51STE NEDERLANDS MATHEMATISCH CONGRES

NMC 2015

under the auspices of
the Dutch Royal Mathematical Society (KWG)

14 – 15 April 2015
Universiteit Leiden

Contents

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2 Preface

We are delighted to welcome you to Leiden and the 51st *Nederlands Mathematisch Congres*!

This congress, like the previous one in 2014, is organised by Leiden University and Delft University of Technology, under the auspices of the Dutch Royal Mathematical Society (KWG). We thank all our sponsors for making the event possible.

We are very pleased with the line-up of speakers for our congress, and are grateful to the members of the scientific advisory board, as well as the boards of national mathematics clusters DIAMANT, GQT, NDNS+, and STAR, and the Applied Mathematics Institute of the 3TU Federation (3TU.AMI) for advice and assistance during the preparation of the scientific programme.

We are also grateful to the Leiden University Graduate School of Teaching (ICLON) and the Freudenthal Institute for Science and Mathematics Education (FI) for organising the *Docentendag 'Wat is wiskunde voor jou?'* on 15 April. For the first time, this traditional part of the programme has been officially recognised as part of the professional development of teachers of mathematics.

The format of the 2015 congress differs significantly from previous years. The number of parallel sessions has been reduced and the focus is given to topics that will be of interest to a broad mathematical audience.

As in previous years, there are various stands where organisations related to mathematics will present themselves. The annual KWG meeting will take place during lunch on 14 April. And last but not least, six PhD students will compete for the KWG prize by presenting their work.

We wish you a stimulating and memorable congress in Leiden!

On behalf of the organising committee,

Ronald van Luijk Evgeny Verbitskiy

3 General information

3.1 Directions to the building

NMC 2015 will take place at the Gorlaeus building of the Faculty of Science of Leiden University, Einsteinweg 55, 2333 CC Leiden.

Via Leiden Centraal. Travel by train to the train station Leiden Centraal. From The Hague it takes about 10 minutes, from Amsterdam or Rotterdam 35 minutes and from Utrecht 45 minutes. For a detailed timetable, consult either `www.ns.nl` or `www.9292ov.nl`.

From Leiden Centraal you may continue by foot, bus or taxi towards the Gorlaeus Building, or you may rent a bicycle at the railway station.

It takes about 15-25 minutes to **walk** from Leiden Centraal to the Gorlaeus building: leave the railway station at the side of the Leiden University Medical Center (LUMC) and go to the left, towards the entrance of the LUMC. Go right, following the Albinusdreef to the roundabout. Go left at the roundabout (2nd exit). You are now on the Sandifortdreef. Follow the road to the next roundabout (350 m). Turn right (1st exit) and follow the Zernikedreef (650 m). At the T crossing at the end of the Zernikedreef turn right onto the Einsteinweg. Follow the Einsteinweg beyond the next roundabout. You see the Gorlaeus Building in front of you.

Or take **bus 43** from Leiden Centraal in the direction of The Hague. Leave the bus at the bus stop 'universiteitsterrein'. For a detailed timetable, please consult `www.9292ov.nl`.

By car. Parking facilities are very limited. Participants are urged to come by public transport as much as possible. One may park at the parking opposite the Huygens and Snellius buildings, at the **Niels Bohrweg**. At the gate, mention that you participate in the Dutch Mathematical Congress.

The easiest way to reach the parking is via the A44 (to the west of Leiden; not the A4, to the east). Take exit 7 Oegstgeest and follow the Rijnzichtweg to the east (towards Leiden). After 750 m, at the roundabout take the first exit, onto the Rhijngeesterstraatweg. Follow this road (including a name change to Endegeesterstraatweg) until you reach a T-crossing after about 1.5 km. Turn left and almost immediately after, turn right onto the university premises. The entrance to the parking is immediately to the left.

From the parking it takes 5–10 minutes by foot to get to the Gorlaeus building. Follow the Niels Bohrweg, which turns into the Einsteinweg at a left turn. The Gorlaeus building is on the Einsteinweg.

3.2 Locations inside the building

When entering the Gorlaeus building through the main entrance, you will arrive in a large hallway with the **registration desk**, **stands** and **coffee and tea**. In the hallway is a large stairway upwards.

After going up the stairs, you will have the **porter's lodge** on the left and the entrance to **auditorium 1** (also known as **C1**) on the right.

If you walk a few steps towards lecture room 1, then the hallway to your left has **auditorium 2 (C2)** and **restrooms** (there are several down the hallway, both for men and women), and the hallway to the right leads to the **restaurant**.
In other words, after taking the stairs up, the hallway in front of you on the right leads to C2 and restrooms, while the hallway behind you on the right (make a U-turn) leads to the restaurant.

On the ground floor, if you do not go up the stairs, but instead walk past the stairs on the right hand side of the stairs, you will find a door leading to **auditorium 6 (C6)** and a place to hang your **coat** (not guarded).

The plenary lectures, opening and closing will take place in C1. Lectures in the Docentendag are in C6. All other lectures are in C1 and C2.

3.3 Registration desk and contact

The registration desk is near the entrance on the ground floor of the Gorlaeus building. Upon registration, you will receive a copy of this booklet, your badge, etc.

The organisers can be recognised by their badges. For first aid or emergencies, go to the porter's lodge at the top of the stairs near the entrance of the Gorlaeus building. For other questions, ask at the registration desk, or contact the organisers via the registration desk.

3.4 Coffee, tea, lunch

You will need to show your badge in order to get coffee, tea and lunch.

Coffee and tea will be served downstairs near the entrance of the Gorlaeus building during registration and during the breaks marked as 'coffee break' in the timetable.

Lunch will be served in the back of the restaurant of the Gorlaeus building.

When exiting lecture room C1 or C2, turn left and follow the curved hallway counterclockwise. When coming from the registration desk, go up the stairs, and make a U-turn to the right.

3.5 Stands

In the hallway downstairs near the Gorlaeus entrance, there will be stands of the following organisations.

- Elsevier
- Epsilon Uitgaven
- Kangoeroe
- Koninklijk Wiskundig Genootschap (KWG)
- Lorentz Center
- Nederlandse Vereniging van Wiskundeleraren (NVvW)
- Optische Fenomenen
- Platform Wiskunde Nederland (PWN)
- PS Zituaction
- Pythagoras
- Vierkant voor Wiskunde
- Wisc — Makelaar in Wiskunde

3.6 Reception

After the final lecture on Tuesday 14 April, there will be a reception in honour of the 50th birthday of the congress ($51^{\text{st}} - 1^{\text{st}} = 50$ years). The first NMC was in 1965 in Enschede. The reception will be downstairs near the registration desk and Gorlaeus building entrance.

4 Timetable

Tuesday 14 April

9:00–10:00	*Registration*	
10:00–10:15	**Opening** by Geert de Snoo (Dean of the Faculty of Science)	C1
10:15–11:15	**Martin Hairer** Weak universality of the KPZ equation	C1
11:15–11:35	*Coffee break*	
11:35–12:35	**Eva Bayer** Classical groups and Hasse principle	C1
	Johan van Leeuwaarden Scaling limits of many-server systems: economies of scale and optimal threshold control	C2
12:35–14:00	*Lunch break, including KWG meeting* *Lunch*	
12:50–13:50	**Algemene Ledenvergadering KWG**	C2
14:00–15:00	**Mikhail Katsnelson** Theory of graphene: CERN on the desk	C1
15:00–15:30	*Coffee break*	
15:30–16:00	**Jacob Fokkema** Deltaplan Wiskunde.NL	C1
16:00–17:00	**Michel Mandjes** Scaling Limits for Stochastic Networks	C1
17:00–18:00	*Reception*	

Wednesday 15 April

9:00– 9:30	*Registration*	
9:30–10:30	**Lenny Taelman** Euler characteristic in topology, logic, and geometry	C1
10:30–11:00	*Coffee break*	
11:00–12:00	**Sander Dahmen** Integral points on curves **Júlia Komjáthy** Fixed speed competition on the configuration model with infinite variance degrees	C1
	Teun Koetsier The Royal Mathematical Society 1778–2015	C2
	Ferdinand Verhulst De vele gezichten van de wiskunde (*)	C6
12:00–13:00	*Lunch*	
13:00–14:00	**Oliver Fabert** Hamiltonian dynamics and superstring theory	C1
	KWG prize (1/2) Presentations by nominated PhD students	C2
	Jeanine Daems De menselijke kant van wiskunde — Het gebruik van geschiedenis in de wiskundeles (*)	C6
14:10–15:10	**Robert Ghrist** Local-to-Global Data: Applied Algebraic Topology	C1
	KWG prize (2/2) Presentations by nominated PhD students	C2
	John Mason What, Where, and When is (or are) Mathematics? (*)	C6

15:10–15:40	*Coffee break*	
15:40–16:40	**Viresh Patel** Connectivity and Hamilton cycles in graphs and directed graphs	C1
	Martin Verlaan Forecasting tides, storm-surges currents and waves along our coasts **Alessandro Di Bucchianico** Big Data: Challenges and Opportunities for Mathematicians	C2
	Aldine Aaten De bril van de wiskundestudent (*)	C6
16:50–17:50	**Günter M. Ziegler** Patterns and Progress in Topological Combinatorics	C1
17:50–18:00	**Closing and KWG prize ceremony**	C1
18:00–18:30	*Informal drinks*	

Lectures marked with (*) are part of the Docentendag 'Wat is wiskunde voor jou?'. All NMC participants are welcome at all lectures of the NMC, but teachers who registered for the Docentendag as an official schooling activity have to attend at least these four lectures, and will have priority at these lectures in case of insufficient seating. The Docentendag is organised by Wouter van Joolingen (Freudenthal Instituut, Utrecht) and Peter Kop (ICLON, Universiteit Leiden)

5 Abstracts and details 14 April

Martin Hairer (University of Warwick)

Weak universality of the KPZ equation

Tuesday 14 April, 10:00 (opening) – 11:15 in C1

Abstract: The KPZ equation is a popular model of one-dimensional interface propagation. From heuristic consideration, it is expected to be "universal" in the sense that any "weakly asymmetric" or "weakly noisy" microscopic model of interface propagation should converge to it if one sends the asymmetry (resp. noise) to zero and simultaneously looks at the interface at a suitable large scale. The only microscopic models for which this has been proven so far all exhibit very particular that allow to perform a microscopic equivalent to the Cole-Hopf transform. The main bottleneck for generalisations to larger classes of models was that until recently it was not even clear what it actually means to solve the equation, other than via the Cole-Hopf transform. In this talk, we will see that there exists a rather large class of continuous models of interface propagation for which convergence to KPZ can be proven rigorously. The main tool for both the proof of convergence and the identification of the limit is the recently developed theory of regularity structures, but with an interesting twist.

Eva Bayer (École Polytechnique Fédérale de Lausanne)

Classical groups and Hasse principle

Tuesday 14 April, 11:35 – 12:35 in C1

Abstract: The classical Hasse-Minkowski theorem states that if two quadratic forms over $\mathbf{Q}$ become isomorphic over $\mathbf{R}$ and over $\mathbf{Q}_p$ for all prime numbers p, then they are isomorphic over $\mathbf{Q}$. This is one of the first examples of the so-called local-global principle, or Hasse principle. Many local-global results were proved since then, and this theme became a central one in number theory. It is well-known that the Hasse principle does not always hold, and most of the counter-examples are explained by the Brauer-Manin obstruction. The aim of this talk is to present some old and new results concerning the Hasse principle and the Brauer-Manin obstruction.

Johan van Leeuwaarden (Technische Universiteit Eindhoven)

Scaling limits of many-server systems: economies of scale and optimal threshold control

Tuesday 14 April, 11:35 – 12:35 in C2

Abstract: We consider many-server systems with admission control operating in a scaling regime where the relative utilization approaches unity while the number of servers grows large, providing natural Economies-of-Scale. In order to determine the optimal admission control policy, we adopt a revenue maximization framework, and suppose that the revenue rate attains a maximum when no customers are waiting and no servers are idling. The revenue is maximized by policies that bar customers from entering when the queue length exceeds a certain threshold. Joint work with Sem Borst, Guido Janssen and Jaron Sanders.

Algemene ledenvergadering KWG

Tuesday 14 April, 12:50–13:50 in C2.

Founded in 1778, the Dutch Royal Mathematical Society (Koninklijk Wiskundig Genootschap) is the oldest of all present-day national mathematical societies. The society serves as professional organization of the Dutch mathematics community. Besides organizing conferences, it also issues journals and magazines like Indagationes Mathematicae, Nieuw Archief voor Wiskunde and Pythagoras. Together with the Dutch society of mathematics teachers, it participates in PWN (Platform Wiskunde Nederland). The society also represents the Dutch mathematical community internationally in the EMS and IMU.

The yearly meeting of the Dutch Royal Mathematical Society is traditionally held during the NMC.

Mikhail Katsnelson (Radboud Universiteit Nijmegen)

Theory of graphene: CERN on the desk

Tuesday 14 April, 14:00 – 15:00 in C1

Abstract: Graphene, a recently (2004) discovered two-dimensional allotrope of carbon (this discovery was awarded by Nobel Prize in physics 2010), has initiated a huge activity in physics, chemistry and materials science, mainly, for three reasons. First, a peculiar character of charge carriers in this material

makes it a "CERN on the desk" allowing us to simulate subtle and hardly achievable effects of high energy physics. Second, it is the simplest possible membrane, an ideal testbed for statistical physics in two dimensions. These two aspects of graphene physics are also of great interest for mathematical physics. Last not least, being the first truly two-dimensional material (just one atom thick) it promises brilliant perspectives for the next generation of electronics which uses mainly only surface of materials.

I will tell about the first aspect of graphene physics, some unexpected relations between materials science and quantum field theory and high-energy physics.

Electrons and holes in this material have properties similar to ultrarelativistic particles (two-dimensional analog of massless Dirac fermions). This leads to some unusual and even counterintuitive phenomena, such as finite conductivity in the limit of zero charge carrier concentration (quantum transport by evanescent waves) or transmission of electrons through high and broad potential barriers with a high probability (Klein tunneling). This allows us to study subtle effects of relativistic quantum mechanics and quantum field theory in condensed-matter experiments, without accelerators and colliders. Some of these effects were considered as practically unreachable. Apart from the Klein tunneling, this is, for example, a vacuum reconstruction near supercritical charges predicted many years ago for collisions of ultra-heavy ions and recently experimentally discovered for graphene. I will discuss related issues concerning Dirac equation in two dimensions.

A huge recent progress in the sample quality makes many-body effects in electron spectrum of graphene near neutrality point observable. I will discuss various aspects of many-body theory of graphene such as realistic calculations of effective electron-electron interactions and possible exciton instability in freely suspended graphene (including the results of quantum Monte Carlo simulations).

Jacob Fokkema / Deltaplan Wiskunde.NL

Tuesday 14 April, 15:30 – 16:00 in C1

Op verzoek van het ministerie van OCW ging de door PWN en NWO ingestelde commissie Deltaplan Wiskunde.NL aan de slag met het in 2014 verschenen visiedocument "Formulas for Insight and Innovation, Mathematical Sciences in the Netherlands 2025".

Zij verwerkt de aanbevelingen uit het visiedocument in een implementatieplan (met werktitel Deltaplan Wiskunde.NL) met concrete acties voor de wiskundigen in hoger onderwijs en onderzoek, maatschappij en innovatie. Deze ac-

ties richten zich op verbeteren van bekendheid van het wiskundeonderzoek, wiskundeonderwijs, de opleiding van wiskundeleraren, de aansluiting bij topsectoren, publiek-private samenwerking en de outreach van het onderzoek.

Tijdens het NMC 2015 geeft de voorzitter van de Commissie Deltaplan Wiskunde.NL Jacob Fokkema een eerste contourenschets van het plan.

De commissie wordt voorgezeten door Jacob Fokkema, voormalig rector magnificus van de TU Delft en het secretariaat is in handen van NWO-Exacte Wetenschappen. De leden van de commissie zijn: Eugene Bernard (voorzitter Ons Middelbaar Onderwijs), Frank den Hollander (UL), Barry Koren (TU/e), John Koster (ASML), Jan Karel Lenstra (CWI), Ieke Moerdijk (RU), Gerrit Timmer (ORTEC/VU), Nellie Verhoef (UT), Petra de Bont (NWO-EW, secretaris) en Christiane Klöditz (NWO-EW, secretaris).

Michel Mandjes (Universiteit van Amsterdam)

Scaling Limits for Stochastic Networks

Tuesday 14 April, 16:00 – 17:00 in C1

Abstract: In this talk I will sketch a body of recent results obtained in the context of a stochastic network of dependently operating resources. These could be thought of to represent real-life networks of all sorts, such as traffic or communication networks, but I'll point out that this setup is also highly relevant in economic and biological applications. For such large networks, one would typically like to describe their dynamic behavior, and to devise procedures that can deal with various undesired events (link failures, sudden overload, etc.). I'll show how for systems that do not allow explicit analyses, various parameter scalings help shedding light on their behavior. More specifically, I discuss situations in which the time-scale corresponding to the fluctuations of the available resources differs from that of the fluctuations of the customer's demand, leading to various appealing limit results.

6 Abstracts and details 15 April

Lenny Taelman (Universiteit van Amsterdam)

Euler characteristic in topology, logic, and geometry

Wednesday 15 April, 9:30 – 10:30 in C1

Abstract: Starting with Euler's polyhedral formula $V - E + F = 2$ and Poincaré's generalization, the notion of Euler characteristic has become ubiquitous in several areas of mathematics. I will survey some beautiful old and new incarnations of Euler characteristic, with an emphasis on its unifying role in geometry and number theory. This colloquium-style talk is aimed at a non-expert audience.

Sander Dahmen (Vrije Universiteit Amsterdam)

Integral points on curves

Wednesday 15 April, 11:00 – 11:30 in C1

Abstract: In this talk we discuss several related infinite families of curves and how to determine their integral points. One of the families is inspired by the congruent number problem; for a positive integers N we will look at integral points on the curve given by $y^2 = x^3 - N^2x$ (i.e. solutions to this equation with x and y integers). Recently, Bennett classified all integer points on these curves when the number of distinct odd primes dividing N is at most one. We will show how this naturally leads to the problem of determining integral points on certain hyperelliptic curves and indicate how a combination of different techniques can be used to solve this problem. Finally, we discuss how this connects to the problem of determining all perfect powers in recurrence sequences.
This is joint work with Michael Bennett, Maurice Mignotte, and Samir Siksek.

Júlia Komjáthy (Technische Universiteit Eindhoven)

Fixed speed competition on the configuration model with infinite variance degrees

Wednesday 15 April, 11:30 – 12:00 in C1

Abstract: In this talk we consider competition of two spreading colors starting

from single sources on the configuration model with i.i.d. degrees following a power-law distribution with exponent $\tau \in (2, 3)$.

In this model two colors spread with a fixed but not necessarily equal speed on the unweighted random graph. We answer the question how many vertices the two colors paint eventually. When the speeds are not equal, then the faster color paints almost all vertices. When the speeds are equal, we show that coexistence sensitively depends on the initial local neighbourhoods of the source vertices. This reinforces the common sense that speed and location are very important features in advertising.

Teun Koetsier (Vrije Universiteit Amsterdam)

The Royal Mathematical Society 1778 – 2015

Wednesday 15 April, 11:00 – 12:00 in C2

Abstract: The organization of the Dutch mathematicians, the Mathematical Society, was founded 237 years ago in 1778. Twelve years ago the Society obtained the predicate 'Royal'. In 1960 Hans Freudenthal wrote: "One may safely say that mathematically the Netherlands at the end of the nineteenth century lagged a century behind the rest of Europe". This seems to imply that in a first approximation the history of mathematics in the Netherlands in the past 237 years consists of two periods: a long period of stagnation followed by an equally long period of mathematical progress. Freudenthal's observation leads inevitably to the question of the significance the Society's existence. In the talk I will attempt to answer this question: What has been the impact of the Society on mathematics in the Netherlands in the past 237 years? Moreover, I will consider a converse question: Which external factors influenced the foundation and development of the Society?

Ferdinand Verhulst (Universiteit Utrecht)

De vele gezichten van de wiskunde

Wednesday 15 April, 11:00 – 12:00 in C6

Abstract: Wiskundige uitspraken die over getaltheorie of over dijkbewaking gaan zijn nogal verschillend. Dat geldt ook voor de wiskundige redeneringen die erbij horen. We geven daar enkele voorbeelden van. Dat brengt ons op stijlverschillen in de wiskunde. Dat gaat zowel over analytisch, meetkundig of algebraïsch denken als over het doel waarmee wiskunde bedreven wordt. Het wiskundige werk van de getaltheoreticus, de researchwiskundige bij een

groot bedrijf en de theoretisch fysicus verschilt. We spitsen dit toe op de manier waarop we wiskundige bewijzen moeten zien. Een bewijs dient om de juistheid van een stelling of bewering aan te tonen, maar minstens evenzeer om de betekenis van die stelling uit te leggen. Het ene bewijs doet dit veel meer dan het andere; indien een bewijs inzicht in een stelling geeft door bijvoorbeeld dwarsverbanden binnen de wiskunde te leggen, dan levert dit een "feel-good gevoel", een esthetische ervaring.

Oliver Fabert (Vrije Universiteit Amsterdam)

Hamiltonian dynamics and superstring theory

Wednesday 15 April, 13:00 – 14:00 in C1

Abstract: Hamiltonian dynamics is a mathematical framework for answering questions about classical mechanical systems, such as the existence and the multiplicity of periodic solutions. In my talk I will present a surprising link between Hamiltonian dynamics and complex geometry. It has originated from the mathematical theory behind superstring theory of high energy physics and predicts the existence of mirror pairs of geometries. Among other things, it can be employed to predict the existence and multiplicity of periodic solutions of special Hamiltonian systems by studying the deformations of appropriate complex structures.

KWG Prize for PhD students (1/2)

Wednesday 15 April, 13:00 – 14:00 in C2

Lotte Sewalt, *Growth thresholds in a dynamical model for tumour invasion*

Folkert Bleichrodt, *Robust artefact reduction in tomographic imaging*

Bert Lindenhovius, *Reconstructing C*-algebras from their posets of commutative C*-subalgebras*

See page 23 for abstracts and more information.

Jeanine Daems (Hogeschool Utrecht)

De menselijke kant van wiskunde — Het gebruik van geschiedenis in de wiskundeles

Wednesday 15 April, 13:00 – 14:00 in C6

Abstract: Voor leerlingen lijkt wiskunde vaak een vaste brok kennis, die er altijd is geweest (of in ieder geval al heel lang) en die uit vaste ideeën en concepten bestaat. Je leert op school uit het boek en van de docent precies hoe je wiskunde moet doen en hoe je je antwoorden moet opschrijven. Mijn beeld van wiskunde is echter ook: wiskunde is een menselijke activiteit, die in de loop van de tijd ontwikkeld is. Je kunt veel zelf oplossen of ontdekken. Het gebruik van geschiedenis van de wiskunde in de wiskundeles kan die kijk op het vak illustreren. Het kan motiverend zijn voor leerlingen om te zien hoe wiskundigen vroeger ook worstelden met nieuwe ideeën. En voor leerlingen die meer in cultuur dan in wiskunde geïnteresseerd zijn, kan bijvoorbeeld het inzicht dat vroeger, in oude culturen, getallen er anders uitzagen en er op een andere manier gerekend werd, interesse opwekken in het vak. In deze lezing ga ik verder in op hoe geschiedenis van de wiskunde een andere kijk op het vak kan bevorderen, bij docenten, leerlingen en leken.

Robert Ghrist (University of Pennsylvania)

Local-to-Global Data: Applied Algebraic Topology

Wednesday 15 April, 14:10 – 15:10 in C1

Abstract: Many contemporary challenges in the engineering sciences concern the inference of global features from local data. This passage from local-to-global data is as subtle as it is fundamental; however, it is not unprecedented. In the mathematical sciences, several types of local-to-global challenges were overcome with new techniques — from topology, homological algebra, and sheaves. This talk will outline both the vision and the first steps of exporting homological and sheaf-theoretic tools for data in the engineering sciences, with examples drawn from sensor networks, signal processing, and network optimization.

KWG Prize for PhD students (2/2)

Wednesday 15 April, 14:10 – 15:10 in C2

Joep Evers, *Flux boundary conditions for measure-valued evolutions*

Djordjo Milovic, *On the* 2*-part of class groups of* $\mathbb{Z}[\sqrt{-2p}]$ *for* $p \equiv 3 \bmod 4$

David de Laat, *Moment methods in extremal geometry*

See page 23 for abstracts and more information.

John Mason (PMTheta)

What, Where, and When is (or are) Mathematics?

Wednesday 15 April, 14:10 – 15:10 in C6

Abstract: Prepositions can be useful, but also misleading! Mathematics is actually a plural noun. Its origins in Greek are to do with understanding. Participants will be invited to engage in some tasks which will be used to distinguish between measurement, arithmetic, and mathematics. My position will be that mathematics (mathematical thinking) only really begins when people encounter contradictory conjectures arising from experiencing, expressing, and then manipulating generalities. Students will be encouraged to develop their mathematical thinking when they are in the presence of teachers who themselves work at developing their own mathematical thinking, being mathematical with and in front of their students.

Viresh Patel (Queen Mary, University of London)

Connectivity and Hamilton cycles in graphs and directed graphs

Wednesday 15 April, 15:40 – 16:40 in C1

Abstract: A Hamilton cycle is one of the most basic global structures one might wish to find in a graph. It is a cycle that visits every vertex of the graph exactly once making it the structure of interest, for example, in the famous Travelling Salesman Problem.

Much research has been carried out in finding useful graph conditions that guarantee the presence of a Hamilton cycle. In this talk, I consider different measures of how well connected a graph is (such as its expansion) and how this relates to the presence of one or more Hamilton cycles. Along the way, I give a flavour of some of the general techniques in the area.

Martin Verlaan (TU Delft and Deltares)

Forecasting tides, storm-surges currents and waves along our coasts

Wednesday 15 April, 15:40 – 16:10 in C2

Abstract: In this talk an overview will be given of the mathematical models and mathematical techniques used to forecasts the conditions at sea. These conditions at sea and along the coast are important for many off-shore activities, but also for the protection of the Netherlands against flooding. Similar to weather forecasting mathematical models are used in a combination with

real-time measurements to compute the conditions for the next few days. Incorporating measurements into large numerical models with mathematical techniques is often called data-assimilation. Especially the use of large numerical models in combination with large numbers of measurements makes this a computational challenge that requires dedicated efficient techniques for estimation. The presentation will use a number of applications to illustrate the current status and challenges for the next years in this field of coastal forecasting and data-assimilation.

Alessandro Di Bucchianico (Technische Universiteit Eindhoven)

Big Data: Challenges and Opportunities for Mathematicians

Wednesday 15 April, 16:10 – 16:40 in C2

Abstract: In this talk I will give an overview of the data revolution (usually referred to as "Big Data") that is taking place and point out the impact on mathematics. The data explosion that we are witnessing today has led to a field called "Data Science", which ideally combines computer science, mathematics and statistics. In practice we usually see that computer scientists are taking the lead.

After a brief introduction to the terminology of big data and data science, I will present some challenges that big data brings to established mathematical approaches like the statistical theory of hypothesis testing. Here there is a need to adapt existing theories and adapt computational tools to deal with big data ("scalable algorithms"). After that, I will also present some examples of opportunities that big data brings for mathematicians. These opportunities will be put into the context of current and future research funding both at a national and EU level.

Aldine Aaten (KU Leuven and Rijksuniversiteit Groningen)

De bril van de wiskundestudent

Wednesday 15 April, 15:40 – 16:40 in C6

Abstract: Wat houdt wiskunde studeren eigenlijk in, gezien door de bril van de wiskundestudent? Op welke wijze bedrijven zij wiskunde? Vinden ze zichzelf daarin succesvol? Hoe weten ze of ze de wiskunde begrepen hebben, en hoe weten hun docenten dat? Wat doen ze er aan als dat niet zo is? En vinden studenten wiskunde studeren eigenlijk wel leuk? Kloppen de ervaringen van

de studie met hun verwachtingen? Op basis van bevindingen uit interviews, wetenschappelijk onderzoek en eigen ervaringen (waaronder die van u) ondernemen we een zoektocht naar wat het is wiskunde te leren op de universiteit en hoe/of dat anders is dan op de middelbare school.

Günter M. Ziegler (Freie Universität Berlin)

Patterns and Progress in Topological Combinatorics

Wednesday 15 April, 16:50 – 17:50 in C1

Abstract: In this lecture, I will discuss four different problems from Topological Combinatorics,

- the Topological Tverberg Problem,
- the Colored Tverberg Problem,
- the Grünbaum Hyperplane Problem, and
- the Fair Polygon Partitions Problem.

These problems have many things in common:

- They are easy to state, and may look harmless,
- They have very nice configuration spaces,
- they may be attacked by "Equivariant Obstruction Theory",
- this solves the problems — but only partially,
- which leads us to ask more questions, look for new tools ...
- and this yields surprising new results.

(Joint work with Pavle Blagojevic, Florian Frick, Albert Haase, and Benjamin Matschke)

7 KWG Prize for PhD students

The KWG Prize for PhD students will be awarded at the 51st Nederlands Mathematisch Congres (Dutch Mathematical Congress), to be held on Tuesday the 14th and Wednesday the 15th of April 2015 at Leiden University.

Six PhD students will have the opportunity to present their work (at most 20 minutes, including questions) during a special minisymposium on 15 April 2015. At the end of the day, the winner selected by the prize committee receives a trophy and a cash prize.

Presentations must be aimed at a general mathematical audience, and the student's ability to make the subject accessible to non-specialists is an important criterion for winning the award. The candidates are full-time PhD students in mathematics affiliated with a Dutch university or research institution and should not yet have received their degree by 15 April 2015.

The jury consists of Hendrik Lenstra (chair), Mark Peletier and Harry van Zanten.

Lotte Sewalt (Universiteit Leiden)

Growth thresholds in a dynamical model for tumour invasion

Wednesday 14 April 13:00 – 13:20 in C2

(advisor: Arjen Doelman)

My Ph.D. project revolves around the formation of patterns in biological and ecological dynamical systems. In practice, this means I work in the context of reaction-diffusion equations, often with a small parameter. Being in the field of applied mathematics, my research projects are both relevant to mathematicians and the general community. As such, the scope of possible applications is very broad. While my previous work has revolved around stripe patterns in vegetation in semi-arid regions and oscillating layers of plankton in the deep ocean, the talk I will present details my most recent study concerning malignant tumour invasion. This is joint work with my collaborators from Australia*, whom I have visited this winter.

Recent experimental studies in the spreading of malignant tumours evidence that the proliferation of cancer cells depends highly on the relative density of the cancer cells compared to the surrounding healthy cells. The growth of cancer cells increases significantly once the density has attained a certain threshold; a feature that is known in ecology as the *Allee effect*. In this talk, I will present how this effect can be incorporated in an advection-reaction-

diffusion model describing the invasion of cancer cells and how this influences earlier results where growth thresholds were not included. In particular, I will discuss the existence of travelling shock wave solutions in two different models. To derive these results we utilise geometric singular perturbation theory and canard theory.

* L. Sewalt, K. Harley, P. van Heijster, S. Balasuriya, Influences of Allee effects in the spreading of malignant tumours, in preparation to be submitted to Journal of Theoretical Biology, 2015.

Folkert Bleichrodt (CWI)

Robust artefact reduction in tomographic imaging

Wednesday 14 April 13:20 – 13:40 in C2

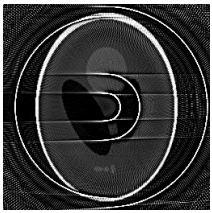
(advisor: Joost Batenburg)

Abstract: Tomography is an imaging technique to reconstruct an image from projection data. A well-known example is image reconstruction from X-rays obtained by medical CT-scanners. We consider algebraic reconstruction methods that involve solving a linear system of equations that models the attenuation of X-rays, transmitted through the object. The system matrix W relates a digital image vector x to the measured projection data p:

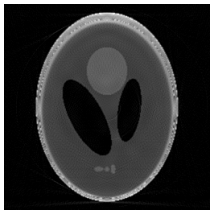
$$Wx = p. \tag{1}$$

Measurement errors or model inconsistencies can lead to image distortions in the reconstruction which are called *artefacts*. A typical least-squares solution of (1) is prone to artefacts because it fits the reconstructed image to this perturbations in the measurement data. A common method to resolve artefacts is to "repair" system (1) by filtering outliers from the measurement data or by correcting the system matrix for model inconsistencies. To use these methods, the location of outliers should be found accurately, which is not a trivial task. We propose the use an alternative penalty function which is based on the statistical Student's t distribution. This penalty function assigns a small penalty to outliers (in contrast to the ℓ_2-norm), such that they have a smaller effect in the minimization of the data misfit without the need to locate outliers. By solving the resulting nonlinear inverse problem, the location of the outliers is discovered by the reconstruction method, effectively eliminating the need to repair the equation system beforehand. We demonstrate for a series of simulation experiments with various perturbations applied to the projection data that our proposed method is able to substantially reduce the artefacts corresponding to these perturbations, see Fig. 1a-c.

(a) original image



(b) least-squares solution



(c) result of the proposed method

Figure 1

Folkert Bleichrodt is a fourth year PhD student at Centrum Wiskunde & Informatica. His research is focused on development of tomographic reconstruction algorithms. In particular he aims to make reconstruction methods more robust to experimental errors and model inconsistencies such that more accurate reconstructions can be obtained if the measured projection data is affected by such errors.

Bert Lindenhovius (Radboud Universiteit Nijmegen)

Reconstructing C-algebras from their posets of commutative C*-subalgebras*

Wednesday 14 April 13:40 – 14:00 in C2

(advisor: Klaas Landsman)

Abstract: *C*-algebras* form a class of topological associative algebras over $\mathbb{C}$ equipped with an involution, with the convenient property that their topological structure is completely determined by their algebraic structure. An example of a C*-algebra is the algebra $B(H)$ of all continuous linear operators $H \to H$ for some Hilbert space H. In this case, the involution is exactly the operation of taking adjoints. Furthermore, every subalgebra of $B(H)$ that is closed under the involution and that is topological closed with respect to the norm topology on $B(H)$ is a C*-algebra; it is actually a theorem by Gelfand and Naimark that every C*-algebra is **-isomorphic* to such a subalgebra of $B(H)$, i.e., there exists an isomorphism between both algebras preserving the involution [6, I.9.18]. Since quantum mechanics is usually described in terms of operators on Hilbert spaces, this allows the use of C*-algebras in quantum physics in order to describe physical systems [3]. We note that if H has finite dimension n, then $B(H) = M_n(\mathbb{C})$. More general, every finite-dimensional

C*-algebra is *-isomorphic to a finite direct sum of matrix algebras over $\mathbb{C}$ [6, I.11.2].

Commutative C*-algebra are of special interest, since there exists a duality between unital commutative C*-algebras and compact Hausdorff spaces, called *Gelfand duality* [6, I.4.4]. It follows that commutative C*-algebras can be regarded as function algebras, and therefore they can be used in physics in order to describe physical systems in classical mechanics, making C*-algebras the appropriate structure for describing the classical limit from quantum physics to classical physics. Moreover, every commutative C*-subalgebra of a C*-algebra A can be identified with a piece of classical information stored in the quantum system corresponding to A. It is a doctrine of Bohr, *the doctrine of classical concepts* that every quantum system should be determined by the classical information it contains [3, 3.1].

Given a unital C*-algebra A, we consider the set $\mathcal{C}(A)$ of commutative C*-subalgebras of A containing the identity element of A, which becomes a poset if we order it by inclusion. A natural question one could ask is: which information about the C*-structure of A can be retrieved from the order-theoretical structure of $\mathcal{C}(A)$? In particular, we are interested in classes of unital C*-algebras A that are completely determined by $\mathcal{C}(A)$ up to *-isomorphism, which can be related to the question whether Bohr's doctrine is sound or not. It turns out that not all C*-algebras are completely determined by their posets of commutative C*-algebras, which follows from a result in [1], but at least the commutative unital C*-algebras form a class of C*-algebras that is completely determined by $\mathcal{C}(A)$ [2], [5].

We will show certain C*-algebraic properties of A translate to order theoretical properties of $\mathcal{C}(A)$. For instance, we show that A is finite dimensional if and only if $\mathcal{C}(A)$ satisfies certain chain conditions. Finally, we use these properties in order to show that $\mathcal{C}(A)$ determines A up to *-isomorphism for two other classes of C*-algebras: finite-dimensional C*-algebras, and C*-algebras of the form $B(H)$ for some Hilbert space H [4].

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[5] F. Mendivil, *Function algebras and the lattices of compactifications*, Proc. Amer. Math. Soc. **127**: 1863-1871 (1999).

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Joep Evers (Technische Universiteit Eindhoven)

Flux boundary conditions for measure-valued evolutions

Wednesday 14 April 14:10 – 14:30 in C2

(advisors: Adrian Muntean and Mark Peletier)

Abstract: Crowds in a railway station, flocks of birds, schools of fish, groups of smart self-driving cars; what these examples have in common is that they are collections of individuals whose motion is determined by interactions with others. These *social interactions* are composed of basic ingredients such as attraction, repulsion and alignment. The behaviour of these groups as a whole is often very complex and this complexity emerges without the presence of a mastermind or leader.

There are many reasons why one would want to model these systems as *measure-valued evolutions* – evolution equations in the space of measures. Measures are the natural concept to describe the distribution of individuals in space, they allow for both discrete and continuous distributions, and mixtures and scale transitions have natural formulations in this framework. For this reason, measure-valued evolutions have recently gained popularity and are used extensively also in other fields, for example in molecular dynamics and material science.

However, the theory of measure-valued evolutions still has some gaping holes. In this talk I focus on the problem of *boundary conditions*. Many relevant problems are set in bounded domains; think of crowds of pedestrians and their interaction with walls and obstacles. The bad news is that one *cannot* treat these scenarios in the current measure-theoretical framework. For instance, the concept of a 'normal derivative' is not even defined. In general, no systematic way exists to find physically and mathematically meaningful boundary conditions in terms of measures.

However, there is still room for optimism.

Recently we showed how to define a flux-type boundary condition for measure-valued evolutions, at least in one space dimension. This boundary condition is derived, and also justified, by creating a finite-thickness boundary layer and letting the thickness shrink to zero. In this talk, I describe this approach, which travels along and across the borderlines between partial differential equations, abstract measure theory, semigroup theory, functional analysis, statistical mechanics and probability theory. Prior knowledge of these fields is not required to follow the talk.

Djordjo Milovic (Universiteit Leiden)

On the 2-part of class groups of $\mathbb{Z}[\sqrt{-2p}]$ *for* $p \equiv 3 \bmod 4$

Wednesday 14 April 14:30 – 14:50 in C2

(advisors: Peter Stevenhagen and Étienne Fouvry, Université Paris-Sud 11)

Abstract: The main object of study in *number theory* is the ring of rational integers, $\mathbb{Z}$. Once we understand some aspect of the arithmetic of $\mathbb{Z}$ sufficiently well, we might next consider a *quadratic ring*, i.e. a commutative ring with unity that is a $\mathbb{Z}$-module of rank 2; an example of such a ring is $\mathbb{Z}[\sqrt{-6}] = \mathbb{Z} \oplus \mathbb{Z} \cdot \sqrt{-6}$.

There are many quadratic rings. In fact, their isomorphism classes are in one-to-one correspondence with the set of integers congruent to 0 or 1 modulo 4, where a quadratic ring corresponds to its *discriminant*. In light of this, my thesis deals with problems in *arithmetic statistics*. Instead of studying a particular quadratic ring, my aim is to study the *average* behavior of certain arithmetic invariants attached to quadratic rings in families parametrized by special types of discriminants. In this talk we focus on the family of quadratic rings $\mathbb{Z}[\sqrt{-2p}]$ of discriminant $-8p$, where p is a prime number congruent to 3 modulo 4.

The *fundamental theorem of arithmetic* states that every non-zero element of $\mathbb{Z}$ has an irreducible factorization (i.e. a factorization into irreducible elements) that is *unique* up to reordering and multiplication by units. In a quadratic ring, an irreducible factorization *might no longer be unique*. For instance, in $\mathbb{Z}[\sqrt{-6}]$,

$$10 = 2 \cdot 5 = (2 + \sqrt{-6}) \cdot (2 - \sqrt{-6}).$$

An invariant of a quadratic ring which measures (in a sense which can be made precise) the failure of unique irreducible factorization is its *ideal class group*. It is one of the principal objects of study in number theory.

The ideal class group $\mathrm{Cl}(-8p)$ of $\mathbb{Z}[\sqrt{-2p}]$ is a finite abelian group of the form

$$\mathrm{Cl}(-8p) \cong \mathbb{Z}/2^{r_p}\mathbb{Z} \oplus (\text{odd}).$$

Well-established heuristics of Cohen and Lenstra and convincing numerics both strongly suggest that the *density* of prime numbers p such that $p \equiv 3 \bmod 4$ and $r_p \geq r$ exists and is equal to 2^{-r} for each integer $r \geq 1$. For $r \leq 3$, $r_p \geq r$ exactly when p belongs to certain congruence classes modulo 16, so the above conjecture was known for $r \leq 3$ (at least as far back as 1969). However, for $r \geq 4$, no similarly simple condition seems to exist and so the conjecture remained open for $r \geq 4$ since then.

We prove the above conjecture for $r = 4$ by adapting an old criterion of Leonard and Williams (1982) to a setting friendly to analytic methods developed by Friedlander and Iwaniec (1997, 2012). The problem reduces to showing that a *Jacobi symbol* (twisted by a certain *Dirichlet character*) attached to a representation of $p \equiv 15 \pmod{16}$ as $p = u^2 - 2v^2$ takes the values $+1$ and -1 equally often, i.e.

$$\lim_{x\to\infty} \frac{\log x}{x} \sum_{\substack{p\leq x \\ p=u^2-2v^2\equiv 15 \ (16)}} \left(\frac{v}{u}\right) \chi(u) = 0.$$

The main difficulty in proving the statement above is that both arguments of the Jacobi symbol $\left(\frac{v}{u}\right)$ depend on the prime p; this prevents us from using the classical theory of L-functions. Instead, we bound the sum above by two related sums, each of which is then treated differently. For the first, one requires a good estimate for *incomplete character sums*, which already on its own is an important area of research in analytic number theory. For the second, the essential ingredient is that the function $u + v\sqrt{2} \mapsto \left(\frac{v}{u}\right)$ defined on an appropriate subset of $\mathbb{Z}[\sqrt{2}]$ is *not* multiplicative! To make everything more difficult, the representation of p as $u^2 - 2v^2$ is far from unique, so we have to carefully construct a fundamental domain for the action of $1 + \sqrt{2}$, a unit of infinite order, on $\mathbb{Z}[\sqrt{2}]$.

All in all, although this result might have some importance as the first to prove a density for the 16-*rank* of ideal class groups in *any* family of quadratic rings, it is the interplay of diverse methods from algebraic and analytic number theory which makes it truly interesting. Most of the time, algebraic and analytic number theorists tend to think in different ways and pursue different goals, but sometimes bringing the subjects closer together can produce powerful results.

David de Laat (TU Delft)

Moment methods in extremal geometry

Wednesday 14 April 14:50 – 15:10 in C2

(advisors: Karen Aardal and Frank Vallentin)

Abstract: What is the ground state energy of a system of interacting particles? How do we pack objects together as densely as possible? These are questions of extremal geometry. Applications range from the study of error correcting codes in computer science to the modeling of materials in chemistry and physics. Identifying optimal configurations and certifying their optimality is difficult. The reason for this is that the search space is an infinite set of feasible configurations among which there there are many which are locally, but not globally, optimal. Although finding good constructions can be hard, verifying their feasibility and computing their energy or density is easy. We are interested in obstructions, which give energy lower bounds or density upper bounds. Again, finding obstructions is hard — and we use computers to find them — but verifying the correctness of the bounds they give is easy. One of our goals is to generate optimality proofs of geometric configurations.

We develop methods for the systematic construction of relaxations for optimization problems in extremal geometry (a relaxation of a problem $\inf_{x \in X} f(x)$ is another, typically easier, problem $\inf_{y \in Y} g(y)$ together with a map $R \colon X \hookrightarrow Y$ such that $g \circ R \leq f$). For this we generalize the moment methods as used in the Lasserre hierarchy in combinatorial optimization to an infinite dimensional setting. In its most basic form, given a polynomial p, the Lasserre hierarchy is a sequence of increasingly large optimization problems whose optimal values give increasingly good lower bounds on the global minimum of p. For our generalized hierarchy we prove this sequence of optimal values converges in finitely many steps to the optimal energy or density.

The first step in our hierarchy is equivalent to relaxations already available in the literature, and which we have used to compute new bounds for binary sphere and binary spherical cap packings. To compute explicit bounds for concrete problems, techniques using harmonic analysis to exploit symmetry and real algebraic geometry to deal with infinite constraint sets have been developed. These allow us to approximate the infinite dimensional relaxations by finite semidefinite programs (semidefinite programming is a broad generalization of linear programming). We extended these techniques to apply them to our higher order bounds, and we develop theory to prove, for instance, that there exist arbitrarily good finite dimensional approximations.

In the talk I will explain some of the techniques we use to to find new relaxations and bounds for geometric optimization problems, and I will show some examples of bounds we have computed for concrete problems.

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