homeira Pajoohesh DOI: 10.36045/j.bbms.240318

For the table of contents of previous issues, see https://projecteuclid.org/all/euclid.bbms.

2 (Online) Meetings, Conferences, Lectures, ...

2.1 October-December 2024

Lecture series on tangible incompleteness

zoom, UGent

Harvey Friedman started on October 10th 2024 an UGent zoom lecture series on tangible incompleteness. It runs every Thursday 4-5pm.

This presented material will become a part of a book project with the title INVARIANT MAXIMALITY AND CHOICE and the following Chapters.

- 1. Introduction
- 2. Shift, Lower Shift, Interval Shift Invariance
- 3. Invariant Maximality and Choice Derivations
- 4. Invariant Maximality Reversals
- 5. Finite Invariant Choice

The lecture plan is as follows.

- Lecture 1. Invariance in piecewise linear and semi algebraic real functions/1.
- Lecture 2. Invariance in piecewise linear and semi algebraic real functions/2.
- Lecture 3. From "every widget has a maximal gadget" to "every invariant widget has an invariant' maximal gadget". Implicitly Pi01.
- Lecture 4. Proofs of "every invariant widget has an invariant' maximal gadget" in Zermelo set theory.
- Lecture 5. Proofs of "every invariant widget has an invariant' maximal gadget" using large cardinals.
- Lecture 6. Reversal to Con(SRP). Graphs, maximal cliques. Atomic representation.
- Lecture 7. Reversal. Negative reduction, tupling.
- Lecture 8. Reversal. Tupling, M = (Q[0,inf),<,R,1,2,...).
- Lecture 9. Reversal. Internal pre well order, X = (D,<,PAIR,SET,epsilon,U[1],U[2],...,c[1],c[2],...).
- Lecture 10. Reversal. Internal Constructibility, Con(SRP).
- Lecture 11. Restricted maximality.
- Lecture 12. Explicitly Pi01.

Interested people can obtain a zoom link from Andreas Weiermann on request, andreas.weiermann@ugent.be.

The sessions are recorded and available on https://www.youtube.com/@AndreasWeiermann

2.2 November 2024

Joint UCL-ULB-VUB Seminar on Quantum groups, Hopf algebras and monoidal categories

27 November 2024, 13h30, VUB

On Wednesday 27 November, 13h30 at VUB, the next edition of the joint UCL-ULB-VUB Seminar on Quantum groups, Hopf algebras and monoidal categories takes place with speakers Joeri De Ro (VUB) and Mao Hoshino (University of Tokyo). For more information, see the website: https://hopfalgb.ulb.be/schedule.html.

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ISAAC-ICMAM Conference of Women in Mathematics

27-29 November 2024, Virtual-Via Zoom

See all the information on https://sites.google.com/view/isaac-icmam-conference-4-women/home

2.3 December 2024

ISAAC-ICMAM Conference of Analysis in Developing Countries

2-6 December 2024, Hybrid via Google Meet and YouTube, in-person at the National University of Colombia, Bogotá, Colombia

See all the information on https://www.matua.edu.co/isaac-icmam-conference-of-analysis-in-developing-countries-2024/

EoS one-day workshop "Beyond Symplectic Geometry"

6 December 2024, ULB

In the framework of the Excellence of Science grant "Beyond Symplectic Geometry", shared by the geometry groups at KU Leuven, ULB and UAntwerpen, there will be 3 days of talks this academic year.

The first one will take place on Friday 6th December, at the ULB. The main aim is to give the junior members of all three groups the chance to meet each other and hear about their research.

If you plan to come, please email marco.zambon@kuleuven.be by 26th November with the following information:

- Whether you intend to come also to the lunch.
- If you have any dietary requirements.

The lunch will certainly cater for vegetarians.

There will be four talks

- 10.30 Andreas Schüssler (KU Leuven)
- 11.45 Federico Zadra (UAntwerpen)
- 13.00 Lunch
- 14.30 Pedro Santos (UAntwerpen)
- 15.45 Mateo Anarella (KU Leuven)

The two talks before lunch will take place in Forum H. The two talks after lunch will take place in the Salle des Profs on the 9th floor of building NO.

A map of the ULB campus de la Plaine (where both lecture rooms are) can be found here.

These details are also available on https://www.uantwerpen.be/nl/personeel/sonja-hohloch/private-webpage/excellence2-of-scien/miniworkshops/.

7th edition of the Dutch-Belgian seminar in discrete mathematics

9 December 2024, UGent

We are happy to announce the 7th edition of the Dutch-Belgian seminar in discrete mathematics at UGent, Belgium, on Monday December 9th 2024.

Aiming to give young researchers a platform, we are glad to present the following program:

- 11:15-11:30 opening
- 11:30-12:00 Eileen Robinson (ULB, Belgium) Coloring antiprismatic graphs
- 12:00-12:30 Thijs van Veluw (UGent-TU/e, Belgium-The Netherlands) Hoffman colorings of graphs
- 12:30-13:30 lunch
- 13:30-14:00 **Emiliano Liwski (KULeuven, Belgium)** An algorithm to identify the set of minimal matroids
- 14:00-14:30 Vlad Taranchuk (UGent, Belgium) Caps, graphs, and polynomials
- 14:30-15:00 coffee break
- 15:00-15:30 Andrea Di Giusto (TU/e, The Netherlands) To Generalized Weights ... and Beyond: new invariants for linear codes
- 15:30-16:00 **Jonathan Mannaert (VUB, Belgium)** Boolean degree d functions in the (q-)Johnson scheme

Registration is free but mandatory and possible through the following link.

More information can be found on https://aidaabiad.win.tue.nl/dutchbelgiandiscretemathseminar.html.

Feel free to forward this invitation to other people that might be interested. Hope to see you then!

The organizers Aida Abiad (TU/e, UGent, VUB), Jan De Beule (VUB), and Sam Mattheus (VUB)

Recent breakthroughs in Mathematics

18 December 2024, ULB

The Belgian Mathematical Society is happy to invite you to its "Recent breakthroughs in Mathematics" symposium which will take on Wednesday December 18 2024 at ULB, Campus Solbosch (room Somville, building S). On this occasion we will also organise the society's general assembly. Participation is free for BMS members and PhD students, but registration is mandatory, see below. Non PhD students who are not BMS members will be invited to become members to enjoy the free drinks :-).

Programme (tentative)

- 10h30-11h00 : Welcome coffee
- 11h00-12h00 : Jean-Michel Roquejoffre about the work of Luis Cafarelli (Abel prize 2023)
- 12h00-14h00 : lunch
- 13h00-13h30 : BMS Board meeting
- 13h30-14h00 : BMS General assembly
- 14h00-15h00 : David Gontier about the work of Maryna Viazovska (Fields Medal 2022)
- 15h00-16h00 : Talk by winner of the YSA 2024
- 16h00-16h30 : coffee break
- 16h30-17h30 : Ronan Herry about the work of Michel Talagrand (Abel prize 2024)
- 17h30-18h30 : drink

See all information and registration on https://bms.ulb.ac.be/conferences/recent-breakthroughs-in-mathematics-and-general-assembly-2024/.

2.4 January 2025

Recipient of the Chaire de la Vallée Poussin 2024: Professor Bernhard Keller (Université Paris Cité)

January 2025

Professor Bernhard Keller (Université Paris Cité) will be the recipient of the Chaire de la Vallée Poussin 2024.

Bernhard Keller will give a series of lectures on "Quiver combinatorics, cluster algebras and categories" at the Institut de Recherche en Mathématique et Physique (https://uclouvain.be/fr/institutsrecherche/irmp) of the Université catholique de Louvain.

The first lecture, called the leçon inaugurale and accessible to a wide audience, is scheduled on Wednesday, 8 January 2025, at 4.15 p.m., in the Auditoire de la Vallée Poussin (CYCL01). The title of the inaugural lecture is From Coxeter-Conway friezes to cluster algebras. This lecture will be followed by a reception to which you are all warmly invited (in case you will attend it please send an email to secretaire-irmp@uclouvain.be by December 16, with subject "CDLVP-drink").

The second lecture, entitled Cluster algebras and quiver representations, will take place on Thursday 9 January, at 11 a.m.

The third lecture on Derived categories and cluster categories is scheduled on Thursday 9 January, at 4.15 p.m.

The fourth lecture on Categorical periodicity will be on Friday, 10 January, at 11 a.m.

The updated information concerning this event is available at the webpage https://uclouvain.be/en/research-institutes/irmp/chaire-de-la-vallee-poussin-2024.html

2.5 January - February 2025

First recipient of the Jacques Tits chair: Emmanuel Breuillard

January - February 2025

The first edition of the Jacques Tits chair (https://bms.ulb.ac.be/bms-prizes/) has been awarded by the BMS to Emmanuel BREUILLARD (University of Oxford).

Emmanuel Breuillard will visit Belgium in the context of the Jacques Tits chair during January 13-24 and February 10-21 (2025).

In the first part of his stay, he will give a mini-course titled 'Character varieties of random groups' following the schedule below. The exact rooms (and any update to the schedule) will be posted on the BMS website, https://bms.ulb.ac.be/conferences/jtc24/.

- Monday 13 Jan. Brussels (15h-18h): Inaugural lecture 'The Tits alternative and its many facets', followed by a reception.
- Wednesday 15 Jan. Louvain-La-Neuve (10h30-12h30): Mini-course 1. Expander graphs and spectral bounds for large finite simple groups.
- Friday 17 Jan. Louvain-La-Neuve (10h30-12h30): Mini-course 2. Diophantine heights on character varieties and the height gap theorem.
- Tuesday 21 Jan. Leuven (10h30-12h30): Mini-course 3. Uniform spectral gaps for group actions and non-concentration estimates for random walks.
- Thursday 23 Jan. Kortrijk (10h30-12h30): Mini-course 4. Random character varieties.

During the second part of his stay (Feb. 10-21), E. Breuillard will be available for discussions or invitations for seminars in any Belgian university.

Abstract:

The mini-course will be devoted to the study of the finite dimensional linear representations of random finitely presented groups. We will show how the combinatorial and probabilistic ideas from the theory of random walks on groups meet diophantine analysis and algebraic geometry over large finite fields to help understand the nature of these representations. The construction of free subgroups - which will be the topic of the inaugural lecture - and the geometric and number-theoretic techniques it involves will play an essential role.

For more information and registration, see https://bms.ulb.ac.be/conferences/jtc24/. For questions, contact francois.thilmany@uclouvain.be or jonas.dere@kuleuven.be.

2.6 April 2025

Global Minds in Pseudo-differential Analysis

14-18 April 2025

https://analysis-pde.org/global-minds-in-pseudo-differential-analysis/

This transformative project focuses on enhancing educational opportunities in Colombia by partnering with prominent Colombian mathematicians. The aim of this project is to impart significant knowledge in the field of pseudo-differential operators to the younger generation. This initiative is part of the Ghent Analysis and PDE Center's commitment to supporting mathematical research in developing countries, particularly in Latin America.

Promotor: Prof. Dr. Michael Ruzhansky (PI), Ghent University. Co-promotors: Dr. Duvan Cardona (Co-PI), Ghent University Dr. Marianna Chatzakou (Co-PI), Ghent University

Global South partners:

Prof. Dr. Jairo Hernández (Universidad del Norte, Colombia)
Prof. Dr. Bienvenido Barraza (Universidad del Norte, Colombia)
Prof. Dr. Carolina Neira Jiménez (National University of Colombia)
Prof. Dr. Liliana Posada (Universidad del Valle, Colombia)
ICMAM Latin America (International Community of Mathematicians from Latin America)

HOPF25

22-26 April 2025

From April 22 until April 26, an international conference on Hopf algebras, quantum groups, monoidal categories and related structures will be organized at the Université Libre de Bruxelles. Invited speakers are Nicolás Andruskiewitsch (Córdoba), Shahn Majid (London), Vanessa Miemietz (Norwich), Dmitri Nikshych (Durham) and Chelsea Walton (Houston). Registration and a call for contributed talks is open until January 31, 2025. For more information and the registration form, please visit the website https://hopfalgb.ulb.be/Hopf2025/.

The organizers,

Ana Agore, Stefaan Caenepeel, Kenny De Commer, Julia Plavnik, Paolo Saracco, Špela Špenko, Pedro Vaz, Leandro Vendramin, Joost Vercruysse, Yinhuo Zhang

2.7 Seminars and colloquia

Analysis & Geometry Seminar

UAntwerpen (usually Wednesdays 16-17h during term)

This is the weekly research seminar of the analysis & geometry-interested people in Antwerp. During the semester, we have once per week a research talk in analysis and/or geometry and/or related topics. The list of speakers comprises researchers from Antwerp as well as other universities. Details (schedule, speakers, titles, abstracts, seminar room/ online/ hybrid etc.) can be found on the seminar webpage https://www.uantwerpen.be/nl/personeel/sonja-hohloch/private-webpage/seminars/analysis-geometry/

> To be added/deleted from the mailing list, please send an email to: sonja dot hohloch AT uantwerpen dot be

Ghent Geometric Analysis Seminar

https://analysis-pde.org/seminars/ghent-on-geometric-analysis/

Ghent Methusalem Junior Seminar

https://analysis-pde.org/ghent-methusalem-junior-seminar/

Seminar of Analysis and PDE

https://analysis-pde.org/seminars/

Ghent Methusalem Colloquium

https://analysis-pde.org/ghent-methusalem-colloquium/

3 PhD theses

Statistical matching and data generation Some contributions to synthetic data creation

> Hugues Annoye UCLouvain 11 September 2024

Thesis advisors: Prof. Dr. Cédric Heuchenne

Summary: In this thesis, we propose several methods to address data issues related to the Beamm project. The core of this project is to develop a tax-benefit microsimulation model for Belgium accessible online, requiring intensive data handling. Our challenges consist in creating a unified data set containing variables from different surveys and developing a completely synthetic database for the online development of the Beamm platform.

In Chapters 2 and 3, we introduce various approaches to perform statistical matching using machine learning techniques such as Kernel Canonical Correlation Analysis (KCCA), Super-Organizing Map (Super-OM), Autoencoder-Canonical Correlation Analysis (A-CCA) and Multi-output Multilayer Perceptron (MMLP). We include sampling weights in all the methodologies. Moreover, we present a two-step approach to handle data sets containing both categorical and continuous variables, and to address inconsistencies between categorical variables. We have seen that the proposed methodologies can be competitive, especially with KCCA and A-CCA, which combine the distinct advantages of the results obtained with both hot-deck and regression-based methods.

In Chapter 4, we employ a range of data generation approaches utilizing various advancements in the Wasserstein Generative Adversarial Network (WGAN) literature. Our algorithms have been adjusted to account for sampling weights, and a new metric based on Support Vector Data Description (SVDD) has been introduced to assess the quality of the generated data. This measure indicates the relative difference between two radii, making it useful for practitioners who have access to a percentage of deviation of the synthetic data compared to the original data. Through our experiments, it became evident that methods employing gradient penalty and sampling weights produced the most favorable outcomes across a spectrum of metrics.

Submanifolds of the pseudo-nearly Kähler $SL(2, \mathbb{R}) \times SL(2, \mathbb{R})$

Mateo Anarella KU Leuven and Université Polytechnique Hauts-de-France 13 September 2024

<u>Thesis advisors</u>: Prof. Dr. Joeri Van der Veken (KU Leuven) and Prof. Dr. Luc Vrancken (Université Polytechnique Hauts-de-France)

Summary: Submanifold theory is a generalization to higher dimensions of the study of surfaces in \mathbb{R}^3 . That is, it is the study of isometric immersions and how the intrinsic and extrinsic invariants relate to each other. In almost Hermitian geometry, we are also interested in how the almost complex structure of the ambient space acts on the tangent spaces of the submanifold. If the almost complex structure maps the tangent bundle into the normal bundle, we say that the submanifold is totally real. Moreover, if the dimension of the submanifold is maximal, i.e. half of the dimension of the ambient space, the submanifold is Lagrangian. This definition agrees with the notion of Lagrangian submanifold in symplectic geometry, since the Kähler form $g(J \cdot, \cdot)$ vanishes everywhere on the submanifold.

The aim of the thesis is to broaden the understanding of the nearly Kähler $SL(2, \mathbb{R}) \times SL(2, \mathbb{R})$ and its submanifolds. Nearly Kähler manifolds are a Riemannian relaxation of the definition of a Kähler manifold: an almost Hermitian manifold (M, g, J) is nearly Kähler if the covariant derivative of the almost complex structure is skew-symmetric. Moreover, to avoid a possible intersection with Kähler manifolds, we require the condition on M of ∇J being non-degenerate, which we call strict nearly Kähler. The nearly Kähler $SL(2, \mathbb{R}) \times SL(2, \mathbb{R})$ is the pseudo-Riemannian dual of $S^3 \times S^3$, one of the only four six-dimensional homogeneous strict nearly Kähler manifolds, classified by Butruille.

In this space we study different types of submanifolds, such as surfaces, Lagrangian submanifolds and hypersurfaces. We divide Lagrangian submanifolds into four different types, which depend on their behavior with respect to an almost product structure. We classify all totally geodesic and extrinsically homogeneous Lagrangian submanifolds. Moreover, we study totally geodesic surfaces and hypersurfaces with constant sectional curvature.

Drinfeld Doubles of Coideals and Quantization of $SL(2, \mathbb{R})$

Joel Right Dzokou Talla Vrije Universiteit Brussel October 30, 2024

Thesis advisors: Prof. Dr. Kenny De Commer

Summary: The goal of this thesis is to provide a general framework for the quantization of noncompact semi-simple Lie groups. We focus on the particular case of quantum $SL(2, \mathbb{R})$. This thesis is divided into two parts:

In the first part, we develop a general theory for the construction of coideals. Let *A* and *B* be two Hopf *-algebras with the pairing between them. We construct the Drinfeld double coideal $\mathcal{D}(J, I)$, constructed as the *-algebra generated by a right coideal *-subalgebra $J \subseteq A$ and its orthogonal left coideal *-subalgebra $I \subseteq B$. Next, when *A* is a compact quantum group Hopf *-algebra and given a unital right coideal *-subalgebra *J* of *A*, we consider the problem of "integrating" the stabilizer coideal $I = J^{\perp}$ and we provide conditions for the existence of a relatively invariant integral on the integrated version of *I* inside the dual discrete multiplier Hopf *-algebra of *A*. Given such a relatively invariant integral, we show how it can be extended to a relatively invariant integral on the integrated version of the Drinfeld double coideal.

In the second part of the thesis, we illustrate the considerations of the first part of the thesis in the rank 1 case of $SL(2, \mathbb{R})$. In fact, we define, for q a real number, a new unital *-algebra $U_q(\mathfrak{sl}(2, \mathbb{R}))$ quantizing the universal enveloping *-algebra of $\mathfrak{sl}(2, \mathbb{R})$, which had up to now not been considered in the literature. The *-algebra $U_q(\mathfrak{sl}(2, \mathbb{R}))$ is realized as a *-subalgebra of the Drinfeld double of $U_q(\mathfrak{su}(2))$ and its dual Hopf *-algebra $\mathcal{O}_q(SU(2))$. More precisely, $U_q(\mathfrak{sl}(2, \mathbb{R}))$ is generated by the equatorial Podleś sphere coideal *-subalgebra $\mathcal{O}_q(K \setminus SU(2)) \subseteq \mathcal{O}_q(SU(2))$ and its associated orthogonal coideal *-subalgebra $U_q(\mathfrak{sl}) \subseteq U_q(\mathfrak{su}(2))$. We then classify all the irreducible *-representations of $U_q(\mathfrak{sl}(2, \mathbb{R}))$. Next, we consider the integrated setting and we define the notion of relatively invariant integral on the integrated version $\mathcal{U}_q(\mathfrak{sl}(2, \mathbb{R}))$ of $\mathcal{U}_q(\mathfrak{sl}(2, \mathbb{R}))$. Finally, based on ideas due to Takeuchi, Müller-Schneider and Chirvasitu, we are able to relate the latter construction with the function algebra of the dynamical quantum SU(2) group, which will allow us in a future work to relate also their representation theories.

The nonlinear Schrödinger equation on metric graphs

Damien Galant UMONS and UPHF December 9, 2024, 14:00, Abel de Pujol 2, UPHF

Thesis advisors: Prof. Dr. Colette De Coster (UPHF) and Prof. Dr. Christophe Troestler (UMONS)

Summary:

In this thesis, we investigate the nonlinear Schrödinger equation

$$-\Delta u + \lambda u = |u|^{p-2}u \tag{NLS}$$

where $\Delta := \sum_{1 \le i \le N} \partial_{ii}$ is the Laplacian, $p, \lambda \in \mathbb{R}$ and p > 2. The equation will be set on open domains of \mathbb{R}^N or, in most chapters, on metric graphs.

To begin with, we set the stage in which the following chapters take place. Thus, we present the superlinear elliptic equation (NLS), metric graphs and the formulation of (NLS) on them.

Then, we introduce several notions. In particular, we consider two ways to tackle the problem variationally: one based on the critical points of the action functional on the Nehari manifold, leading to (nodal) action ground states, the other based on critical points of the energy functional on a L^2 -mass constraint, leading to normalized solutions. Five chapters follow, dedicated to:

- 1. an existence theorem of solutions to (NLS) on metric graphs which allows to construct examples where one may compare the notions of action ground state and of minimal action solution on noncompact domains;
- 2. existence and non-existence results for action ground states and nodal action ground states on several classes of metric graphs;
- 3. a new method to prove the existence of (positive and nodal) L^2 -normalized solutions to (NLS) with the Dirichlet boundary condition on bounded open sets of \mathbb{R}^N , including in the L^2 -supercritical regime;
- 4. the infinite multiplicity of normalized solutions, on metric graphs and in the L^2 -supercritical regime, to the nonlinear Schrödinger equation with localized nonlinearity;
- 5. the asymptotic analysis of (NLS) on compact graphs in the asymptotic regime $p \rightarrow 2$ thanks to a Lyapunov-Schmidt reduction, the study of nodal ground states vanishing identically on edges on compact star graphs as well as the detailed study of the "tetrahedron graph" thanks to a computer-assisted proof using computations certified by interval arithmetic.

4 News from the universities and other societies

4.1 Books series "Research Perspectives Ghent Analysis and PDE Center"

First books in the series "Research Perspectives Ghent Analysis and PDE Center" are published. It is a subseries within the esteemed book series "Trends in Mathematics" published by Birkhäuser/Springer. This series is dedicated to publishing extended abstracts of seminars, conferences, workshops, and other scientific events associated with the Ghent Analysis and PDE Center.

Book Details https://www.springer.com/series/17271:

- Extended Abstracts PSORT 2024: Pseudo-Differential Operators and Related Topics (2025) Editors: Vishvesh Kumar, David Rottensteiner and Michael Ruzhansky;
- Women in Analysis and PDE (2024) Editors: Marianna Chatzakou, Michael Ruzhansky and Diana Stoeva;
- Modern Problems in PDEs and Applications: Extended Abstracts of the 2023 GAP Center Summer School (2024)

Editors: Marianna Chatzakou, Joel Restrepo, Michael Ruzhansky, Berikbol Torebek and Karel Van Bockstal;

- Analysis and Applied Mathematics: Extended Abstracts of the 2022 Joint Seminar (2024) Editors: Allaberen Ashyralyev, Michael Ruzhansky and Makhmud A. Sadybekov;
- Tbilisi Analysis and PDE Seminar: Extended Abstracts of the 2020-2023 Seminar Talks (2024) Editors: Roland Duduchava, Eugene Shargorodsky and George Tephnadze;
- Extended Abstracts MWCAPDE 2023: Methusalem Workshop on Classical Analysis and Partial Differential Equations (2024)
 - Editors: Michael Ruzhansky and Berikbol Torebek;
- Extended Abstracts 2021/2022: Ghent Analysis and PDE Seminar (2024) Editors: Michael Ruzhansky and Karel Van Bockstal;
- Extended Abstracts 2021/2022: Methusalem Lectures (2024) Editors: Duván Cardona, Joel Restrepo, and Michael Ruzhansky.

5 History, maths and art, fiction, jokes, quotations ...

5.1 Exhibition



https://hosting.uantwerpen.be/400jaarmechanischrekenen/inleiding.htm

5.2 Review of "Modern Mathematics. An International Movement?"

At the end of this newsletter you find a review on "Modern Mathematics. An International Movement?" by Dirk De Bock (Ed.).

5.3 Adhemar's corner

Next follows a review on two books from the Imagine Math series about the interaction between mathematics and culture, volumes 7 and 8 of *Imagine Math* by M. Emmer and M. Abate (eds.). Enjoy reading! Imagine Math, vols 7 & 8 Michele Emmer, Marco Abate (eds.). Springer Nature, 2020, 2022 (473, 604 p.), isbn: 978-3-030-42652-1, 978-3-030-92689-2.

Volume 7 of the Imagine Math series contains the proceedings of the *Mathematics and Culture* held in Venice in 2019 and volume 8 is a conference-free pandemic successor. Like other volumes, these also



contain a selection of original papers highlighting the relation between mathematics and almost all aspects of society and culture, from science to art and from biology to comic strips. I have reviewed in this Newsletter previous volumes in more detail, but it may be a good idea to remind the readers of the existence of the series. With a total of more than 1000 pages in these two volumes, it is impossible to cover here all the topics separately. So I will restrict myself to mentioning some of the topics and show that in several cases the relation with mathematics goes both ways.

Cinema has been a returning topic in several of the previous volumes, and we find it also in these. That includes for example mathematical methods for the restoration of old films, but also a survey of movies about mathematicians of which we had a few winners lately (Good Will hunting, A beautiful mind, The imitation game, The theory of everything, Hidden figures) with a separate paper devoted to Octavia Spencer, one of the actresses in Hidden figures.

Most contributions are dealing with mathematics and *art* in a broad sense and also that goes both ways. Art in Venice is discussed, but also the MOSE project



that should somewhat protect Venice against flooding. There are proposals to measure aesthetics, and a discussion how painters and stage performers deal with the fourth dimension. The role of polytopes and polyhedra in art and in mathematics is discussed and how symmetry can bring beauty, not only in these constructs but also in tilings of the plane, which brings us back to the mathematics of groups. Another returning subject is a discussion of *origami*. How can the folding algorithm be denoted? The rationalism and abstraction of the *Bauhaus* can be seen as a parallel to the movement in mathematics early 20th century. A separate paper discusses Paul Klee who had a keen interest in mathematics. The Bauhaus relates to architecture and design, represented



as usual by several papers, classic as well as modern designs. For example, if you do not want a staircase to have only equal steps bringing you in a straight line from level 1 to level 2, but you want this to follow a sigmoid curve like the sine increases from -1 to 1. How should we calculate the steps? Soap bubbles are not only the subject of mathematical research with Joseph Plateau from Ghent as

a protagonist, but we find also a discussion of an exposition of paintings showing soap bubbles, and minimal surfaces and shapes of bubbles in foam have been used in architecture. Literature is also represented with several papers. In a remarkable contribution we learn about François Le Lionnais (1901-1984), a French chemical engineer and mathematician who combined science and literature. Connections are made with Bourbaki and *Oulipo*.

Perhaps I should mention a paper devoted to Roger Penrose whom we know from his impossible triangle, Penrose tilings, (impossible figures and tilings are both intensively explored in the work of M.C. Escher). Penrose got the Nobel Prize in 2020 (he was then 89) for his study of black holes.

These two Imgagine Math volumes are once more two excellent books for any reader interested in mathematics and culture. Adhemar Bultheel Modern Mathematics. An International Movement? *Dirk De Bock* (Ed.), History of mathematics education, Springer Cham, 2023 (596 p.) doi: 10.1007/978-3-031-11166-2

After the Second World War, in the 1950s, a sense of renewal swept through society, including education and, more specifically, school mathematics. It was felt that school mathematics was too far removed from the mathematics taught at universities and, more generally, from the mathematics needed in a modernising society. As a result, school mathematics curricula were changed in the 1960s and early 1970s under the name "Modern Mathematics" or "New Math". Extensive computation and Euclidean geometry were replaced or preceded by set theory and algebraic structures (such as groups), and new domains such as logic, statistics and analysis were introduced.

In "Rods, Sets and Arrows. The Rise and Fall of Modern Mathematics in Belgium", Dirk De Bock and Geert Vanpaemel presented

a detailed account of the Modern Mathematics Movement in Belgium, see Philippe Cara's review in BMS Newsletter 133, 15 May 2021. This book is now complemented by an international perspective on this radical and global curriculum change in school mathematics in "Modern Mathematics. An International Movement?", edited by Dirk De Bock.

The book begins by describing how the climate of the 1950s led to the emergence of the New Math Movement in the USA and the Modern Mathematics Movement in Europe. In Chapter 2, David Lindsay Roberts deepens how the political situations, i.e. the Second World War and the Cold War, and the revision of undergraduate mathematics education, i.e. mathematics is the study of structures as described by Bourbaki, provided the soil and funding for the installation of New Math in secondary education in the USA. Several programmes and experiments took place, of which we mention the University of Illinois Committee on School Mathematics (UICSM), which set up an experimental curriculum for the affiliated secondary school. In the 1954 UICSM material, natural numbers are defined as classes of sets that are in one-to-one correspondence with each other, and integers are defined as equivalence classes of ordered pairs of natural numbers.

The European side of the origin of Modern Mathematics is explained in Chapter 3 by Dirk De Bock. First, the CIEAEM (Commission Internationale pour l'Étude et l'Amélioration de l'Enseignement des Mathématiques/International Commission for the Study and Improvement of Mathematics Education), officially founded in 1952, is presented. Then it is outlined how the CIEAEM's founder, Caleb Gattegno, who had a doctorate in mathematics and one in psychology, suggested to combine the concept of mathematical structure in Bourbaki's work with structuralism in psychology, as advocated mainly by Jean Piaget. From Piaget's identification of Bourbaki's mathematical structures and the basic structures of thought follows the conclusion: "A model for the science of mathematics was promoted as a model for the teaching of mathematics." (p. 46). In this way, the foundations of the Modern Mathematics Movement of the 1960s were laid in the early 1950s: "Bourbaki provided the mathematical rationale and Piaget the psychological justification." (p. 47).

It is clear from Chapters 2 and 3 that the New Math Movement in the USA and the Modern Mathematics Movement in Europe developed largely independently of each other. Of course, these movements were influenced by similar trends and events, and there were occasions when protagonists of the two movements met. These occasions, in the form of meetings, seminars and conferences, are discussed in Chapter 4. The Royaumont seminar of 1959 is often regarded as a crucial meeting, since it gave additional impetus to several national Modern Mathematics Movements. Fulvia Furinghetti and Marta Menghini discuss in Chapter 4 the run-up to the Royaumont Seminar, the Royaumont Seminar itself, and the series of meetings that followed in the 1960s and 1970s. The authors do not confine themselves



to Western Europe, but also include meetings held in Eastern Europe, i.e. behind the Iron Curtain, as well as in Africa and Asia.

The international view from Chapter 4 is continued in the remainder of "Modern Mathematics. An International Movement?". In Chapters 5 to 24 different authors study the prelude, implementation, and fall of Modern Mathematics in some 28 countries spread over all continents. Depending on the local situation, the stress is put on organisations, people, projects or publications. These specific choices made by the different authors might make a full comparison of the Modern Mathematics Movements in different countries a bit difficult, but that is also not an objective of the book. In this review I restrict myself to presenting two chapters in a bit more detail.

Chapter 13, "Reforms inspired by *Mathématique Moderne* in Poland, 1967-1980", by Zbigniew Semadeni, shows the importance of international meetings and contacts in the dissemination of Modern Mathematics. It is described how Anna Zofia Krygowska was influenced by amongst others Piaget and Georges Papy, and how she steered the mathematics curricula and research on mathematics education in Poland. Of special interest, from a mathematical point of view, is the detailed summary of the axioms for teaching geometry in upper secondary education.

The extensive Chapter 21 by Nerida F. Ellerton and M. A. (Ken) Clements on Australia contains three main parts, the first one on Gattegno and the Cuisenaire rods (see also De Bock and Vanpaemel's Rods, Sets and Arrows for information on this teaching aid) and the last one on the entry of New Math in secondary school curricula. The middle part is on the influence of Zoltán Pál (Zoltan Paul) Dienes on school mathematics in Australia. His multibase arithmetic blocs, algebraic experience material and logic blocks make an appearance, and so is his theory of mathematics learning, which is confronted with Piaget's ideas.

From several chapters in "Modern Mathematics. An International Movement?", it is clear that the drastic changes in the curriculum for school mathematics did not survive for long in the countries in which it was implemented. Already in the 1970s the extremes of Modern Mathematics or New Math were often abandoned again. The question whether Modern Mathematics was a failed experiment is answered several times explicit or implicit in this book. Apart from the mathematical content, Modern Mathematics was an occurrence of thinking about how to teach mathematics. Mathematicians, teacher trainers and teachers reflected not only on mathematics, but also on teaching methods and which tools to use. National and international associations of teachers were formed, training sessions for teachers were organised, ..., mathematics education became a discipline.

All those interested in the historical background of the Modern Mathematics Movement should definitely read Chapters 2 and 3 of "Modern Mathematics. An International Movement?". The chapters on a specific country or a group of countries are self-contained, hence, can be read independently, according to personal interest. This makes the book adaptable to personal preference, one can read it front to back, or stroll in it.

Wendy Goemans