NEDERLANDS MATHEMATISCH CONGRES 2011

onder auspiciën van het
Koninklijk Wiskundig Genootschap

14 en 15 april 2011
Universiteit Twente
Enschede

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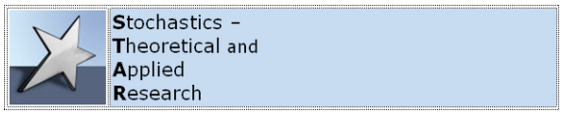

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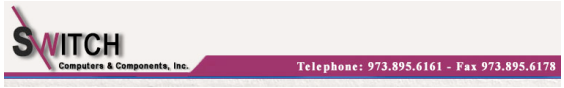


Texas Instruments

Voorwoord

Hartelijk welkom op het Nederlands Mathematisch Congres 2011.

Het is de 47e keer dat het Nederlands Mathematisch Congres wordt gehouden. In het jaar waarin de Universiteit Twente haar 50e verjaardag viert, komt het NMC voor de 5e keer naar de campus van de UT, de bakermat van het NMC.

De congrescommissie presenteert u met veel plezier en trots het programma van NMC 2011, waarin de balans wordt gezocht tussen wiskunde voor de schoonheid van de wiskunde en wiskunde voor de schoonheid van de toepassingen. In het programma is verder balans gevonden tussen wiskundigen die hun sporen al ruimschoots verdiend hebben en de aanstormende generatie wiskundigen, en de balans tussen onderzoek en onderwijs. Moderne wiskunde en de geschiedenis van de wiskunde hebben een prominente plaats gevonden.

Het programma wordt omlijst door op wiskunde gebaseerde kunst, zoals de schuifstructuren van Rinus Roelofs, Escher's onmogelijke kubus, en de Rhombicosidodecahedrische Diprismatohexacosihecatonicosachoron van Paul van de Veen, waarvan het logo van NMC 2011, de kleine rombische icosidodecaëder, een belangrijke bouwsteen is. Verder wordt wiskunde uitgebeeld middels muziek met een wiskundige toets door Vocaal Ensemble Il Cocodrillo Cante, en door op wiskunde geïnspireerde kunst door studenten van ArtEZ Academie voor Art & Design te Enschede (AKI).

Met drie plenaire voordrachten, zes parallelvoordrachten en twaalf minisymposia is het wetenschappelijke programma interessant voor een breed wiskundig publiek. Op het wiskunde onderwijssymposium op vrijdag is veel aandacht voor de onderwijsprogramma's op de middelbare school en in het hoger onderwijs, alsmede voor de aansluiting tussen deze programma's en voor de opleiding van docenten.

Op donderdagavond 14 april staan de driejaarlijkse Brouwerlezing en de uitreiking van de Brouwermedaille op het programma. Op 15 april wordt voor de 6e keer de Philips wiskundeprijs voor promovendi uitgereikt. Voor de eerste keer zal tijdens NMC 2011 een postersessie worden georganiseerd voor master studenten en promovendi met bijbehorende beste poster prijs. Voor de eerste keer is een minisymposium georganiseerd door master-studenten, waarin zij hun afstudeerwerk presenteren. Verder vindt met steun van Mastermath voor de tweede keer op een NMC een Mastermath-lunch plaats en wel op vrijdag.

De congrescommissie heeft gestreefd naar een grotere rol en zichtbaarheid van studenten en promovendi en is er van overtuigd dat juist de nieuwe generatie wiskundigen een duidelijke ontmoetingsplaats vindt op het NMC.

De congresorganisatie is in handen van leden van de afdeling Toegepaste Wiskunde van de UT. Studenten hebben een belangrijke rol in de organisatie.

Wij wensen u een heel mooi en onderhoudend congres toe!

Namens de congrescommissie,

Richard Boucherie, voorzitter

Inhoudsopgave

1 Algemene informatie

De organisatiecommissie van het congres is voor de aanvang van het congres bereikbaar via Linda Wychgel-van Dalm, tel. +31(0)53 489 3372 of Thyra Kamphuis-Kuijpers, tel. +31(0)53 489 3434, email NMC2011@ewi.utwente.nl.

De congresbalie bevindt zich in de aankomsthal van de Waaier. De congresbalie is op beide dagen vanaf 8:45 uur geopend. Bij de balie kunt u terecht voor de ontvangst van de congresbescheiden, badge, etc. Ook mededelingen over het programma en eventuele berichten voor deelnemers aan het congres treft u aan bij de balie.

Locatie en bereikbaarheid. Het congres vindt plaats in de Waaier op het campusterrein van de Universiteit Twente. Vanaf station Hengelo is de campus bereikbaar met buslijnen 9 en 15 (spitsbus), vanaf station Enschede met buslijnen 1 en 9, en vanaf station Enschede Drienerloo met buslijn 1. Tijdens spitsuur is de verbinding via station Hengelo heeft meest efficiënt. Er zijn parkeerplaatsen op het campusterrein. In verband met thuiswedstrijd van FC Twente in de Europacup op donderdagavond 21:00 uur is het vinden van een parkeerplaats op donderdagavond lastig. Plattegronden met een overzicht van de zalen en exposities bevinden zich achterin het programmaboekje.

Posters en wiskunst. Posters zijn gedurende het gehele congres te zien. De kunstvoorwerpen staan verspreid over de Waaier opgesteld. Vocaal Ensemble Il Cocodrillo Cante zal haar optreden verzorgen direct voorafgaand aan de Brouwerlezing.

Display boeken etc. KWG verzorgt een boekententoonstelling. Het Tell Me project verzorgt toelichting op 4 iMac's van de digitale wiskunde leeromgeving. Texas Instruments biedt informatie over rekenmachines voor het middelbaar onderwijs.

Sponsors. Een aantal sponsors heeft een stand ingericht met informatie voor studenten.

Plaats van de voordrachten. Alle voordrachten vinden plaats in de Waaier, zalen 1–4. De plenaire voordrachten vinden plaats in Waaier 2.

Koffie/thee en lunches. Koffie/thee en lunches zijn op vertoon van de congresbadge gratis verkrijgbaar.

Tijden koffie/thee	
donderdag	09:30 – 10:15
	11:45 – 12:15
	16:15 – 16:45
vrijdag	09:45 – 10:15
	15:45 – 16:15

Tijden lunch	
donderdag	13:00 – 14:15
vrijdag	12:45 – 13:45

Buffet. Buffet op donderdag 17:30 – 19:30 is op vertoon van de buffetvoucher verkrijgbaar.

Receptie. Het KWG biedt de deelnemers van het congres een receptie aan. Deze vindt plaats op donderdag 14 april van 20:30 tot 22:30 en biedt gelegenheid de Brouwer laureaat Kim Plofker geluk te wensen.

Ledenvergadering van KWG. Tijdens het congres vindt de ledenvergadering van het Koninklijk Wiskundig Genootschap plaats, op donderdag 14 april 13:15 – 14:00 uur in Waaier 4.

2 Programma

Programma donderdag 14 april

Tijd	Zaal		Pagina
09:30-10:15		**Inschrijving en koffie/thee**	
10:15-11:15	Waaier 2	**Opening congres**	
		Ed Brinksma (rector Universiteit Twente)	
		Plenaire voordracht	
		Sara van de Geer	13
		Mathematical Challenges in High-Dimensional Statistics	
11:15-11:45	Waaier 2	**Elevator pitches**	50
11:45-12:15		**Pauze en posters**	
12:15-13:00		**Semiplenaire voordrachten**	
	Waaier 2	Arjen Doelman	16
		The mathematics of desertification:	
		searching for early warning signals	
	Waaier 3	Klaas Landsman	17
		Randomness, quantum mechanics and free will	
	Waaier 4	Leen Stougie	18
		Scheduling under uncertainty	
13:00-14:15		**Lunch en posters**	
13:15-14:00	Waaier 4	**Algemene ledenvergadering KWG**	12
14:15-16:15		**Minisymposia A**	21–29
	Waaier 1	NDNS+ — *Multiscale Dynamical Systems and Solutions*	22–24
	Waaier 2	STAR — *Stochastic - Theoretical and Applied Research*	25–26
	Waaier 3	DIAMANT — *Discrete, Interactive and Algorithmic Mathematics, Algebra and Number Theory*	26–27
	Waaier 4	GQT — *Geometry & Quantum Theory*	28–29
16:15-16:45		**Pauze**	
16:45-17:30	Waaier 2	**Plenaire voordracht**	
		Rolf Möhring	13
		Mathematical Aspects of Dynamic Network Routing	
17:30-19:30		**Buffet**	
18:45-19:05	Waaier 2	**Lezing**	
		Rinus Roelofs	59
		Schuifstructuren	
19:10-19:25	Waaier 2	**Muziek met een wiskundige toets**	
		Il Cocodrillo Cante	62
		The mysterious equations of love	
19:30-20:30	Waaier 2	**Brouwerlezing**	11
		Kim Plofker	15
		Mathematics and the History of Mathematics in Western and Non-Western Traditions	
20:30-22:30		**Receptie**	

Programma vrijdag 15 april

Tijd	Zaal		Pagina
09:00-09:45		**Semiplenaire voordrachten**	
	Waaier 2	Hans Schumacher	19
		The mathematics of risk sharing, with applications to Dutch pensions	
	Waaier 3	Peter Stevenhagen	20
		Constructing algebraic objects by analytic means	
	Waaier 4	Ionica Smeets	20
		Dropping pennies – explaining mathematics to laymen	
09:45-10:15		**Pauze**	
10:15-12:15		**Minisymposia B**	30–39
	Waaier 1	Scientific Computing	31–32
	Waaier 2	Philips Wiskundeprijs voor promovendi	32–35
	Waaier 3	Geschiedenis Wiskunde — *Toonaangevende wiskundeboeken*	36–38
	Waaier 4	Wiskunde onderwijs I — *Beroep: leraar wiskunde*	38–39
12:15-12:45	Waaier 2	**Elevator pitches**	54
12:45-13:45		**Lunch en posters**	
13:45-15:45		**Minisymposia C**	40–49
	Waaier 1	SWI — *Study Group Mathematics with Industry 2007-2010*	41–42
	Waaier 2	Financiële Wiskunde	43–44
	Waaier 3	MSc Studentensymposium	44–47
	Waaier 4	Wiskunde onderwijs II — *Aansluiting wiskunde vo-ho*	48–49
15:45-16:15		**Pauze**	
16:15-17:00	Waaier 2	**Slotvoordracht**	
		Odo Diekmann	14
		The many guises of Mathematical Biology	
17:00-17:15	Waaier 2	**Uitreiking posterprijs & Philips Wiskundeprijs**	
	Waaier 2	**Sluiting**	

3 Programmatoelichting

3.1 Postersessie, elevator pitches en MSc symposium

Masterstudenten en promovendi presenteren tijdens het congres hun onderzoek via posters, die in vogelvlucht worden toegelicht op donderdag en vrijdag tijdens een plenaire elevator pitch sessie, waarin iedere deelnemer van de poster sessie in 2 minuten zijn of haar poster mag presenteren. De prijs voor de beste poster wordt uitgereikt tijdens de afsluiting op vrijdag.

Masterstudenten presenteren op vrijdag hun onderzoek in een door masterstudenten georganiseerd minisymposium.

3.2 Philips Wiskundeprijs voor promovendi

Er zal dit jaar voor de zesde maal de Philips Wiskundeprijs voor promovendi worden toegekend. De toekeningen uit de voorafgaande jaren zijn:

2006 *Joost Batenburg (Universiteit Leiden)* met de voordracht “Steps toward 3D atomic resolution microscopy using discrete tomography",

2007 *Johan Bosman (Universiteit Leiden)* met de voordracht over “Computations in Inverse Galois Theory",

2008 *Erik Jan van Leeuwen (CWI)* met zijn voordracht “Geometric optimization for wireless networks and computational biology",

2009 *Stefan van Zwam (Technische Universiteit Eindhoven)* met zijn voordracht “How to show it does not fit”,

2010 *Matthias Mnich (Technische Universiteit Eindhoven)* met zijn voordracht “Allemaal op een rijtje”.

Tijdens het mini-symposium “Philips Wiskundeprijs voor promovendi” krijgen de zes finalisten de gelegenheid om gedurende maximaal 20 minuten (inclusief vragen) over hun werk te vertellen. De jury voor de Philips Wiskundeprijs voor promovendi 2011 bestaat uit:

prof. dr. *Ferdinand Verhulst*
(voorzitter, Universiteit Utrecht)

prof. dr. *Chris Klaassen*
(Universiteit van Amsterdam)

prof. dr. *Jaap Top*
(Rijksuniversiteit Groningen)

De wisseltrofee. Gemaakt door Joke Bontenbal

De voordrachten zijn gericht op een algemeen wiskundig publiek. Een belangrijk criterium voor de toekenning van de prijs is dan ook dat de voordracht van maximaal 20 minuten voor niet-specialisten begrijpelijk moet zijn. De kandidaten zijn promovendi op het gebied van de wiskunde aan een Nederlandse instelling en op 15 april 2011 nog niet gepromoveerd.

De prijs, bestaande uit een geldbedrag en een wisseltrofee, zal voorafgaand aan de sluiting van het congres aan de winnende promovendus of promovenda worden overhandigd.

3.3 The Brouwer Lecture and The Brouwer Medal

L.E.J. Brouwer was perhaps The Netherlands' most distinguished mathematician. Shortly after his death in 1966, the Royal Dutch Mathematical Society (KWG) and the Royal Netherlands Academy of Sciences (KNAW) established a tri-annual event referred to as the Brouwer Prize. To that purpose, once every three years the KWG chooses a sub-field of mathematics and an expert committee then selects a lecturer from that field. If the selected person agrees to give this lecture, on that occasion he or she receives the Brouwer memorial medal[1]. Traditionaly, this lecture is delivered during the annual Dutch Mathematical Congress.

The Brouwer lecture with the Brouwer medal is The Netherlands' most prestigious award in mathematics and it also enjoys great international prestige. Previous laureates are given in the following table.

year	name	field of mathematics
1970	R. Thom	topology
1973	A. Robinson	foundations
1978	A. Borel	Lie groups
1981	H. Kesten	probability theory
1984	J. Moser	analysis
1987	Y. Manin	number theory
1990	W.M. Wonham	control theory
1993	L. Lovász	discrete mathematics
1996	W. Hackbusch	numerical mathematics
1999	G. Lusztig	algebra
2002	M. Aizenman	mathematical physics
2005	L. Birgé	mathematical statistics
2008	P.A. Griffiths	geometry

For 2011, the Society has selected the field of **History of Mathematics**. An expert committee consisting of Jan Hogendijk (chair), Teun Koetsier, Hendrik Lenstra, Jan van Maanen, Steven Wepster and Gert Vegter (in his capacity of president of the KWG) unanimously proposed **Kim Plofker** of the Department of Mathematics of Union College in Schenectady, USA as the 2011 Brouwer Lecturer. She is an

[1] Originally this was made of pure gold but for economic reasons this year it is made of goldplated silver.

expert in the History of Science in Antiquity and in the Middle Ages, and in Sanskrit. In 1995 she got her PhD degree under David Pingree at Brown University, USA. After that she worked in Cambridge (Massachusetts), Delhi and Utrecht. Her book "Mathematics in India" appeared in 2009 with Princeton University Press. She was invited speaker during the International Congress of Mathematicians 2010 in Hyderabad, India.

Kim Plofker will present the Brouwer lecture during this congres on Thursday evening and after her lecture she will receive the Brouwer medal. Her lecture will be preceded by a laudatio by the chair of the Brouwer committee Jan Hogendijk.

3.4 Jaarvergadering Koninklijk Wiskundig Genootschap

Het NMC2011 vindt plaats onder auspiciën van het Koninklijk Wiskundig Genootschap (KWG). Het KWG is een landelijke vereniging van beoefenaars van de wiskunde en iedereen die de wiskunde een warm hart toedraagt.

De vereniging is in 1778 opgericht en is 's werelds oudste nationale wiskundegenootschap. Het genootschap heeft als doel de wiskunde te bevorderen en haar beoefening en toepassingen aan te moedigen. Daarnaast vertegenwoordigt het KWG de Nederlandse wiskundige gemeenschap in binnen- en buitenland.

Volgens de traditie is het NMC de gelegenheid waar veel leden van het KWG elkaar ontmoeten, terwijl de jaarlijkse ledenvergadering van het KWG altijd tijdens dit congres wordt gehouden. Tijdens het NMC2011 staat de 234ste Algemene Ledenvergadering gepland op

> donderdag 14 april, tussen 13:15 en 14:00 uur in Waaier 4.

De vergaderstukken zijn beschikbaar via de website van het KWG:

> `www.wiskgenoot.nl`

4 Plenaire voordrachten

Mathematical Challenges in High-Dimensional Statistics

Sara van de Geer (ETH Zürich) *Waaier 2, do 10:30-11:15*

Abstract: A statistical model is called high-dimensional if the number of parameters p is larger than the number of observations n (for instance $p = 10^4$, $n = 100$). An important example is the linear model, where $Y = X\beta + \text{error}$, the output Y being an n-vector, the input X an $(n \times p)$-matrix, and $\beta \in \mathbb{R}^p$ being a vector of unknown coefficients. A popular way to deal with the situation is to fit the parameters using an appropriate loss function (for instance least squares) in combination with ℓ_1-regularization, i.e., large values of $\sum_{j=1}^{p} |\beta_j|$ are penalized. The study of the theoretical properties of the fitted parameters leads to many mathematical challenges. We will discuss concentration and contraction inequalities for random elements in high-dimensional spaces, the size of convex bodies, sparse approximations and restricted eigenvalues.

Biografie: Sara van de Geer (Ph.D. 1987 at Leiden University) has been working in Tilburg, Amsterdam, Bristol, Utrecht, Toulouse and Leiden, and is from 2005 full professor at the ETH Zürich. Her current area of research is statistical theory for high-dimensional data.

Mathematical Aspects of Dynamic Network Routing

Rolf Möhring (TU Berlin) *Waaier 2, do 16:45-17:30*

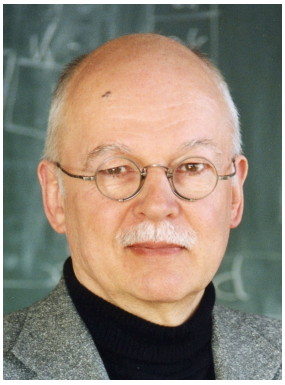
Abstract: Transport management and routing in logistic systems are optimization problem by nature. We want to utilize the available transport or logistic network in such a way that the total network "load" is minimized or the "throughput" is maximized. This lecture deals with the mathematical aspects of these optimization problems from the viewpoint of network flow theory and scheduling. It leads to flow models in which – in contrast to static flows – the aspects of "time" and "congestion" play a crucial role.

We illustrate these aspects on two selected applications:

(1) Routing automated guided vehicles in container terminals (cooperation with HHLA).

(2) Ship Traffic Optimization for the Kiel Canal (cooperation with the German Federal Waterways and Shipping Administration).

Both applications benefit from new insights into routing in graphs. In (1), the theory of flows over time leads to a very fast real-time routing algorithm that avoids collisions, deadlocks, and other conflicts already at route computation. Project (2) uses the techniques from (1) and enhances them with special purpose scheduling algorithms.



Biografie: Rolf H. Möhring (PhD 1975 at RWTH Aachen) is since 1987 Professor for Applied Mathematics and Computer Science at Berlin University of Technology. His research group focusses on graph algorithms, combinatorial optimization, scheduling, and industrial applications. Möhring is scientist in charge at the DFG Research Center Matheon, responsible for the application area "Logistics, traffic, and telecommunication networks". He is member of the editorial board of leading scientific journals, has served as chair of the German Operations Research Society GOR as well as the Mathematical Programming Society (MPS). In 2005, Möhring was awarded the Scientific Award of the German Operations Research Society GOR, and in 2010 he received the EURO Gold Medal of the European Association of Operational Research Societies.

The many guises of Mathematical Biology

Odo Diekmann (Universiteit Utrecht) *Waaier 2, vr 16:15-17:00*

Abstract: By combining a journey through the past with a bit of speculation about the future, a personal view on Mathematical Biology will be presented, with special attention for the Dutch situation.

Biografie: Odo Diekmann worked from 1972 to 1995 at CWI. In the last 10 of those CWI years he was part-time professor at the Institute of Theoretical Biology of Leiden University in a joint venture with Hans Metz. In 1995 he moved to the Mathematical Institute of Utrecht University to succeed Wiktor Eckhaus. He is a honorary editor of the Journal of Mathematical Biology and the co-author of various books on population dynamics, delay equations and the epidemiology of infectious diseases.

Mathematics and the History of Mathematics in Western and Non-Western Traditions

Kim Plofker (Department of Mathematics, Union College, Schenectady, USA)

Waaier 2, do 19:30-20:30

Abstract: Perhaps more than any other science, mathematics contains its own history, both as a field of study and as a professional discipline. This paper discusses changing aims and current priorities in the history of mathematics, with special reference to comparisons between "western" (i.e., Euclid-based) and "non-western" traditions of mathematical knowledge. Among our examples we offer some remarkable results from late-medieval Indian mathematics that illustrate the creative tension between mathematical experiment and proof.

Biografie: Kim Plofker studied mathematics, history of science and Sanskrit language. She obtained her Ph.D. degree in 1995 with David Pingree (Brown University). Her dissertation was about medieval mathematical texts in Sanskrit. She held positions at Brown University, MIT, Utrecht and Leiden Universities, and she catalogued Sanskrit manuscripts in Jaipur (India). She is currently a member of Union College, Schenectady, NY, USA. Her book "Mathematics in India", on the history of mathematics in India between 500 BC and 1800 AD, appeared in 2009 with Princeton University Press.

5 Semiplenaire voordrachten

The mathematics of desertification: searching for early warning signals

Arjen Doelman (Universiteit Leiden) *Waaier 2, do 12:15-13:00*

Abstract: The process of desertification can be modeled by systems of reaction-diffusion equations that describe the interactions between (ground)water and vegetation. Numerical simulations of these models agree remarkably well with field observations; both of these show that "vegetation patterns" – i.e. regions in which the vegetation only survives in localized "patches" – naturally appear as the transition between a healthy homogeneously vegetated state and the (non-vegetated) desert state. Desertification is a catastrophic and non-reversible event during which huge patterned vegetation areas "collapse" into the desert state at a fast time scale – for instance as a consequence of a slow decrease of yearly rainfall, or through an increased grazing pressure. From the environmental point of view, it is crucial to be able to recognize whether or not a patterned state is close to collapse; ecologists are thus searching for "early warning signals". In this talk, we will translate the issues raised by the desertification process into mathematical terms and relate these to very recent developments in the field of pattern formation. It will be shown that the process of desertification yields deep mathematical challenges and that these have already led to the development of novel mathematical theory.

Biografie: Arjen Doelman (PhD 1990 at Utrecht University) has a full-time appointment at Leiden University, partly as professor at the Mathematical Institute and partly as director of the Lorentz Center. His main research interests are in the fields of nonlinear dynamical systems, pattern formation, singular perturbation theory and their applications (in oceanography, geophysics, chemistry, hydrodynamics, ecology, biology). Arjen is Editor-in-Chief of Physica D and editor of the Journal on Computational Science.

Randomness, quantum mechanics, and free will

Klaas Landsman (Radboud Universiteit Nijmegen) *Waaier 3, do 12:15-13:00*

Abstract: This talk is an attempt to explain the content and background of the spectacular Free Will Theorem of John Conway and Simon Kochen, which (among other places) appeared in the Notices of the AMS, Vol. 56, No. 2, Feb 2009. Their mathematical reasoning fits into a long literature on possible hidden variables in quantum mechanics. It is based on a beautiful earlier theorem of Kochen and Ernst Specker from 1967, which in turn sharpened the very first no-go theorem for hidden variables due to John von Neumann (1932). However, the philosophical interpretation Conway and Kochen attribute to their result is, in my opinion, flawed and is even based on an elementary logical mistake. But enough of value remains!

Biografie: Klaas Landsman (1963) has published 75 papers and 2 books on high-energy physics, the mathematical foundations of quantum theory, noncommutative geometry, and the history and philosophy of science. He originally studied theoretical physics at the UvA, where he obtained his PhD in theoretical high-energy physics in 1989. Following research appointments at Cambridge, Hamburg, and Amsterdam, he was appointed full professor of Mathematical Physics at the UvA in 2001. He moved to Nijmegen in 2004, where he was initially professor of Analysis. Since 2007, he has occupied the new Chair in Mathematical Physics. Besides his research and teaching, he spent a considerable part of his time at Nijmegen on outreach towards school-children and national math policy (concerning both education and research). For example, in 2005 he was the PI of the *Fellowship of Geometry and Quantum Theory* (GQT cluster), in 2008 he coauthored the *Masterplan Toekomst Wiskunde*, and from 2006-2008 he was a member of the *Resonansgroep Wiskunde* (Sounding Board for Mathematics Education) of the Dutch Ministry of OC&W (Education, Science and Culture). He has given hundreds of invited talks all over the world.

Scheduling under uncertainty

Leen Stougie (Vrije Universiteit Amsterdam & CWI) *Waaier 4, do 12:15-13:00*

Abstract: Scheduling problems belong to the classical problems in combinatorial optimisation. Traditionally, especially by combinatorial optimisation researchers, deterministic variations of scheduling problems have been studied. Over the past half century this has led to an overwhelming body of research results, even if we concentrate on the scheduling results related to computational complexity theory, as we do in this lecture.

From a practical point of view however, scheduling problems do usually not appear with all input data known. Usually there is uncertainty about the processing times of jobs, machine availability, etc. We will present various ways for modelling uncertainty in scheduling, which can be viewed as a guide to modelling uncertainty in any combinatorial optimisation problem.

We will treat stochastic scheduling, a stochastic programming approach to scheduling (which is quite different from stochastic scheduling), on-line scheduling, robust scheduling, and universal scheduling, everything in the context of computational complexity. Of all models mathematical results on specific scheduling examples will be given. Time permitted, I will present a resent result on a universal scheduling problem.

In universal scheduling we take into account that machines might not be available for preventive maintenance, they may slow down due to simultaneous utilization by other users, they may break down completely for some time, etc.; i.e., unavailability is unpredictable. Thus the quest for a schedule that is robust against machine calamities emerges: the only influence the scheduler has is on the order in which he offers his jobs to be processed. We analyze the worst case performance of algorithms on this problem by comparing the solution value provided by an algorithm with that of an optimal clairvoyant algorithm that knows the machine behavior in advance, and that is even allowed to preempt jobs at any time.

Biografie: Leen Stougie (PhD 1985 at Erasmus Universiteit Rotterdam) is full professor in Operations Research at the Vrije Universiteit Amsterdam and researcher at CWI in Amsterdam. Leen has previously worked at the TU Eindhoven and at the University of Amsterdam. His research area is in Discrete Optimization, with applications among others in Computational Biology.

The mathematics of risk sharing, with applications to Dutch pensions

Hans Schumacher (Universiteit van Tilburg) *Waaier 2, vr 09:00-09:45*

Abstract: Risk sharing is a basic notion both in finance and in insurance. When agents are exposed to different risks, it is possible that they can all improve their ex-ante utility by agreeing on a contract that will induce the ones who turn out to be lucky to provide compensation to those who do not come out so fortunate. It may not be so easy though to say when a system of risk sharing is to be considered "fair". The talk will discuss several models that can be used to answer this question. Applications will be given to highly stylized situations, but also to the intergenerational risk sharing that is implemented in the Dutch collective pension system. Mathematical disciplines that are touched upon include stochastic processes, control theory, convex analysis, and graph theory.

Biografie: J. M. (Hans) Schumacher obtained the PhD degree in Mathematics from the Vrije Universiteit in Amsterdam in 1981. He held postdoc and visiting positions at the Laboratory for Information and Decision Systems of MIT, the Department of Econometrics of Erasmus University, Rotterdam, and the European Space Agency's research center ESTEC in Noordwijk, the Netherlands. In 1984 he joined the Centre for Mathematics and Computer Science (CWI) in Amsterdam, where his research was mainly focused on mathematical systems theory. In 1987 he was appointed to his current position as Professor of Mathematics at the Department of Econometrics and Operations Research of Tilburg University, first on a part-time basis, and since 1999 on a full-time basis. Hans Schumacher has served as corresponding editor of SIAM Journal on Control and Optimization, and he is Academic Director of the Executive Master of Actuarial Science (EMAS) program at TiasNimbas Business School. He is also affiliated with Netspar, the Dutch national network for studies on pensions, aging, and retirement.

Constructing algebraic objects by analytic means

Peter Stevenhagen (Universiteit Leiden) *Waaier 3, vr 09:00-09:45*

Abstract: In Dutch cluster speak, number theory is an integral part of DIAMANT, the cluster focusing on problems belonging to "the branches of mathematics that are 'discrete' in the sense of not being primarily concerned with continuously varying quantities". Number theory itself is blissfully unaware of such borders, and I will illustrate this by elaborating on the use of complex analytic tools in the construction of varieties of low dimension over finite fields. In true DIAMANT spirit, the problems considered will have an algorithmic slant.

Biografie: Peter Stevenhagen (PhD University of California at Berkeley, 1988) is full professor and director of the Mathematisch Instituut in Leiden, and chairman of the Diamant cluster. His research is in algebra and (algorithmic) number theory.

Dropping pennies – explaining mathematics to laymen

Ionica Smeets (Universiteit Leiden) *Waaier 4, vr 09:00-09:45*

Abstract: How can you bring the excitement of mathematics to the general public? How do you explain important concepts and make the penny drop? Smeets shows some excellent examples of popularization. From a thought experiment of Galileo Galilei to Marcus du Sautoy's way of explaining symmetry. She will talk about what good texts for laymen have in common. Hopefully these examples will inspire you to bring mathematics to the masses.

Biografie: Ionica Smeets (1979) is a postdoc at Public Understanding of Science at Leiden University and a science writer. She writes about mathematics for several Dutch newspapers and magazines. In 2010 she published *Vallende Kwartjes*, an anthology of texts that explain science well, compiled together with Bas Haring. With Jeanine Deams she forms the math girls *(wiskundemeisjes)*, their blog has won many awards and they gave popular scientific talks from Oslo to Kortrijk.

6 Minisymposia A — donderdagmiddag 14 april

Zaal/Tijd	
Waaier 1	**NDNS+ — Multiscale Dynamical Systems and Solutions**
14:15-14:35	Sebastiaan Janssens
	Discrete-time dynamics on a space of measures
14:35-14:55	Martijn Zaal
	Gradient Flow Model for Osmotic Cell Swelling
14:55-15:15	Lucia Scardia
	Gradient theory for plasticity as the Γ-limit of a nonlinear dislocation energy
15:15-15:35	Sjors van der Stelt
	Desertification: instabilities of patterns
15:35-15:55	Xia Liu
	Bifurcations and stability analysis of planar Hopf-transversal systems
15:55-16:15	Abdul H. Sheikh. *A scalable Helmholtz solver*
	combining the deflation with shifted Laplace preconditioner
Waaier 2	**STAR — Stochastic - Theoretical and Applied Research**
14:15-14:45	Nelly Litvak
	A scaling analysis of a cat and mouse Markov chain
14:45-15:15	Rob van den Berg
	A stochastic growth process where large finite clusters are frozen
15:15-15:45	Alexander Gnedin
	On the number of collisions in lambda-coalescents
15:45-16:15	Maria Vlasiou
	A Lévy input fluid queue with workload and input regulation
Waaier 3	**DIAMANT — Discrete, Interactive and Algorithmic Mathematics, Algebra and Number Theory**
14:15-14:45	Sander Dahmen
	The generalized Fermat equation
14:45-15:15	Tobias Müller
	Random geometric graphs
15:15-15:45	Arne Smeets
	Rational points and zero-cycles on p-adic varieties
15:45-16:15	Frank Vallentin
	Grothendieck inequalities for rank constraint semidefinite programs
Waaier 4	**GQT — Geometry & Quantum Theory**
14:15-14:45	Eric Opdam, Maarten Solleveld
	Extensions of tempered representations
14:45-15:15	Job Kuit. *A support theorem*
	for the horospherical transform on a semisimple symmetric space
15:15-15:45	Jochen Heinloth
	An example of the geometric Langlands correspondence
15:45-16:15	Michael Mueger
	On a new Witt group

6.1 NDNS+ mini-symposium: Multiscale Dynamical Systems and Solutions

Organisator & voorzitter: *Michiel Renger (Technische Universiteit Eindhoven)*

Discrete-time dynamics on a space of measures

Sebastiaan Janssens (Universiteit Utrecht) *Waaier 1, do 14:15-14:35*

Consider a population of agents (e.g. cells or biological oscillators such as integrate-and-fire neurons) whose individual state (i-state) corresponds to a point moving on the one-dimensional unit circle S. Assume furthermore that interaction between agents is indirect, via contribution to and dependence on a so-called environmental condition. Then the population state (p-state) at a particular moment is given by a measure $\mu \in M+(S)$, the cone of finite positive Borel measures on S. Depending on the presence of birth and death effects, μ may or may not be a probability measure.

We investigate the existence, stability and bifurcation of Dirac-type periodic solutions of the p-state dynamics by studying the fixed points of an associated return map defined on $M+(S)$. The underlying interpretation is that a stable (unstable) Dirac fixed point corresponds to a synchronised (de-synchronised) p-state.

Gradient Flow Model for Osmotic Cell Swelling

Martijn Zaal (Vrije Universiteit Amsterdam) *Waaier 1, do 14:35-14:55*

A basic model for cell swelling by osmosis is constructed, resulting in a free boundary problem. For radially symmetric initial conditions, this model can be formulated as a gradient flow on a metric by choosing a suitable pair of functional and metric. This particular choice does not require the osmotic force to be included in the formulation explicitly. It appears that this result can be generalized to non-symmetric initial conditions.

Gradient theory for plasticity as the gamma-limit of a nonlinear dislocation energy

Lucia Scardia (Technische Universiteit Eindhoven) *Waaier 1, do 14:55-15:15*

Since the motion of dislocations is regarded as the main cause of plastic deformation, a large literature is focused on the problem of deriving plasticity theories from more fundamental dislocation models. Although a dislocation is a lattice defect, in most dislocation models it has been described in the framework of a continuum theory, in which the positions of the atoms are averaged out. Indeed this reduces enormously the total number of degrees of freedom: From all atom positions to a few geometric quantities (displacement / deformation, dislocation line, slip planes, etc.).

The starting point of our derivation is also a continuum dislocation model. The main novelty of our approach is that we consider a nonlinear dislocation energy, whereas most mathematical and engineering papers treat only a quadratic dislocation energy, so that the constitutive relation between stress and strain is linear. Clearly, the linear constitutive relation is not satisfactory close to the dislocations' cores, where the strains are too large for the linear approximation to hold. Moreover, the quadratic dislocation energy blows up at a dislocation, and an ad hoc parameter needs to be introduced, the so called core radius, representing the size of the region around the dislocation which needs to be removed in order to have a finite strain energy.

Our choice of a nonlinear dislocation energy allows us to define the strain energy in the whole domain, hence also close to the dislocations. Moreover, the Γ-limit of the nonlinear dislocation energy as the length of the Burgers vector tends to zero has the same form as the Γ-limit obtained by starting from a linear, semi-discrete dislocation energy, but now obtained without resorting to the introduction of an ad hoc cut-off radius. The nonlinearity, however, creates severe mathematical difficulties, which we tackled by proving suitable versions of the Rigidity Estimate in non-simply-connected domains and by performing a rigorous two-scale linearisation of the energy around an equilibrium configuration.

Desertification: instabilities of patterns

Sjors van der Stelt (Universiteit van Amsterdam & CWI)

Waaier 1, do 15:15-15:35

Semi-arid ecosystems, ecosystems with an annual precipitation of about 250-500 mm, are typically found at the borders of deserts around the world. They cover about 30% of the emerged surface of the earth. Aerial photographs of many of these ecosystems show interesting regular and irregular patterns that vary in scale and shape and remind the observer of similar patterns known from the skin of panthers or zebras.

In this talk, we introduce a reaction diffusion model through which we gain insight in the emergence and disappearance of these patterns. In particular, we will discuss the possible instabilities through which spatially periodic patterns disappear and through which the ecosystem will suddenly change into a desert.

Bifurcations and stability analysis of planar Hopf-transversal systems

Xia Liu (Rijksuniversiteit Groningen) *Waaier 1, do 15:35-15:55*

Discontinuous vector fields, or Filippov vector fields, find applications in several fields including mechanical engineering, electrical engineering, and ecology. In this work we consider planar Filippov vector fields which consist of two smooth vector fields separated by a discontinuity boundary. One of the vector fields goes through a Hopf bifurcation while the other one is constant, transversally crosses the boundary. This Filippov system, called Hopf-transversal system, depends on three parameters.

We study the Hopf-transversal system and determine its bifurcations and its phase portraits. Furthermore, we prove persistence of these bifurcations.

A scalable Helmholtz solver combining the deflation with shifted Laplace preconditioner

Abdul H. Sheikh (Technische Universiteit Delft) *Waaier 1, do 15:55-16:15*

The Helmholtz equation appears in the diverse phenomena such as elastic waves in solids, sound and acoustic waves, electromagnetic waves and seismic waves. Our object is to develop high performance iterative solution algorithm for solving the discrete indefinite Helmholtz equation modeling wave propagation on large scale for e.g. seismic waves for mining,

$$-\Delta u - k^2 u = g \quad \text{on boundary} \quad \Omega.$$

Ingredients in our work are the shifted Laplace preconditioner and deflation. The development of the shifted Laplace preconditioner for the Helmholtz equation was a breakthrough in the development of efficient solution techniques for the Helmholtz equation. The distinct feature of this preconditioner is the introduction of a complex shift, effective introducing damping of wave propagation in the approximate solve. This preconditioner was extensively discussed in various texts and applied in a number of different contexts. Although performant, the resulting algorithm is not truly scalable. The bigger the wavenumber, the more spectrum scatters away from one, hampering the convergence. Idea of projection has been used since long to deflate unfavorable eigenvalues. By inducting eigenvectors corresponding to unwanted eigenvalues, better convergence for CG and GMRES has been reported in various texts. We also combine the idea of deflation with shifted Laplace preconditioner, which leads to a scalable Helmholtz solver, in the sense iterations does not depend upon parameters. We provide a convergence analysis. We perform a Fourier two-grid analysis of one-dimensional model problem with Dirichlet boundary conditions discretized by a second order accurate finite difference scheme. The components analyzed are the shifted Laplace preconditioner used as smoother, full-weighting and linear interpolation inter-grid transfer operators, and a Galerkin coarsening scheme. This Fourier analysis results in a closed form expression for the eigenvalues of the two-grid operator. This expressions shows that the spectrum is favourable for convergence of Krylov subspace methods. We apply the deflated shifted Laplace preconditioner to two-dimensional model problems method with constant and non-constant wave numbers and Sommerfeld boundary conditions discretized by second order accurate finite difference scheme on uniform meshes. Numerical results show that the number of GMRES iterations is wave-number independent.

6.2 STAR — Stochastics - Theoretical and Applied Research

Organisator & voorzitter: *Onno Boxma (Technische Universiteit Eindhoven)*

The stochastics cluster STAR presents four lectures on various topics in applied probability. Keywords are Markov processes, Lévy processes, growth processes and random spatial structures.

A scaling analysis of a cat and mouse Markov chain

Nelly Litvak (Universiteit Twente) *Waaier 2, do 14:15-14:45*

Based on a Markov chain with discrete state space, a two-dimensional Markov chain is constructed. The first coordinate (the cat) behaves like the original Markov chain and the second component (the mouse) changes only when both coordinates are equal (i.e. when the mouse is found by the cat). We obtain an invariant measure of this Markov chain. We show that when the state space is infinite, and the initial Markov chain is positive recurrent and reversible, then the cat-and-mouse Markov chain is null recurrent. In this context, the scaling properties of the location of the second component, the mouse, are investigated in various situations: simple one- and two-dimensional random walks, and reflected random walks on non-negative integers. For several of these processes, a time scaling with rapid growth gives an interesting and surprising asymptotic behaviour related to limit results for occupation times and rare events of Markov processes. It is a joint work with Philippe Robert.

A stochastic growth process where large finite clusters are frozen

Rob van den Berg (CWI & Vrije Universiteit Amsterdam)
Waaier 2, do 14:45-15:15

About twelve years ago, David Aldous, motivated by studies of sol-gel transitions, constructed a fascinating growth process for the binary tree. In this process clusters freeze as soon as they become infinite. It was pointed out by Itai Benjamini and Oded Schramm that such a process does not exist on (nice) two-dimensional grids. This motivated us to investigate the modified process, where clusters freeze as soon as they have diameter larger than or equal to a finite parameter N. In particular we were interested in the question whether this $N-$parameter model in two dimensions shows (compared with the process on trees) some form of "anomalous" behaviour as N goes to ∞. In this talk, which is based on cooperation with Demeter Kiss, Pierre Nolin and Bernardo de Lima, I will give a partial answer.

On the number of collisions in lambda-coalescents

Alexander Gnedin (Universiteit Utrecht) *Waaier 2, do 15:15-15:45*

The lambda-coalescent (introduced by Pitman and Sagitov) is a Markovian process in which particles merge according to certain rules, to eventually form a single

cluster. We discuss the number of collisions (i.e. internal nodes of the coalescent tree) X for the process starting with n particles. The asymptotic behaviour of X for large n strongly depends on the concentration of the parameter measure near 0. In this talk we shall survey known limit theorems for X, with emphasis on the case when the coalescent can be coupled with an increasing Lévy process.

A Lévy input fluid queue with workload and input regulation

Maria Vlasiou (Technische Universiteit Eindhoven) *Waaier 2, do 15:45-16:15*

We consider a queuing model with the workload evolving between consecutive i.i.d. exponential timers $\{e_q^{(i)}\}_{i=1,2,\ldots}$ according to two spectrally positive Lévy processes Y_1 and Y_2, both reflected at 0. When the exponential clock $e_q^{(i)}$ ends, the additional state-dependent service requirement modifies the workload so that the latter is equal to $F_i^{(1)}(Y_k(e_q^{(i)}))$ at epoch $e_q^{(1)}+\cdots+e_q^{(i)}$ for some random nonnegative i.i.d. functionals $F_i^{(1)}$. Moreover, at these moments the feedback information is available and the label of the Laplace exponent is changed according to the functional

$$F^{(2)}\left(Y_k(e_q^{(i)}),\ \sup_{s\le e_q^{(i)}} Y_k(s),\ \inf_{s\le e_q^{(i)}} Y_k(s),\ k\right).$$

For example, $F^{(2)}(x,y,z,k)=1_{\{y\ge K\}}+2\star 1_{\{y<K\}}$ if the workload process crossed a fixed level K. In that case, we change the Lévy input process to Y_1, which corresponds to the lighter load. Otherwise, if the load did not exceed the threshold K we choose the process Y_2, which corresponds to the "regular load". We analyse the steady-state workload distribution for the general model and provide several examples.

6.3 Mathematics Cluster DIAMANT — Discrete, Interactive and Algorithmic Mathematics, Algebra and Number Theory

Organisator & voorzitter: *Robin de Jong (Universiteit Leiden)*

The generalized Fermat equation

Sander Dahmen (Universiteit Utrecht) *Waaier 3, do 14:15-14:45*

In this talk we consider the equation $x^p+y^q=z^r$ in nonzero coprime integers x,y,z and integers $p,q,r>1$. We will give an overview of current techniques to attack this equation and describe their successes and limitations.

Random geometric graphs

Tobias Müller (CWI) *Waaier 3, do 14:45-15:15*

If we pick n points at random from d-dimensional space (i.i.d. according to some probability measure) and fix an $r > 0$, then we obtain a random geometric graph by joining two points by an edge whenever their distance is at most r.

I will give a brief overview of some of the main results on random geometric graphs and then describe my own work on Hamilton cycles and the chromatic number of random geometric graphs.

Rational points and zero-cycles on p-adic varieties

Arne Smeets (Université Paris-Sud/Orsay) *Waaier 3, do 15:15-15:45*

Let p be a prime number and let K be a p-adic field. Artin's conjecture predicts that any homogeneous form of degree d over K in $n > d^2$ variables has a non-trivial zero in K^n. Special cases of this conjecture are known, and Ax and Kochen proved an "asymptotic version", but a counterexample was constructed by Terjanian. However Kato and Kuzumaki formulated a modified version of Artin's conjecture which, when translated into the language of algebraic geometry, predicts the existence of zero-cycles of degree 1 on certain p-adic varieties in projective space – rather than the existence of rational points. They have proved their conjecture for hypersurfaces of prime degree. Recently, Heath-Brown proved the Kato-Kuzumaki conjecture for intersections of quadric hypersurfaces. His result has led to interesting progress on the u-invariant problem for p-adic function fields. In this talk I will present an overview of the recent results and their consequences. If time permits, I will also discuss some interesting open cases of the conjecture (and possible strategies to tackle these cases).

Grothendieck inequalities for rank constraint semidefinite programs

Frank Vallentin (Technische Universiteit Delft) *Waaier 3, do 15:45-16:15*

In 1953 Grothendieck worked on the theory of Banach spaces where he proved the "fundamental theorem in the metric theory of tensor product", nowadays called Grothendieck inequality. This inequality is a fundamental and unifying tool in many areas of mathematics and computer science (functional analysis, combinatorics, machine learning, system theory, quantum information theory, numerical linear algebra). With hindsight one can view Grothendieck's inequality and its proof (which is algorithmic) as the first randomized approximation algorithm based on semidefinite programming. In the talk I want to extend Grothendieck's inequality so that it can be used to give approximation algorithms for finding ground states of the n-vector model in statistical mechanics. Grothendieck's inequality itself together with the best known constant (due to Krivine) gives a 0.56 approximation algorithm for the Ising model on the integer lattice. For the three-dimensional Heisenberg model the algorithm achieves a ratio of 0.78. (based on joint work with Jop Briet, Fernando de Oliveira Filho, http://arxiv.org/abs/1011.1754)

6.4 Mathematics Cluster GQT — Geometry & Quantum Theory

Organisator & voorzitter: *Klaas Landsman (Radboud Universiteit Nijmegen)*

Extensions of tempered representations

Eric Opdam (Universiteit van Amsterdam),
Maarten Solleveld (Universität Göttingen) *Waaier 4, do 14:15-14:45*

The spaces of higher extensions in the abelian category of smooth representations of a reductive p-adic group between two irreducible tempered representations can be computed explicitly in terms of so-called analytic R-groups. We will explain some of the techniques on which this computation is based. The result has surprising applications in harmonic analysis. For example it implies Kazhdan's orthogonality conjecture for elliptic inner products of admissible characters of reductive p-adic groups.

A support theorem for the horospherical transform on a semisimple symmetric space

Job Kuit (Universiteit Utrecht) *Waaier 4, do 14:45-15:15*

A symmetric space is a pseudo-Riemannian manifold with the property that in each point x the geodesic reflection in x extends to a globally defined isometry. Let X be a Riemannian symmetric space of the non-compact type, i.e. a symmetric space with a Riemannian structure and negative sectional curvature. The connected component of the isometry group G acts transitively on X and the stabilizer of a given point is a maximal compact subgroup K. Therefore X is isometric to the homogeneous space G/K. An example of a Riemannian symmetric space of non-compact type is the Poincaré disk $D \simeq \mathsf{SL}(2,\mathbb{R})/\mathsf{SO}(2)$.

There exists a distinguished family of submanifolds of X called horospheres. (A horosphere in a symmetric space G/K is an orbit in X of the unipotent radical of a minimal parabolic subgroup of G.) The horospheres in the Poincaré disk D are the circles tangential to the boundary of the disk. (If N denotes the subgroup of $\mathsf{SL}(2,\mathbb{R})$ of upper triangular matrices with 1's on the diagonal, then the horospheres are the orbits of subgroups conjugate to N.)

The horospherical transform $\mathcal{R}\phi$ of a suitable function ϕ on X is the function on the set of horospheres Ξ given by

$$\mathcal{R}\phi(\xi) = \int_\xi \phi(x)\, d_\xi x \qquad (\xi \in \Xi).$$

Here $d_\xi x$ denotes the measure on a horosphere ξ induced by the Riemannian structure on X. The horospherical transform is an example of a Radon transform.

In 1973 Helgason proved the following support theorem: Let V be a closed ball in X. If $\mathcal{R}\phi(\xi) = 0$ for every horosphere ξ with $\xi \cap V = \emptyset$, then $\phi(x) = 0$ for $x \notin V$.

We present a support theorem for the horospherical transform on a general pseudo-Riemannian semisimple symmetric space. Our theorem generalizes the theorem by Helgason.

An example of the geometric Langlands correspondence

Jochen Heinloth (Universiteit van Amsterdam) *Waaier 4, do 15:15-15:45*

The relation between analytic properties of modular forms and arithmetic results has led to many famous results and conjectures. A geometric analogue of this conjectural relation is called geometric Langlands correspondence. We will try to give an idea of what modular forms are in this context.

Unlike in the classical theory of modular forms, in this geometric version very few explicit examples of modular forms are known. In joint work with B. C. Ngô and Z. Yun – which was motivated by work of Gross and Frenkel – we found an explicit series of such forms which on the one hand give an example of the (wild) geometric Langlands correspondence and on the other hand turn out to be closely related to classical Kloosterman sums.

On a new Witt group

Michael Mueger (Radboud Universiteit Nijmegen) *Waaier 4, do 15:45-16:15*

Let k be a field. Two non-degenerate quadratic forms on finite dimensional k-vector spaces are called Witt equivalent if they become isomorphic upon adding suitable hyperbolic quadratic forms. The set of equivalence classes is the Witt group $W(k)$ of k. Similarly, one can consider quadratic forms over free abelian groups or over finite abelian groups. The Witt group W_f over finite abelian groups was computed by C. T. C. Wall and others. We give an interpretation, due to V. Drinfeld, S. Gelaki, D. Nikshych and V. Ostrik, of W_f in terms of certain braided tensor categories. Enlarging the class of categories under consideration to all modular categories, where the role of hyperbolic quadratic forms is taken over by the center construction of Majid, Drinfeld, Joyal and Street, leads to a new Witt group W_M that contains W_f as a proper subgroup. W_M is of considerable interest in mathematical physics. We state what is presently known about W_M as well as a conjecture. This is joint work with A. Davydov, D. Nikshych and V. Ostrik, cf. arXiv:1009.2117.

7 Minisymposia B — vrijdagochtend 15 april

Zaal/Tijd	
Waaier 1	**Scientific Computing**
10:15-10:45	Arthur E. P. Veldman
	The numerical prediction of extreme hydrodynamic wave loads
10:45-11:15	Paul Zegeling
	Adaptive grids for non-monotone waves in an extended Richards model
11:15-11:45	Harald van Brummelen
	Goal-Adaptive Methods for Fluid-Structure Interaction
11:45-12:15	C. Vuik, M. ur Rehman, A. Segal
	Preconditioners for the discretized incompressible Navier-Stokes equations
Waaier 2	**Philips Wiskundeprijs voor promovendi**
10:15-10:35	Julia Mikhal
	Immersed boundary method for pulsatile flow in cerebral aneurysms
10:35-10:55	Marten Wortel
	Representations of finite groups on ordered vector spaces
10:55-11:15	Sandra van Wijk
	Cost Reductions in Inventory Systems by the Use of Lateral Transshipments
11:15-11:35	Eka Budiarto. *A population-based model to describe geometrical uncertainties in radiotherapy: applied to prostate cases*
11:35-11:55	Harsh Vinjamoor
	Controlling plants
11:55-12:15	Bartek Knapik
	Bayesian approach to inverse problems
Waaier 3	**Geschiedenis Wiskunde — Toonaangevende wiskundeboeken**
10:15-10:45	Tim Nicolaije. *Tussen "Hantwerk" en "Wiskonst". De Geheele Mathesis van Abraham de Graaf en het wiskundeonderwijs in de 17de eeuw*
10:45-11:15	Harm-Jan Smid
	Het Dubbele Programma van Jan Versluys
11:15-11:45	Gerard Alberts
	Moderne Algebra als modernisme in de wiskunde
11:45-12:15	Daan van Smaalen
	De Wageningse Methode. Wiskunde "buiten het boekje"
Waaier 4	**Wiskunde Onderwijs I — Beroep: leraar wiskunde**
10:15-10:45	Nellie Verhoef
	Samen(scholen) voor de toekomst
10:45-11:15	Jan Essers. *Eerstegraadsdocent wiskunde. Het traject by Fontys Leraren Opleiding Tilburg in het kader van de landelijk vastgestelde kennisbasis*
11:15-11:45	Dirk Janssens
	Wiskunde op de middelbare school in het Nederlandstalig onderwijs in België
11:45-12:15	Dirk Siersma
	Wiskundeonderwijs vernieuwt

7.1 Scientific Computing

Organisator & voorzitter: *Jaap van der Vegt (Universiteit Twente)*

The numerical prediction of extreme hydrodynamic wave loads

Arthur E. P. Veldman (Rijksuniversiteit Groningen) *Waaier 1, vr 10:15-10:45*

Non-linear free-surface phenomena, such as extreme waves and violent sloshing, and their impact on the endangered offshore and coastal constructions have long been subjects that could only be studied with experimental methods. Nowadays, computational luid dynamics tools can make a significant contribution to these flow problems. The presentation will sketch the computational modeling aspects of the simulation method ComFLOW, which is developed in close connection with MARIN, Deltares and the offshore industry. The method solves the one- and two-phase Navier-Stokes equations with a volume of fluid based free-surface treatment. Special attention will be paid to recent algorithmic refinements. Its current capabilities will be validated against a diverse series of experiments.

Adaptive grids for non-monotone waves in an extended Richards model

Paul Zegeling (Universiteit Utrecht) *Waaier 1, vr 10:45-11:15*

In this talk we will emphasize the importance of both analysis and computation in relation to a bifurcation problem in a non-equilibrium Richards model from hydrology. The extension of the Richards PDE for the water saturation to take into account dynamic memory effects was suggested by Hassanizadeh and Gray in the 90's. This gives rise to an extra third-order mixed space-time-derivative term in the PDE. Theory from applied analysis can, however, only used to predict the general solution behavior. We show that numerical adaptive grid PDE solutions can be nicely compared with the experimental observations from the laboratory, both in one dimension (non-monotone waves) and in two space dimensions (instabilities).

Goal-Adaptive Methods for Fluid-Structure Interaction

Harald van Brummelen (Technische Universiteit Eindhoven)
Waaier 1, vr 11:15-11:45

The numerical solution of fluid-structure-interaction problems poses a paradox, in that most of the computational resources are consumed by the subsystem that is of least practical interest, viz., the fluid. Goal-adaptive discretization methods provide a paradigm to bypass this paradox. Based on the solution of a dual problem, the contribution of local errors to the error in a specific goal functional is estimated, and only the regions that yield a dominant contribution are refined.

In the present work, we address two fundamental complications in goal adaptivity for fluid-structure-interaction problems. The first pertains to the free-boundary character of fluid-structure-interaction problems, which induces so-called shape-derivatives in the linearized adjoint problem. The second complication concerns the

treatment of the interface conditions, which has nontrivial consequences for the dual problem. Numerical results are presented to illustrate these different aspects.

Preconditioners for the discretized incompressible Navier-Stokes equations

C. Vuik, M. ur Rehman, A. Segal
(Technische Universiteit Delft) *Waaier 1, vr 11:45-12:15*

In this talk we consider simulation with the incompressible Navier Stokes equations. After discretization by the Finite Element Method and linearization (using Picard or Newton-Raphson) one obtains a large sparse linear system. Due to the incompressibility constraint a large zero block appears on the main diagonal of the system matrix. This type of problems is also known as a saddle point problem. Straightforward application of direct or iterative solvers leads to breakdown or divergence of the methods. For large 3 dimensional problems only iterative methods are feasible due to large time and memory requirements of direct solvers.

For the iterative methods several Krylov subspace solvers can be used as there are: Bi-CGSTAB, GMRES, GCR and PCG. We also use a recently described Krylov solver: IDR(s). The most important part is always to find a suitable preconditioner. As a preconditioner we consider an adaptation of the SIMPLE(R) method, which is mostly used for Finite Volume Methods, but can also be used for problems originating from Finite Elements Methods. It appears that the Modified SIMPLER (MSIMPLER) preconditioner leads to the best results comparing with other known preconditioners. The resulting method depends only weakly on the grid size. Finally, we consider Stokes problems with variable viscosity. Applications are from geomechanics, for instance modeling the flow in the inner parts of the earth. A combination of the Schur complement method, the pressure mass matrix as preconditioner and the Multi-Level (ML) method for the subdomain problems leads to an iterative solution method, which is independent of the grid size, the variation in the viscosity and has a scalable parallel behavior.

7.2 Philips Wiskundeprijs voor promovendi

Jury: *Ferdinand Verhulst (Universiteit Utrecht),*
Chris Klaassen (Universiteit van Amsterdam),
Jaap Top (Rijksuniversiteit Groningen)

Immersed boundary method for pulsatile flow in cerebral aneurysms

Julia Mikhal (Universiteit Twente) *Waaier 2, vr 10:15-10:35*

We present a numerical method for simulation of blood flow inside the human brain. The focus is on cerebral aneurysms that may form on some vessels. The precise blood flow and the forces on the vessel wall are computed. This contributes to our understanding of possible long-term rupture of aneurysms from an analysis of the short-time pulsatile flow. The computational model is based on the incompressible

Navier-Stokes equations in 3D. Flow in complex aneurysm geometries is represented with the use of a volume-penalizing Immersed Boundary (IB) method. The main fea- ture of our IB method is the so-called masking function which equals "0" inside the flow domain while in solid parts it takes the value "1". This technique allows a fast and relatively simple definition of any geometry. The flow inside the defined geometry is simulated on the basis of a skew-symmetric finite-volume discretization and explicit time-stepping. We compute the blood flow at various physiologically relevant flow speeds and for several types of pulsatile forcing of the flow. The model aneurysm consists of a curved vessel with a spherical cavity attached to it. Time-dependent flow and the evolution of the forces on the vessel wall are analyzed for a basic sinusoidal forcing and a parameterized realistic cardiac cycle. For relatively slow flows the flow forcing pattern dominates the forces on the walls. Upon increasing the flow-speed we observe a lively unsteady flow with more and more vortical structures arising inside the curved vessel and in the spherical cavity of the aneurysm. At these faster flows the pulsatile forcing pattern is less pronounced and the flow is dominated by its intrinsic Navier- Stokes unsteadiness. The simulations confirm that, within a physiologically relevant range of flow speeds, strong transitions in flow behavior and in force levels develop inside the aneurysm cavity, which may contribute to the long-term risk of aneurysm rupture.

Representations of finite groups on ordered vector spaces

Marten Wortel (Universiteit Leiden) *Waaier 2, vr 10:35-10:55*

In this talk we study representations of groups as positive automorphisms of ordered vector spaces, and the theory of ordered decompositions of such represen- tations, which is not at all well developed, not even for finite groups. We will lay down the basic notions of positive representations and present our results for finite groups. We will explain how the concept of ordered decompositions leads to the notion of band-irreducible representations, and indicate why it is not evident that a band-irreducible representation of a finite group is finite-dimensional. Nevertheless, this is in fact the case, and furthermore, we can completely determine the structure of finite-dimensional positive representations of a finite group.

Cost Reductions in Inventory Systems by the Use of Lateral Transshipments

Sandra van Wijk (Technische Universiteit Eindhoven) *Waaier 2, vr 10:55-11:15*

We consider an inventory system with multiple stock points. When a demand occurs at a stock point and there is a part on stock, the demand can be immediately satisfied. Otherwise, one may apply a lateral transshipment, in which case a part is shipped from a nearby stock point if it has a part on stock. The demand is lost otherwise. Both options have a cost, and the optimal choice may depend on the stock levels of all stock points in the system. For inventory problems with lateral transshipments, currently only limited insights are available on optimal policy structures. It is known that a lot of costs can be saved via lateral transshipments;

see in particular Kranenburg [2006], who showed a cost reduction of 50% for a spare parts inventory control problem at ASML, compared to the situation without lateral transshipments. But, there is a lack of insights into when exactly costs can be saved via lateral transshipments. This depends on the parameters settings, such as the costs for a lateral transshipment.

For this, we studied a system with two stock points, for which we completely characterized the structure of the optimal policy. We derived conditions under which simple, easy to implement, policies are always optimal. Furthermore, we identified the parameter settings under which one can gain most from lateral transshipments. For more than two stock points, we characterized the optimal policy structure for a system where only one stock point issues lateral transshipments. Moreover, we constructed an approximation algorithm for the general multi- location setting, determining the performance when executing a given policy. This can also be used for the optimization of parameters within a given class of policies, as from an implementation point of view, a simple parameterized policy may be much more attractive than an overall optimal policy. Furthermore, we investigated the gap between the optimal policy within a given class of parameterized policies and the overall optimal policy.

A population-based model to describe geometrical uncertainties in radiotherapy: applied to prostate cases

Eka Budiarto (Technische Universiteit Delft) *Waaier 2, vr 11:15-11:35*

Cancer patients receive radiotherapy treatments in a number of sessions or fractions. Local motions and deformations of organs between treatment fractions introduce geometrical uncertainties into radiotherapy. These un- certainties can decrease the quality of the treatment, since these can lead to underdosage in the tumour tissue, making the treatment less effective, or overdosage in the surrounding healthy tissue, damaging the healthy organs. A practical method to fully include these uncertainties is still lacking. This research proposes a model based on principal component analysis to describe the patient specific local probability distributions of voxel motions (to be used later in inverse treatment planning). As usually only a very limited number of data for a new patient is available, the analysis is extended to use population data, taken from patients with similar conditions. One of the challenges is to filter out the effects of variations in the shapes of the organ over the population, and get only the general movements and deformations. The assumption that general movements and deformations of a specific organ are similar despite the shape variations is justified retrospectively. A proof of principle of the method for deformations of the prostate and the seminal vesicles is presented.

Controlling plants

Harsh Vinjamoor (Rijksuniversiteit Groningen) *Waaier 2, vr 11:35-11:55*

Several physical systems such as ships, chemical plants, surgical robots etc. play

an important role in everyday life. We call such systems "plants". In the above plants some variables are available to the user. The rudder angle in ships, the flow of chemicals in reactors, the knob for the desired position of a robot tip etc. are variables that are manipulated by the user. The user in turn wants the plant to behave as desired. "Desirable" can have different meanings depending on the application. For a chemical plant it can mean that a certain product acquires the desired concentration quickly. For a surgical robot it can mean that the robot tip moves without vibrations. Many of these plants and desired behaviours can be represented by differential equation models. Our aim is to study these models and modify them so that they have a desired behaviour. We influence the behaviour of the plant by attaching another system to it; this other system is called a "controller". We present a general scheme for constructing such a controller and discuss its applications for various classes of plants and desired behaviours.

Bayesian approach to inverse problems

Bartek Knapik (Vrije Universiteit Amsterdam) *Waaier 2, vr 11:55-12:15*

In this talk we study a Bayesian approach to estimating a parameter μ from an observation Y following the model

$$Y = K\mu + \frac{1}{\sqrt{n}}Z.$$

The unknown parameter μ is an element of a separable Hilbert space H_1, and is mapped into another Hilbert space H_2 by a known, compact, injective, linear operator $K : H_1 \to H_2$. The image $K\mu$ is perturbed by unobserved, scaled Gaussian white noise Z. The inverse problem of estimating μ been studied by both statisticians and numerical mathematicians, but rarely from a theoretical Bayesian perspective.

In order to make inference about μ we put a Gaussian process prior on μ. Our interest is in studying the properties of the posterior distribution in two aspects of inverse problems – recovering the full parameter μ and recovering linear functionals of μ.

This talk provides the main results of our work that can be compared with well known frequentist theory. Both in nonparametric and linear functional case, we show the rate of the contraction of the posterior distribution around the truth, and we investigate frequentist coverage of Bayesian credible sets. The additional result is Bernstein-von Mises phenomenon for linear functionals of μ, which under suitable conditions on the linear functional and the prior shows that the posterior for the linear functional of the truth is centered at the frequentist maximum likelihood estimator.

In particular, we explain how the behavior of the posterior depends on the regularity of the element μ, the regularity of the prior, and the ill-posedness of the operator K, which is defined by its spectral properties. We illustrate the results by simulations and pictures in the particular example that K is the Volterra operator.

7.3 Geschiedenis Wiskunde – Toonaangevende wiskundeboeken

Organisator & voorzitter: *Fokko Jan Dijksterhuis (Universiteit Twente)*

De veranderende praktijken in de wiskunde en de veranderende opvattingen over wiskunde komen tot uitdrukking in boeken die in een bepaalde periode de toon aangaven. Dergelijke boeken weerspiegelen aan de ene kant de tijdgeest, waarin wiskunde verandert van een nuttig praktijkvak naar een wetenschappelijke discipline naar maatschappelijk dienstbare vorming. Aan de andere kant maken dergelijke boeken letterlijk en figuurlijk school, doordat ze vorm geven aan het onderwijs in de wiskunde en het denken daarover. In het veelstemmige debat over doel en methode van de wiskunde, zetten deze boeken een tijd lang de toon.

Tussen "Hantwerk" en "Wiskonst". De Geheele Mathesis van Abraham de Graaf en het wiskundeonderwijs in de 17de eeuw

Tim Nicolaije (Universiteit Twente) *Waaier 3, vr 10:15-10:45*

Wie in de zeventiende eeuw onderwijs in de wiskunde wilde volgen kon daarvoor terecht bij "rekenmeesters", privéonderwijzers die aan huis scholen in de wiskunde hadden. Hier kon men zich bekwamen in het hele spectrum van wiskundige vakken waaruit de vroegmoderne wiskunde bestond, van de beginselen van de aritmetica en geometrie tot meer praktische vakken als boekhouden, navigatie, fortificatie en landmeten. Hoe wiskundig hetgeen onderwezen werd naar onze huidige maatstaven daadwerkelijk was is echter nog maar de vraag. De wiskundelessen van deze meesters bestonden hoofdzakelijk uit het geven van vele rekenregels, die als het ware konden dienen als kant-en-klare invuloefeningen voor de toekomstige beroepspraktijk.

In zijn in 1676 voor het eerst gepubliceerde lesboek *De geheele mathesis* probeerde de gerenommeerde rekenmeester Abraham de Graaf de hele wiskunde op een systematische manier te presenteren. Hierin wilde hij naar Euclidisch voorbeeld de wiskunde, zowel de "theoretisch" als de "praktische" kant ervan, vanaf eerste beginselen opbouwen. Ik zal laten zien dat De Graaf zich echter niet los kon maken van de gangbare praktijk van receptachtige wiskunde, en dat zijn *Geheele mathesis* hierdoor een mengvorm is geworden van "hantwerk" en "wiskonst".

Het Dubbele Programma van Jan Versluys

Harm-Jan Smid (Technische Universiteit Delft) *Waaier 3, vr 10:45-11:15*

In 1874 verscheen het eerste Nederlandse boek over de didaktiek van de wiskunde, onder de titel: "Methoden bij het onderwijs in de wiskunde en de wetenschappelijke behandeling van dat vak". Auteur was Jan Versluys, toen een jonge docent wiskunde, die het later nog tot voorzitter van het Wiskundig Genootschap zou brengen. Het zou bijna honderd jaar duren voor er in Nederland weer een boek op het terrein van didactiek van de wiskunde verscheen. Versluys ontvouwt in zijn boek een dubbel programma: hij spreekt over methoden van onderwijs, en hij bepleit

een wetenschappelijke aanpak van de wiskunde als schoolvak. Versluys ontwikkelt daarbij geen originele theorieën, hij geeft een goed, soms kritisch, maar ook wat rommelig overzicht van de didactische opvattingen die toen gangbaar waren en neemt daarover duidelijke standpunten in.

Versluys heeft vermoedelijk veel meer invloed gehad door zijn schoolboeken dan door zijn zuiver didactisch werk. Die schoolboeken, hoe verdienstelijk op zich zelf ook, kunnen gemakkelijk gebruikt worden in onderwijsvormen die weinig met de didactische idealen van Versluys te maken hebben. Zijn didactiekboek bevat echter ook enkele elementen die door de generaties na hem wel werden overgenomen. Doordat die elementen echter geïsoleerd werden uit het geheel van zijn werk is dat achteraf gezien weinig vruchtbaar geweest. In de eerste helft van de twintigste eeuw verstarde het Nederlandse wiskundeonderwijs, was er nauwelijks nog belangstelling voor "methoden bij het onderwijs in de wiskunde" en werd de "wetenschappelijke behandeling" een parodie van zichzelf.

Moderne Algebra als modernisme in de wiskunde

Gerard Alberts (Universiteit van Amsterdam) *Waaier 3, vr 11:15-11:45*

Moderne Algebra veranderde de wiskunde voorgoed. Het verscheen voor het eerst in twee delen in 1930 en 1931. Bartel van der Waerden, jong hoogleraar in Groningen toen hij het schreef, presenteerde zijn boek graag als eenvoudigweg een weergave van de lessen van Noether en Artin die hij in Göttingen had genoten. De titel gaf intussen wel degelijk meer aan: de aspiratie om de algebra te vernieuwen, te moderniseren. Daarin slaagde Van der Waerden en andere wiskundigen herkenden de nieuwe stijl. De Bourbaki-groep nam dit werk zelfs tot voorbeeld voor haar publicatiereeks en dit maakte het tot toonbeeld van de twintigste-eeuwse leerboeken in de wiskunde.

Moderne Algebra was een nieuwe stijl, het stond voor een nieuwe eenheid van vorm en inhoud in de presentatie van wiskunde. Daarmee veranderde het ook de inhoud van de wiskunde-beoefening. *Moderne Algebra* was een modernisme. De theologie, de architectuur, de literatuur en de schilderkunst kenden alle hun modernisme: het omarmen en tot leidraad verheffen (vandaar -isme) van de resultaten van moderne wetenschap en techniek. Op vele cultuurgebieden ontwikkelde zich in de late negentiende of vroege twintigste eeuw een modernisme, zo ook in de wetenschapsbeoefening zelf. De manier van presenteren was geïnspireerd op de wetenschap. En omdat diezelfde wetenschap erin werd weergegeven, lag de overeenstemming van vorm en inhoud, hoewel niet vanzelfsprekend, voor het oprapen. En waar dat gebeurde, daar had het stijl, zoals *Moderne Algebra*.

De Wageningse Methode. Wiskunde "buiten het boekje"

Daan van Smaalen (Universiteit Twente) *Waaier 3, vr 11:45-12:15*

Tijdens de werkgroep krijgen de deelnemers een kijkje in de keuken van de Wageningse Methode. Er wordt ingegaan op het ontstaan van de methode begin jaren

'70 en de tegenwoordige tijd van wiskunde "buiten het boekje". Daartoe ontwikkelt de Wageningse Methode momenteel lessuggesties. Lessuggesties zijn concreet uitgewerkte ideeën die de docent zo kan inzetten in zijn of haar les, maar ook kan bewerken naar zijn of haar eigen smaak. De deelnemers doen tijdens de werkgroep een schat aan inspiratie op aan de hand van concrete voorbeelden.

7.4 Wiskunde Onderwijs I — Beroep: leraar wiskunde

Organisator & voorzitter: *Hans Sterk (Technische Universiteit Eindhoven)*

In dit minisymposium belichten we het beroep "leraar wiskunde" van verschillende kanten: onderzoek ten behoeve van het onderwijs, plannen met het wiskundeonderwijs, de hbo-lerarenopleidingen wiskunde van binnenuit en wiskunde en leraarschap in Vlaanderen.

Samen(scholen) voor de toekomst

Nellie Verhoef (vakdidacticus wiskunde, Universiteit Twente / ELAN)
Waaier 4, vr 10:15-10:45

Leraren zijn autonoom in hun leslokaal. Daarom juist is scholing in de vorm van een Community of Learners (CoL) zo inspirerend. Een CoL is van oudsher een onderzoeksnetwerk waarin intensief wordt samengwerkt. De jaarlijks groeiende Twentse CoL bestaat uit vijf UT-medewerkers en zeven vo-leraren van verschillende scholen. Samen worden vakdidactische onderzoeksresultaten aan elkaar gepresenteerd, en bediscussieerd. Op grond daarvan ontwerpen de Collers één les, de onderzoeksles. De les wordt uitgevoerd – waarbij Collers en andere geïnteresseerden – de les observeren, na afloop evalueren, bijstellen en opnieuw geven op een andere locatie. Deze effectieve "lesson study" aanpak is afkomstig uit Japan. De observaties tijdens de onderzoeksles richten zich op leerlingen, niet op leraren. Het gaat erom dat leerprocessen van leerlingen worden blootgelegd. Zo bleek vorig jaar dat leerlingen geen enkel probleem hebben met het tekenen van drie raaklijnen in een punt aan grafiek, terwijl ze weten dat er één formule bestaat. In de lezing zal benadrukt worden hoe enthousiast deze vorm van professionaliseren docenten maakt en wat de positieve effecten zijn voor de dagelijkse lespraktijk.

Eerstegraadsdocent wiskunde. Het traject bij Fontys Leraren Opleiding Tilburg in het kader van de landelijk vastgestelde kennisbasis

Jan Essers (coördinator Fontys Lerarenopleiding, redactievoorzitter kennisbasis master wiskunde)
Waaier 4, vr 10:45-11:15

Om les te mogen geven in de bovenbouw vwo of havo is een eerstegraadsbevoegdheid vereist. De bevoegdheid voor wiskunde kan behaald worden aan een van de negen universitaire lerarenopleidingen die aansluiten op de bacheloropleiding wiskunde en waarin vooral aan vakdidactische en onderwijskundige competenties aandacht wordt gegeven. Een andere opleiding is de masteropleiding wiskunde die op

vijf hbo-instellingen wordt aangeboden. Toegang tot die opleiding is alleen mogelijk voor studenten met een tweedegraadsbevoegdheid wiskunde, een opleiding waarin men wordt opgeleid om les te geven in de onderbouw van het vo en waarin studenten veel onderwijskundige en vakdidactische competenties hebben ontwikkeld. In de aansluitende eerstegraadsopleiding worden ongeveer 60 studiepunten besteed aan vak- en vakdidactiek en worden 30 studiepunten besteed aan stage in de bovenbouw, onderwijskunde en onderzoek. In de presentatie zal het opleidingstraject aan de masteropleiding van Fontys Tilburg worden geschetst, geplaatst in het licht van de vernieuwde landelijk vastgelegde kennisbasis die met ingang van volgend jaar wordt ingevoerd.

Wiskunde op de middelbare school in het Nederlandstalig onderwijs in België

Dirk Janssens (Departement Wiskunde Specifieke Lerarenopleiding Wiskunde, Katholieke Universiteit Leuven) *Waaier 4, vr 11:15-11:45*

Krijgen leerlingen in Vlaamse scholen een andere wiskundeopleiding dan in Nederland? Is het werk van een wiskundeleraar in het Vlaamse onderwijs anders dan dat van de Nederlandse collega? Er zijn enkele belangrijke structurele verschillen in de organisatie van het secundair onderwijs en de positie van de wiskundepakketten in de diverse studietrajecten. Het behalen van het diploma verloopt ook anders.

De huidige wiskundecurricula met hun specifieke aandachtspunten en de "beliefs" het leren en onderwijzen van wiskunde zijn voor beide systemen op een andere manier tot stand gekomen. De verschillende evolutie resulteert in andere specifieke aandachtspunten en "waarden", met aanpassingen van "beliefs" bij het doorvoeren van wijzigingen in de aanpak van het wiskundeonderwijs. Met een selectie van enkele typische voorbeelden uit de actuele praktijk in de wiskundelessen in Vlaanderen kunnen we mogelijke actuele verschillen alvast beter begrijpen.

Wiskundeonderwijs vernieuwt

Dirk Siersma (Universiteit Utrecht / voorzitter vernieuwingscommissie wiskunde cTWO) *Waaier 4, vr 11:45-12:15*

In de afgelopen decennia is het wiskundeonderwijs met enige regelmaat veranderd. Wat is de rol van Den Haag daarin en wat is de rol van het veld? Zijn er nog andere spelers? Welke effecten hebben de nieuwe programma's op het beroep van leraar wiskunde A. We zullen ingaan op de ontwikkelingen voor havo-vwo, die enkele jaren geleden zijn ingezet en zullen leiden tot

- een vernieuwde onderbouw vanaf 2012
- een vernieuwde bovenbouw vanaf 2015
- eerste vernieuwde examens in 2017 (havo) en 2018 (vwo).

Wat verandert er? We zullen ook verslag doen van de ervaringen met het experimentele programma, dat op een aantal scholen wordt uitgeprobeerd. Tenslotte: Zij er nog actuele ontwikkelingen te melden op grond van het "Aktieplan Beter Presteren", dat door de Minister wordt voorbereid?

8 Minisymposia C — vrijdagmiddag 15 april

Zaal/Tijd	
Waaier 1	**Study Group Mathematics with Industry: selected research 2007-2010**
13:45-14:15	Alessandro Sbrizzi. *Understanding the electromagnetic field in an MRI scanner: applications to parallel MRI techniques*
14:15-14:45	Sandra van Wijk *Increasing detection performance of surveillance sensor networks*
14:45-15:15	Ed van Daalen, M. Gunsing, Johan Grasman, J. Remmert *Roll dynamics of ships in large amplitude head waves*
15:15-15:45	Jason Frank, Gabriël Bloemhof *Optimal distributed power generation under network load constraints*
Waaier 2	**Financiële Wiskunde**
13:45-14:15	Harrie Hendriks *Risk calculus for certain multivariate distributions*
14:15-14:45	Peter Spreij *Nonparametric estimation of the multivariate distribution of a stationary volatility process under discrete observations*
14:45-15:15	Berend Roorda. *Axioms of Acceptance*
15:15-15:45	Hans van der Weide *Een nieuwe formule voor Brownse Beweging*
Waaier 3	**MSc Studentensymposium**
13:45-14:00	Martin van Buuren *TIFAR modeling package for the evaluation of ambulance dispatch strategies*
14:00-14:15	Jan Rozendaal *Een decompositiestelling voor groepsrepresentaties op L^p-ruimtes*
14:15-14:30	Marjan van der Velde *Planning en wachttijden voor Kinderspiercentrum*
14:30-14:45	Jorn van der Pol *Analysis of the Brill-Noether game on metric cactus graphs*
14:45-15:00	Jan-Pieter Dorsman *Approximations for the waiting-time distribution in polling*
15:00-15:15	Lorijn van Rooijen *Generalised Kripke semantics for the Lambek-Grishin calculus*
15:15-15:30	Michiel Janssen *Blood platelet inventory management: production, allocation and transport*
15:30-15:45	Wouter Lueks *Identiteit zonder traceerbaarheid: Anonieme credentials op een chipkaart*
Waaier 4	**Wiskunde Onderwijs II — Aansluiting wiskunde vo-ho**
13:45-14:15	Wim Caspers. *De instaptoetsen voorbij*
14:15-14:45	Dirk Tempelaar. *Wiskunde bijspijkeren: de internationale context en de lessen daaruit voor het Nederlandse wiskundeonderwijs*
14:45-15:45	Henk Procee, Kees Ruijter, Anneke Verschut, Henk van der Kooij, Hans Sterk *Van vwo naar wo: wie doet wat?*

8.1 SWI — Study Group Mathematics with Industry: selected research 2007-2010

Organisator & voorzitter: *Onno Bokhove (Universiteit Twente)*

Understanding the electromagnetic field in an MRI scanner: applications to parallel MRI techniques

Alessandro Sbrizzi (Imaging Division, University Medical Center Utrecht)
Waaier 1, vr 13:45-14:15

Magnetic Resonance Imaging (MRI) is a technique for non-invasive inner inspection of the human body. In the last decade, MRI has been subject of extensive research with the main goals of shortening the scanning time and acquiring better resolution images. For these reasons, higher magnetic fields have being employed and parallel imaging techniques (pMRI) have being developed. These new tools require detailed information about the electromagnetic fields in the scanner. In this presentation, an introduction to the mathematical foundation of pMRI is given and a method to acquire the information needed is described. The method is based on a simplification of Maxwell's equations into a single, scalar, Helmholtz equation. The foundation of this work has been laid during the SWI workshop in 2007.

Increasing detection performance of surveillance sensor networks

Sandra van Wijk (Technische Universiteit Eindhoven) *Waaier 1, vr 14:15-14:45*

We study a surveillance wireless sensor network (SWSN) comprised of small and low-cost sensors. These are deployed in a region in order to detect objects crossing the field of interest. We address two problems concerning the design and performance of an SWSN: optimal sensor placement and algorithms for object detection in the presence of false alarms. For both problems, we propose explicit decision rules and efficient algorithmic solutions. Further, we provide several numerical examples and present a simulation model that combines our placement and detection methods. The problem was presented to the Study Group Mathematics with Industry in 2008 by Thales.

Roll dynamics of ships in large amplitude head waves

Ed van Daalen, M. Gunsing (Maritime Research Institute Netherlands),
Johan Grasman (Biometris, Wageningen University and Research Centre),
J. Remmert (Dept. of Maritime Technology, Technische Universiteit Delft)
Waaier 1, vr 14:45-15:15

Some ship types may show large amplitude rolling when sailing in large amplitude head waves. The dynamics of the ship is such that roll is affected by the surface elevation of the encountering waves. If the natural roll period (without forcing) is

about half the period of the forcing by the surface elevation, then the stationary solution will have an amplitude that is much larger than for other forcing frequencies. This phenomenon is called parametric resonance. Due to the shape of the hull its heave motion is influenced considerably by the phase of the wave as it passes the ship. Moreover, the waves will also have a direct effect upon the roll dynamics. For these processes a differential equation model is formulated, being a Mathieu type of equation. Furthermore, the waves are of a type that is met in open seas; as a parameterization of these waves the Pierson-Moskowitz spectrum is used. The risk that the roll angle reaches a critical size is characterized by the time of arrival at this value, starting from an arbitrary pattern of the waves and the dynamic state of the vessel in the stationary situation. Large scale Monte Carlo simulations of this process are carried out. The percentiles of the distribution of arrival times give an indication of the risk of extreme roll to which the vessel is exposed. Furthermore, a method is proposed to estimate the maximum roll angle in a stationary sea by just taking into consideration the part of the wave spectrum that relates to the state of parametric resonance. The result is compared with the outcome of the Monte Carlo simulations.

Optimal distributed power generation under network load constraints

Jason Frank (CWI),
Gabriël Bloemhof (KEMA Consulting) *Waaier 1, vr 15:15-15:45*

In modern electrical power networks more and more customers are becoming power producers, mainly because of the development of novel components for decentral power generation (solar panels, small wind turbines and heat pumps). KEMA is interested in the question how much generation of each type (solar panel, small wind turbine or central heating power units) can be inserted into any transmission line in the network, such that under given distributions on the typical production and consumption over time, the maximum loads on the lines and components will not be exceeded. For SWI2010, we developed a linear programming model for maximizing the amount of decentral power generation while respecting the load limitations of the network. We describe a prototype showing that for an example network the maximization problem can be solved efficiently. We also modelled the case were the power consumption and decentral power generation are considered as stochastic variables, which is inherently more complex.

Links to last four SWI's:

`http://www.math.utwente.nl/~swi2008`
`http://www.swi2009.wur.nl/UK`
`http://swi2010.cwi.nl`
`http://www.few.vu.nl/~swi2011`

8.2 Financiële Wiskunde

Organisator & voorzitter: *Michel Vellekoop (Universiteit van Amsterdam)*

De laatste 40 jaar heeft het aantal toepassingen van wiskunde in Finance een grote groei doorgemaakt. Dit zijn toepassingen waarbij diverse vakgebieden een rol spelen, zoals optimalisatie, control theory, numerieke wiskunde en stochastiek. Inmiddels zijn wiskundigen aanwezig op research afdelingen van vrijwel alle banken en verzekeraars en het onderzoek is zeer uitdagend van karakter. Ook omgekeerd komt het voor dat Finance onderzoek leidt tot nieuwe resultaten binnen de wiskunde. In dit minisymposium worden daar een aantal voorbeelden van gegeven door Nederlandse onderzoekers.

Risk calculus for certain multivariate distributions

Harrie Hendriks (Radboud Universiteit Nijmegen) *Waaier 2, vr 13:45-14:15*

We consider non-negative real valued random variables $X_1, \ldots, X_n$ with a joint distribution of the form

$$\mathbb{P}(X_1 \geq x_1, \ldots, X_n \geq x_n) = h(\lambda_1 x_1 + \cdots + \lambda_n x_n)$$

where the $\lambda_i > 0$ are postive real numbers, and where h is a monotone increasing function so that $h(x) = 1$ for $x \leq 0$ and $\lim_{x\to\infty} h(x) = 0$. The univariate marginals belong to the same scale family with the standard exceedance function h. An example is a collection of independent exponentially distributed random variables. Distributions as above have been proposed in the literature, especially the case where $\lambda_1 = \cdots = \lambda_n = 1$. We will discuss the sum $S = X_1 + \cdots + X_n$, and the expected values and correlations of $X_1, \ldots, X_n$, conditional on the event $S \geq s$.

This is work done in collaboration with Zinoviy Landsman (Haifa University).

Nonparametric estimation of the multivariate distribution of a stationary volatility process under discrete observations

Peter Spreij (Universiteit van Amsterdam) *Waaier 2, vr 14:15-14:45*

We consider a continuous-time stochastic volatility model. The model contains a stationary volatility process, the multivariate density of the finite dimensional distributions of which we aim to estimate. We assume that we observe the process at discrete instants in time. The sampling times will be equidistant with vanishing distance.

A multivariate Fourier-type deconvolution kernel density estimator based on the logarithm of the squared processes is proposed to estimate the multivariate volatility density. An expansion of the bias and a bound on the variance are derived. We will also discuss results form other approaches to density estimation, such as minimum contrast methods and wavelet based methods.

Axioms of Acceptance

Berend Roorda (Universiteit Twente) *Waaier 2, vr 14:45-15:15*

Many models in mathematical finance can be interpreted as the specification of a subset of acceptable positions, represented as random variables describing their uncertain payoff. In the context of trading, prices may be deduced from this "acceptance set" as the maximum amount of cash so that the net payoff is still acceptable. Similarly, in risk management a capital buffer for extreme losses can be determined as the amount required to shift the position into the acceptable region. In this way models for price and risk may be formally identified with a dichotomy of random variables in a suitable probability space.

In this presentation we translate recent insights from risk measure theory into a set of axioms for acceptability, and give representation results at several levels of generality. We concentrate on dynamic aspects, working in a standard filtered probability space. A key result is a universal rule for updating acceptance sets on the basis of new information. This extends the well-known law of iterated expectations in several ways.

We illustrate the main ideas by risk measures based on entropy.

Een nieuwe formule voor Brownse Beweging

Hans van der Weide (Technische Universiteit Delft) *Waaier 2, vr 15:15-15:45*

Gegeven Brownse Beweging $B = (B(t); t \geq 0)$ en $a, b > 0$. De kans dat de Brownse Beweging niveau a eerder treft dan niveau $-b$ wordt gegeven door $b/(a+b)$. De verwachtingswaarde van de tijd waarop de verzameling $\{-b, a\}$ getroffen wordt is gelijk aan ab. Deze simpele formules staan in iedere inleiding over Brownse Beweging. In deze voordracht willen we kijken naar excursies boven niveau a en onder niveau $-b$. We bespreken de kans dat een excursie van lengte l_a boven niveau a eerder optreedt dan een excursie van lengte l_b beneden niveau $-b$ en de verwachte tijd tot een excursie van lengte l_a boven niveau a of een excursie van lengte l_b beneden niveau $-b$.

8.3 MSc Studentensymposium

Organisatoren & voorzitters: *Sijmen de Bruijn & Martin Wevers (Universiteit Twente)*

TIFAR modeling package for the evaluation of ambulance dispatch strategies

Martin van Buuren (Technische Universiteit Delft / CWI)
Waaier 3, vr 13:45-14:00

The operation of emergency medical services (EMS) is an important part of society and an interesting field of research for applied mathematicians.

As part of my master project I've made a simulation tool that can be used to evaluate EMS dispatch strategies. This tool includes realistic elements. Amongst them are:

- Realistic generation of accidents.
- Several call priorities (A1 and A2).
- EMS dispatch from various bases in the region (RAV).
- Realistic chance that a patient can be treated at the accident scene instead of being brought to a hospital (EHGV).
- Realistic use of optical and auditory signals, and realistic driving speeds.
- EMS relocations between bases for better regional coverage.

The results of this software packet, named "Testing Interface for Ambulance Research" or TIFAR in short, are close to the real statistics: In reality 91.7% of the calls have a response time lower than 15 minutes. TIFAR's simulations estimate this to be 91.0%.

Een decompositiestelling voor groepsrepresentaties op L^p-ruimtes

Jan Rozendaal (Universiteit Leiden) *Waaier 3, vr 14:00-14:15*

Eén van de grote doelen in representatietheorie is de ontbinding van een representatie van een groep in irreducibele representaties. Voor groepen die unitair werken op Hilbertruimtes zijn er resultaten bekend die dit doel bewerkstelligen. Daarentegen is er veel minder bekend over acties van een groep op een Banach ruimte, laat staan over acties op een geordende Banach ruimte of Banach rooster.

In mijn scriptie bewijs ik het bestaan van een dergelijke decompositie voor een klasse van representaties van groepen op bepaalde specifieke Banach roosters, L^p-ruimtes van p-integreerbare functies. Om precies te zijn, voor een lokaal compacte Poolse transformatiegroep (G, X) en een eindige G-invariante maat μ op X kan de werking van G op $L^p(X, \mu)$ geïnduceerd door die op X ontbonden worden in band-irreducibele representaties. Bij mijn weten is dit een resultaat dat nog niet eerder is verschenen in de literatuur.

In mijn presentatie zal ik kort ingaan op de grote lijnen van het bewijs van het bestaan van deze decompositie.

Planning en wachttijden voor Kinderspiercentrum

Marjan van der Velde (Universiteit Twente) *Waaier 3, vr 14:15-14:30*

Kinderen met spierziekten staan onder behandeling bij veel verschillende specialisten. Tot nu toe moesten deze kinderen voor elk consult of onderzoek een aparte afspraak maken, maar door de recente opening van het Kinderspiercentrum in het AMC in Amsterdam is dit nu verleden tijd.

Aan een dagplanning voor het centrum worden veel verschillende eisen gesteld, daarom is een Integer Lineair Program ontwikkeld dat een optimale planning maakt.

Onderzocht is ook welke eisen beperkend zijn voor de capaciteit van een behandeldag, en hoe dit eventueel kan worden opgelost.

Omdat het een kleine patientgroep betreft mag er slechts eens per maand een behandeldag gepland worden. Door de vele eisen aan de dagplanning kan het daarom echter voorkomen dat de toegangstijden erg oplopen, daarom worden ook deze onderzocht.

Analysis of the Brill-Noether game on metric cactus graphs

Jorn van der Pol (Technische Universiteit Eindhoven) *Waaier 3, vr 14:30-14:45*

A metric graph is a metric realisation of a weighted discrete graph. We investigate the existence of winning strategies in a certain chip-firing game on metric cactus graphs, i.e. metric realisations of discrete cactus graphs. We link the Brill-Noether game to the concept of linear systems of divisors on metric graphs. Existence of winning strategies is then implied by Brill-Noether theory on algebraic curves and recent work by Matthew Baker, linking linear systems on algebraic curves to linear systems on metric graphs v.v., an argument which uses sophisticated algebraic geometry. We provide a new elementary proof of the existence of winning strategies.

Approximations for the waiting-time distribution in polling

Jan-Pieter Dorsman (Vrije Unversiteit Amsterdam / CWI)
Waaier 3, vr 14:45-15:00

Queueing theory, the mathematical study of waiting lines or queues, enables performance analysis of all kinds of queueing models. One such model is the polling system, which consists of a number of queues, attended by a single server, typically in a cyclic order. Polling models find many applications in areas such as computer-communication systems, manufacturing systems and traffic systems. We focus on the waiting-time distribution for polling systems with general customer inter-arrival times and exhaustive service at each of the queues. In absence of exact results, we propose a closed-form approximation for the distribution of the waiting time of customers in these systems. An extensive simulation study shows that the approximation is highly accurate.

Generalised Kripke semantics for the Lambek-Grishin calculus

Lorijn van Rooijen (Radboud Universiteit Nijmegen) *Waaier 3, vr 15:00-15:15*

The Lambek-Grishin calculus is a propositional logic that captures certain sentence forming mechanisms in linguistics. Semantics are mathematical models of a logic rich enough to determine the logic. The semantics that I will present use relational structures and associated Galois connections. In this talk I will give an introduction to the general ideas rather than focussing on technical results.

Blood platelet inventory management: production, allocation and transport

Michiel Janssen (Universiteit van Amsterdam) *Waaier 3, vr 15:15-15:30*

Because the maximum shelf life of platelet concentrates (PC's) is limited to only a few days and the demand for PC's is highly variable, production planning is complicated. Common PC inventory management relies on experience-based replenishment rules. As shortages are not allowed – because a life may be at stake – blood banks tend to operate at high levels of inventory leading to a high disposal of PC's due to outdating in the order of 10-20 percent. These high outdating figures are undesirable as disposal of PC's is a waste of production costs and valuable (voluntary) donor material. Moreover, as average inventories are high, the time between donation of the blood platelets and the moment of delivery at the hospital is relatively high. As PC's deteriorate over time, this also affects the quality of the patients treatment. Besides the production of the PC's, the allocation of these products over multiple distribution points and hospital inventories further complicate the PC's inventory management. We used stochastic dynamic programming to calculate optimal replenishment production rules. In order to reduce the state-space and make the problem computationally tractable some simplifying assumptions are made and a scaling technique is applied in conjunction with computer simulation. The most stringent assumptions are that of a single blood group and that of a single distribution point. To evaluate the calculated replenishment rules in a more realistic setting and to address the allocation problem, an extensive simulation model is build. We find that the optimality of the calculated replenishment rules is not effected by the simplifying assumptions under simple and robust allocation rules. We show that shortages and outdating of PC's can be reduced to virtually zero percent and platelets can arrive "younger" at the hospitals. Moreover the simulation model can help reduce the number of needed deliveries of PC's to a hospital by providing valuable insights in the relation between the hospital's inventory level, the outdating at the hospital and the resulting number of deliveries to this hospital.

Identiteit zonder traceerbaarheid: Anonieme credentials op een chipkaart

Wouter Lueks (Rijksuniversiteit Groningen) *Waaier 3, vr 15:30-15:45*

Tegenwoordig is het steeds vaker nodig om je te identificeren voordat je van een dienst gebruik kan maken. Zo hebben we voor het gebruik van het openbaar vervoer een OV-chipkaart nodig en moeten we ons bij de slijter identificeren met een paspoort of rijbewijs. Opmerkelijk is dat niet alleen noodzakelijke informatie, in dit geval geldigheid van het vervoersbewijs en meerderjarigheid, beschikbaar wordt gemaakt maar ook andere niet noodzakelijke informatie zoals geboortedatum en achternaam. Het doel van anonieme credentials is om selectief informatie te openbaren, zonder dat het gebruik ervan herleid kan worden naar de eigenaar. Veel van deze anonieme credentials zijn zo ingewikkeld dat ze niet toegepast kunnen worden op chipkaarten. Ik zal laten zien hoe we met behulp van self-blindable credentials kunnen zorgen voor een systeem dat wel op chipkaarten kan worden toegepast.

8.4 Wiskunde onderwijs II — Aansluiting wiskunde vo-ho

Organisator & voorzitter: *Steffen Posthuma (Universiteit Twente)*

De instaptoetsen voorbij

Wim Caspers (Technische Universiteit Eindhoven) *Waaier 4, vr 13:45-14:15*

Om de basisvaardigheden wiskunde te meten worden er aan veel universiteiten en hogescholen instaptoetsen afgenomen. Sinds een aantal jaar gebeurt dat in Delft, Eindhoven en Twente in 3TU-verband. Jaarlijks worden ongeveer drieduizend studenten aan eenzelfde toets onderworpen. En in het project NKBW lijken het hogeren het voortgezet onderwijs elkaar gevonden te hebben. Over en weer zou duidelijk zijn wat men van elkaar mag verwachten en remedieringsmateriaal is voorhanden, ook voor later in de opleiding in projecten als Telmme. In het voortgezet onderwijs zijn de examenprogrammas wiskunde veranderd, er is meer aandacht voor basisvaardigheden op het centraal examen, de formulekaart is afgeschaft en ook methodes in de onderbouw zijn vernieuwd. Kortom exit voor de instaptoets? In ieder geval niet voordat er grondig gemeten is of de resultaten ook verbeteren. De stand van zaken in aansluitland en hoe heeft de eerste lichting wiskunde B (en D) leerlingen het gedaan?

Wiskunde bijspijkeren: de internationale context en de lessen daaruit voor het Nederlandse wiskundeonderwijs

Dirk Tempelaar (Universiteit Maastricht) *Waaier 4, vr 14:15-14:45*

Zo'n kleine 10 jaar wordt in het kader van opeenvolgende SURFprojecten (Web-Spijkeren I, II; NKBW I, II; Onbetwist) bijspijkeronderwijs wiskunde georganiseerd om de aansluiting VWO-WO te bevorderen. Dit aansluitonderwijs heeft zich op twee verschillende groepen van aankomende studenten gericht: Nederlandse VWO-leerlingen met tekortschietende beheersing van algebraïsche vaardigheden en internationale studenten, die een wiskundeprogramma hebben doorlopen dat sterk afwijkt van het Nederlandse VWO-programma. Vooral universiteiten in het grensgebied met Duitsland kennen een grote toestroom van studenten met een sterk verschillende vooropleiding. Bij het ontwerpen van aansluitonderwijs voor deze internationale studenten is intensief gebruik gemaakt van ervaringen in vooral Angelsaksische landen met "remedial education" in de wiskunde. In deze bijdrage zal deze internationale context geschetst worden, en zal gerapporteerd worden over de UM praktijk van bijspijkeronderwijs aan grote groepen van zowel Nederlandse als internationale studenten. Tevens wordt ingegaan op de uitkomsten van de afname van landelijke (NKBW & 3TU) instaptoetsen bij deze studenten.

Van vwo naar wo: wie doet wat?

Forumdiscussie *Waaier 4, vr 14:45-15:45*

Onder leiding van moderator Henk Procee (Universiteit Twente, Studium Generale) discussieert een deskundig forum en het publiek in de zaal over onderwerpen die de overgang van vwo naar wo betreffen. Elk forumlid presenteert in vijf minuten een pittig statement over deze belangwekkende materie waarna de discussie kan losbarsten. Het forum bestaat uit Kees Ruijter (Universiteit Twente. Oud opleidingsdirecteur werktuigbouwkunde en trekker van het op te zetten University College), Anneke Verschut (Wiskundedocent aan het Etty Hillesum Lyceum Deventer), Henk van der Kooij (Freudental Instituut en Bestuurslid van de Nederlandse Vereniging van Wiskundeleraren), Hans Sterk (Technische Universiteit Eindhoven).

9 Elevator pitches

Masterstudenten en promovendi presenteren hun onderzoek via posters en lichten deze toe in een presentatie van twee minuten.

9.1 Elevator pitches — donderdag 14 april

Voorzitter: *Ruben Hoeksma (Universiteit Twente)* *Waaier 2, do 11:15-11:45*

Delays at signalised intersections with exhaustive traffic control

Marko Boon (Technische Universiteit Eindhoven) *Waaier 2, do 11:15-11:18*

In this paper we study a traffic intersection with vehicle-actuated traffic signal control. Traffic lights stay green until all lanes within a group are emptied. Assuming general renewal arrival processes, we derive exact limiting distributions of the delays under Heavy Traffic (HT) conditions, using theory on polling models. Furthermore, we derive the Light Traffic (LT) limit of the mean delays for intersections with Poisson arrivals, and develop a heuristic adaptation of this limit to capture the LT behaviour for other interarrival-time distributions. We combine the LT and HT results to develop closed-form approximations for the mean delays of vehicles in each lane. These closed-form approximations are quite accurate, very insightful and simple to implement.

Minimizing the Waiting Time of Emergency Surgery

Theresia van Essen (Universiteit Twente) *Waaier 2, do 11:18-11:21*

Hospitals aim to deliver high quality of care. One aspect in this context is to schedule emergency surgeries as quick as possible. Postponing these surgeries may increase a patient's risk of complications and morbidity. Reserving capacity in the Operating Rooms (ORs) for emergency surgeries can be done in two ways: (1) dedicating an entire OR to emergency surgeries or (2) scheduling the emergency surgeries in one of the elective ORs. Previous literature has shown that the second option is the best one in terms of waiting time, staff overtime, and OR utilization. In this situation, emergency patients are operated once an ongoing elective surgery is finished. These moments in time are denoted by "break-in-moments" (BIMs). By spreading the BIMs as evenly as possible over the day, the waiting time of the emergency surgeries can be reduced even further. We discuss the problem of spreading these BIMs and we treat several solution methods for the off-line and on-line version of this problem.

Persistence of noncompact Normally Hyperbolic Invariant Manifolds

Jaap Eldering (Universiteit Utrecht) *Waaier 2, do 11:21-11:24*

Within dynamical systems, normally hyperbolic invariant manifolds (NHIMs) are a generalization to hyperbolic fixed points. The fixed point is replaced by a whole invariant manifold with corresponding generalized hyperbolicity criteria. Similar to a hyperbolic fixed point, a NHIM has (un)stable manifolds and persists under small perturbations. These structures play an important role in studying local and global nonlinear behavior, such as in bifurcation analysis and dimensional reduction. The classical theorems by Fenichel and by Hirsch, Pugh and Shub on persistence of NHIMs assume compactness of the invariant manifold. We will formulate a persistence theorem for general noncompact NHIMs. To properly generalize to arbitrary manifolds, e.g. with non-trivial normal bundle, we require the concept of a Riemannian manifold of *bounded geometry*. We illustrate why the perturbed manifold has only finite smoothness and, using examples, we show some of the issues specific to the noncompact setting and how bounded geometry comes into play.

Model Based Control – Improving efficiency on Wastewater Treatment Plants

Maartje van de Vrugt (Universiteit Twente) *Waaier 2, do 11:24-11:27*

Wastewater treatment plants in the Netherlands are forced by a new Dutch law to increase their efficiency with 2% each year until 2020. In many treatment plants the wastewater is cleaned by a biological process that consumes oxygen. This process accounts for about 60% of the energy consumption of the plant. In collaboration with Witteveen+Bos we have developed a new mechanism for the oxygen supply, referred to as Model Based Control, that is based on a model that predicts the pollution level of the wastewater. In a pilot study in treatment plant Westpoort the efficiency increase was shown to be substantial.

The pollution level in the wastewater was predicted with an adaptive model. To this end, a moving average filter was applied to the input signals to increase the correlation coefficient between prediction and measurements. Using adaptive control techniques an unsupervised adaptive oxygen supply mechanism was developed. Simulation results for Westpoort show that the new mechanism increases efficiency by 9%.

A decomposition result for representations on L^p-spaces

Jan Rozendaal (Universiteit Leiden) *Waaier 2, do 11:28-11:31*

In representation theory one is often interested in decomposing a representation of a group on some space into a sum of irreducible representations. In the case of groups acting unitarily on Hilbert spaces, results of this form have been found. Less is known about actions on Banach spaces, let alone on ordered Banach spaces or Banach lattices. Moreover, representations are usually decomposed into direct sums of irreducible representations. Sometimes one cannot hope to find such a direct sum decomposition, and one wishes to consider a type of direct integral.

Such a concept exists for Hilbert spaces, but for Banach spaces there is no widely accepted theory.

In my thesis, I prove a decomposition result for group actions on certain specific Banach lattices, L^p-spaces of p-integrable functions. These spaces carry a pointwise ordering which behaves nicely with respect to the norm, and we would like to decompose such a space in a manner which respects this ordering. Hence our goal is to decompose a representation on these ordered Banach spaces in an order irreducible manner.

I use the theory of so-called Banach bundles to consider an "integral" of Banach spaces, thereby providing a possible alternative to the direct integral concept for Banach spaces. Combining this with results on integral decompositions of invariant measures, we have the tools necessary to decompose a representation of a group on such an L^p-space into representations which are order irreducible.

To be more precise, I prove that for any locally compact Polish transformation group (G, X) and any finite G-invariant measure μ on X, the action of G on $L^p(X, \mu)$ induced by that on X can be decomposed into band-irreducible representations for any $p \in [1, \infty)$. This is done by constructing an isometric lattice isomorphism between the space $L^p(X, \mu)$ and a space of p-integrable sections of a certain Banach bundle having spaces $L^p(X, \lambda)$, for λ ranging over the ergodic measures on X, as fibers. As far as the author is aware of, such a result has not yet appeared in the literature.

Differentiaalvergelijkingen begrijpen

Joke Zwarteveen-Roosenbrand (Universiteit Twente / ELAN)

Waaier 2, do 11:32-11:35

The concept of differential equations (DEs) is essential in university science. The Dutch government introduced a new subject, Mathematics D, in the existing mathematics curriculum of the secondary education in recent years. Mathematics D aims to prepare for university science education. The concept of DEs' introduction is a principal part of this preparation. A key objective on this topic, according to the Dutch government's mathematics innovation committee, is analyzing (the solutions of) dynamic systems. Therefore the mostly used textbooks describe how to solve some types of DEs using algebraic methods and focus on the behavior of DEs, like equilibrium. In these cases the DEs are given, but the concept of a DE as a model of dynamic phenomena is not highlighted. This is not only the case in the Netherlands. However, research outcomes show that students have great difficulties in analyzing dynamic systems when they don't know how to model those systems. So conceptual understanding of the concept of DEs needs the knowledge of setting up a DE. Therefore instructions are designed to promote understanding of the concept of DEs by means of setting up DEs. The poster shows the cyclic design research process of improving the design of the instructions as well as measuring the effects of the instructions. So the research question of my PhD research is: What are the characteristics of teaching the concept of DEs in line

with students' thinking processes?

Invariant Measures of Random Walks in the Quarter-plane

Yanting Chen (Universiteit Twente) *Waaier 2, do 11:35-11:38*

We consider the invariant measure of homogeneous random walks in the quarter-plane. In previous research, it is revealed that there are some random walks for which the invariant measure is of geometric product form. We consider the class of measures that can be expressed as a linear combination of geometric product forms. First, it is shown that no finite linear combination of terms can be the invariant measure of an ergodic random walk. Second, it is shown that the only class of countable linear combinations are of the form in which terms occur in pairs. This completely characterizes the class of series of geometric terms that can be the invariant measure of a random walk in the quarter-plane.

Model Checking Stochastic Systems using Rare Event Simulation

Daniël Reijsbergen (University of Twente) *Waaier 2, do 11:39-11:42*

We are interested in estimating system failure probabilities in highly dependable systems, such as a telecommunications network or a nuclear power plant. Examples of probabilities of interest could be system failure before some time bound, or the long run fraction of time that the system is down. Often, the models have state spaces that are too large for iterative methods (such as the Gauss-Seidel method). Stochastic simulation is then typically used as the alternative. Obviously, in a highly dependable system, system failure is a *rare event*, so we need to apply *efficient* simulation techniques. We use Importance Sampling, i.e. we simulate under a new distribution which oversamples occurrence of the rare event. The focus of our research is to find simulation distributions that perform well for a given model setting.

Immersed boundary method for pulsatile flow in cerebral aneurysms

Julia Mikhal (Universiteit Twente) *Waaier 2, do 11:42-11:45*

We present a numerical method for simulation of blood flow inside the human brain. The focus is on cerebral aneurysms that may form on some vessels. The precise blood flow and the forces on the vessel wall are computed. This contributes to our understanding of possible long-term rupture of aneurysms from an analysis of the short-time pulsatile flow. The computational model is based on the incompressible Navier-Stokes equations in 3D. Flow in complex aneurysm geometries is represented with the use of a volume-penalizing Immersed Boundary (IB) method. The main feature of our IB method is the so-called masking function which equals "0" inside the flow domain while in solid parts it takes the value "1". This technique allows a fast and relatively simple definition of any geometry. The flow inside the defined geometry is simulated on the basis of a skew-symmetric finite-volume

discretization and explicit time-stepping. We compute the blood flow at various physiologically relevant flow speeds and for several types of pulsatile forcing of the flow. The model aneurysm consists of a curved vessel with a spherical cavity attached to it. Time-dependent flow and the evolution of the forces on the vessel wall are analyzed for a basic sinusoidal forcing and a parameterized realistic cardiac cycle. For relatively slow flows the flow forcing pattern dominates the forces on the walls. Upon increasing the flow-speed we observe a lively unsteady flow with more and more vortical structures arising inside the curved vessel and in the spherical cavity of the aneurysm. At these faster flows the pulsatile forcing pattern is less pronounced and the flow is dominated by its intrinsic Navier-Stokes unsteadiness. The simulations confirm that, within a physiologically relevant range of flow speeds, strong transitions in flow behavior and in force levels develop inside the aneurysm cavity, which may contribute to the long-term risk of aneurysm rupture.

9.2 Elevator pitches — vrijdag 15 april

Voorzitter: *Julia Mikhal (Universiteit Twente)* *Waaier 2, vr 12:45-13:15*

Decentralized energy generation: a column generation approach

Maurice G.C. Bosman (Universiteit Twente) *Waaier 2, vr 12:15-12:18*

The ongoing shift towards a decentralized energy supply chain asks for new tools and methods to predict, plan and control the generation, storage and consumption of energy. The existing energy world needs to incorporate a large variation of distributed, smaller-scale generation technologies, which increase both the size and the complexity of the energy management problem, which in its simplest form is to realtime match supply and demand with limited storage possibilities.

A column generation approach is developed to plan the production commitment of a fleet of decentralized energy generators, taking into account bounds on the total energy profile. This approach separates the local constraints on the production profiles from the global constraints on the total production to simplify the planning problem. The approach is able to compute solutions of relatively good quality in reasonable computation time.

Parameterization of atmospheric convection with conditional Markov chains

Jesse Dorrestijn (CWI) *Waaier 2, vr 12:18-12:21*

The effect of clouds and convection on the state of the atmosphere is a major source of uncertainty in weather and climate models. Explicit modeling of convection requires model resolutions on the order of 50 meters, whereas global climate models have horizontal resolutions starting at $\sim$100 km. As a consequence, the effects of convection in individual vertical model columns must be represented ("parameterized") in a simplified yet adequate way. We use a new method to parameterize convection stochastically. A Markov chain is constructed by using realistic

data obtained from large-eddy simulation (LES) of atmospheric convection. With a cluster method representative vertical heat and moisture flux profiles are found and the corresponding transition probability matrix is estimated by counting the number of transitions between profiles. By conditioning the probabilities on the atmospheric state, a conditional Markov chain (CMC) is obtained that can produce realistic turbulent fluxes. These fluxes are crucial for convection parameterization in weather and climate models.

Online Outlier Detection in Testing of Integrated Circuits

Harm Bossers (Universiteit Twente) *Waaier 2, vr 12:21-12:24*

Testing of Integrated Circuits (IC's) consists of measurements of all kind of values such as speed or leakage currents (IDDQ). The measurements need to be within certain specification limits, but these limits are usually quite wide to accommodate for variations caused by the production process or tester condition. Therefore, manufacturers want to apply outlier detection, since the outliers are potentially unreliable as is shown by empirical evidence. An outlier is defined as a measurement which differs significantly from an expected pattern of behavior, but is still within specification limits. However, most outlier detection methods are used in an offline setting and hence are not applicable to the Final Test stage, where immediate pass/fail decisions are required. So we need an online outlier detection method, since measurement distributions can shift due to all kind of variations.

We developed a univariate online outlier detection method that is applicable to Final Test. Test limits are constructed based on previous measurements and updated with a rolling horizon. Robust statistics are used to ensure a stable start to the method. We analyzed our method using real-world data. We identified some cases which can result in performance degradation, but most experiments showed that our method is robust to outliers and able to detect them in an online setting. Furthermore, we show some work in progress about a bivariate online outlier detection method. This method is also a rolling horizon method, but it uses kernel density estimation to distinguish between "normal" (dense) regions and outlier regions.

Asymptotic behaviour of second order linear autonomous neutral delay differential equations

Guiling Chen (Universiteit Leiden) *Waaier 2, vr 12:24-12:27*

We present the asymptotic behaviour of the following second order linear autonomous neutral delay differential equation by ODE approach and spectral approach,

$$x''(t) + cx''(t-\sigma) = ax(t) + bx(t-\tau)$$

where a, b, c are real numbers, σ and τ are positive real numbers. The main idea of ODE approach is that of transforming the second order delay differential equation

into first order delay differential equation, by using of a real root of the corresponding characteristic equation, while spectral approach is emphasis on the explicit computation of the large time behaviour by using spectral projections. Furthermore, the conditions given by the ODE approach are further studied and some examples are shown to illustrate the main results of this paper. The main results are based on the work of Driver's asymptotic behaviour for first order delay differential equations and Frasson and Verduyn Lunel's spectral theory for functional differential equations.

Balancing walk-in and appointments in health care

Nikky Kortbeek (Universiteit Twente) *Waaier 2, vr 12:28-12:31*

Outpatient and diagnostic testing clinics have long provided patients with appointments, to match capacity with demand. However, the main disadvantage of a pure appointment policy is that substantial access delays can be created. This study explores the viability of a walk-in based policy: a mixed strategy of walk-in and appointments. We present a stochastic method that finds the mixed strategy that achieves an optimal balance between the benefits and drawbacks of a pure appointment and a pure walk-in policy. The optimal policy successfully counterbalances the non-stationary nature of walk-in arrivals at both the daily and weekly levels, by prescribing how many appointment slots to reserve and at which times.

Kronecker product covariance structure models

Beata Ros (Vrije Universiteit Amsterdam) *Waaier 2, vr 12:32-12:35*

We investigate properties of the Kronecker product covariance structure models. Namely, we assume that $X \in \mathcal{M}_{p,q}(\mathbb{R})$ is a random matrix and $vec(X) \sim \mathcal{N}(0, \Psi \otimes \Gamma)$ with some additional assumptions about matrices Γ and Ψ. A nice property is that the matrix $\Psi \otimes \Gamma$ has much fewer parameters than the unrestricted covariance matrix Σ.

Suppose we have $X_1, \ldots, X_N$ -the data. We are interested in estimating $\Psi \otimes \Gamma$ with use of the data. We consider maximum likelihood estimation, thus obtain maximum likelihood equations. We investigate two aspects of these equations. First is the existence of solutions of the equations. The second is uniqueness of the solution.

Depending on additional assumptions about Γ and Ψ as well as p, q -number of rows, columns of X and N -number of samples, we have different properties of the likelihood equations with respect to existence and uniqueness of solutions.

We are interested in using this model for the analysis of simultaneously collected EEG and fMRI data.

Mathematics teachers' professional development by means of lesson study

Daan van Smaalen (Universiteit Twente) *Waaier 2, vr 12:35-12:38*

Lesson study is a professional development practice in which teachers collaborate to develop a lesson, teach and observe the lesson to collect data on student learning and development, and use their observations to refine their lesson. It is a process that teachers engage in to learn more about teaching and learning, it is not about designing a perfect lesson. Observing students and discussing the lesson and instruction more broadly are central activities of *lesson study*.

Lesson study originated in Japan, where this practice is seen as the means for teacher development for several decades now. Since the millennium *lesson study* is slowly receiving some attention in western countries like America, Britain and Australia. In the Netherlands, the first initiatives are launched recently. The phenomenon *lesson study* is thus hardly documented. Therefore, there is a need to expand the knowledgebase regarding this professional development practice. The central research question related to my PhD research is: *What and how do teachers learn when they participate in a lesson study team?*

Planning and scheduling of semi-urgent surgeries

Maartje E. Zonderland (Universiteit Twente / Leids Universitair Medisch Centrum)
Waaier 2, vr 12:39-12:42

We consider a surgical department where elective, semi-urgent and urgent patients patients are treated. The latter patient type needs treatment immediately, which is carried out in a separate emergency OR; semi-urgent patients, who arrive unexpectedly, need surgery within one or two weeks and are treated, just as elective patients, in regular OR time.

Elective patients are canceled to accommodate semi-urgent patients, which is highly undesirable from a patient perspective. Therefore a part of regular OR capacity is dedicated to semi-urgent patients. However, no semi-urgent patients may show up. Since elective patients cannot be planned on such short notice, scarce OR time is not used, which is very undesirable from a financial point of view.

We describe a methodology, based on a queueing theory approach, to handle the uncertainty caused by semi-urgent patients.

Decentralized Scheduling on Related Machines

Ruben Hoeksma (Universiteit Twente) *Waaier 2, vr 12:42-12:45*

The price of anarchy measures by how much the performance of a system deteriorates due to the lack of central coordination. We address the classical uniformly related machine scheduling problem. This problem treats the scheduling of multiple jobs with different lengths on a number of parallel machines with different speeds. We assume that the jobs may choose the machine on which they are processed. When jobs seek to minimize their own completion time, the utilitarian social choice function is to minimize the average job completion time. In this setting we analyze

the price of anarchy for the natural coordination mechanism where jobs are sequenced shortest first per machine. We show that the price of anarchy is bounded from below by $e/(e-1) \approx 1.58$ and from above by 2. This complements recent results on the price of anarchy for the more general unrelated machine scheduling problem by Cole et al. Moreover, as Nash equilibria correspond one-to-one to SPT schedules, the same bounds hold for the SPT heuristic on uniformly related machines. Thereby, our work also fills a gap in the literature.

10 Omlijsting van het programma

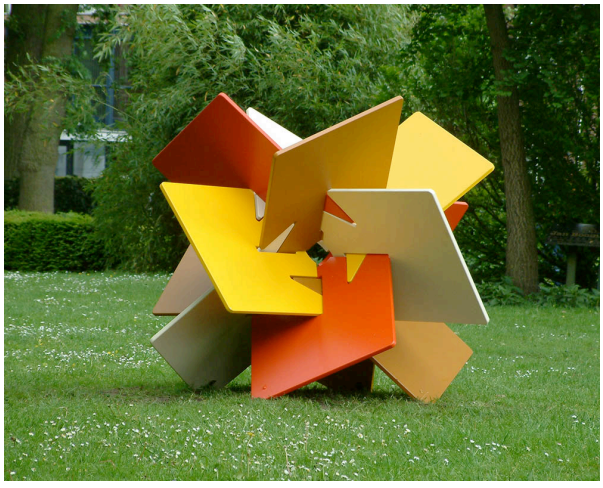
Schuifstructuren

Rinus Roelofs *Waaier 2, do 18:45-19:05*

Het bestuderen van mogelijkheden om objecten te maken door middel van het samen schuiven van onderdelen is de basis van een aantal van mijn beelden. (Zie de afbeelding op deze pagina.)

Zeker wanneer als extra eis geldt dat delen niet buigbaar mogen zijn leidt dit tot interessante oplossingen. Ik wil iets laten zien van de verschillende schuifstructuren die ik in mijn werk heb toegepast en tevens wil ik ingaan op de verschillende schuifstrategieën die hierbij een rol spelen. Evenwijdige schuifrichtingen, radiale- en tangentiële schuifrichtingen, alsmede combinaties daarvan zien we terug in de gerealiseerde objecten. Met behulp van animaties is dan het samenschuiven in beeld gebracht.

Biografie: Rinus Roelofs (1954). Na een studie Toegepaste Wiskunde aan de Universiteit Twente heb ik de opleiding voor Beeldend Kunstenaar gevolgd aan de AKI te Enschede. Sinds 1983 werk ik als beeldhouwer. Al snel is in mijn werk de belangstelling voor de wiskunde een hoofdonderwerp geworden. Geinspireerd door voorgangers op dit gebied als M. C. Escher en Leonardo da Vinci ben ik mij bezig gaan houden met het verbeelden van mijn fascinatie voor wiskundige strukturen. De ontwikkelingen in de techniek maken het mij mogelijk om mijn ideeen nu ook duidelijk visueel te maken en zelfs uit te voeren als fysieke objecten middels de 3D-print technieken. Met het produceren van een 2 meter hoog beeld geprint in “steen” als voorlopig hoogtepunt. De vooropleiding Toegepaste Wiskunde komt hierbij op meerdere manieren van pas. Toegepaste wiskunde dus, maar toegepast in de kunst.

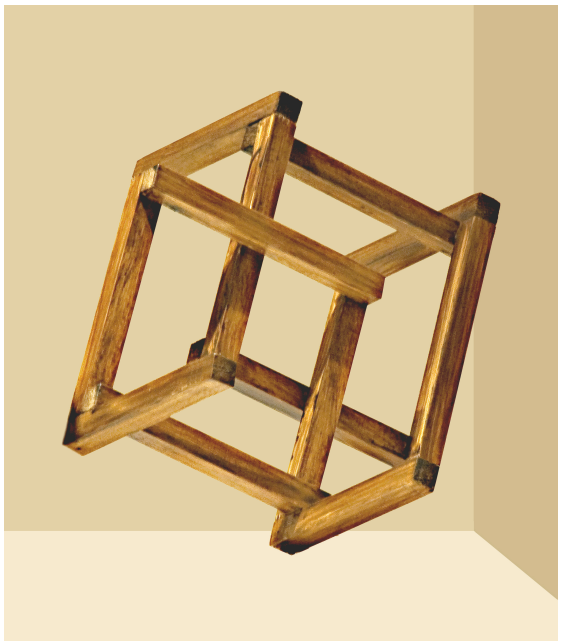


An Impossible 3-D Framework

F. C. M. op den Kamp *Waaier, verdieping 1*

Necker's cube, published in 1832, combined with Escher's interpretation as used in his drawing "Belvédère" of 1958, results in an intricate cube frame by enlarging the ribs. Changing this cube to a similarly looking framework provided an opportunity to fabricate an impossible structure in 3-D. But can it mathematically be realised for production suitable for public viewing without revealing the precise details? The picture below shows a structurally-non-photo-shopped image (minor retouches excluded) of the Impossible 3-D Framework on display at the NMC 2011.

Biografie: F. C. M. op den Kamp Graduated as Architect at the University of Pretoria, South Africa. Now retired, the professional career has concentrated on airports in various parts of the world as an Airport Architect with NACO (Netherlands Airport Consultants), ICAO (International Civil Aviation Organisation) and others. Autodidact and professionally related artistry resulted in a number of exhibitions showing drawings, watercolours and later on, 3-D collages depicting computer terminology and other subjects. Realisation of the Impossible 3-D Framework is a direct result of architectural working-model activity and interest.

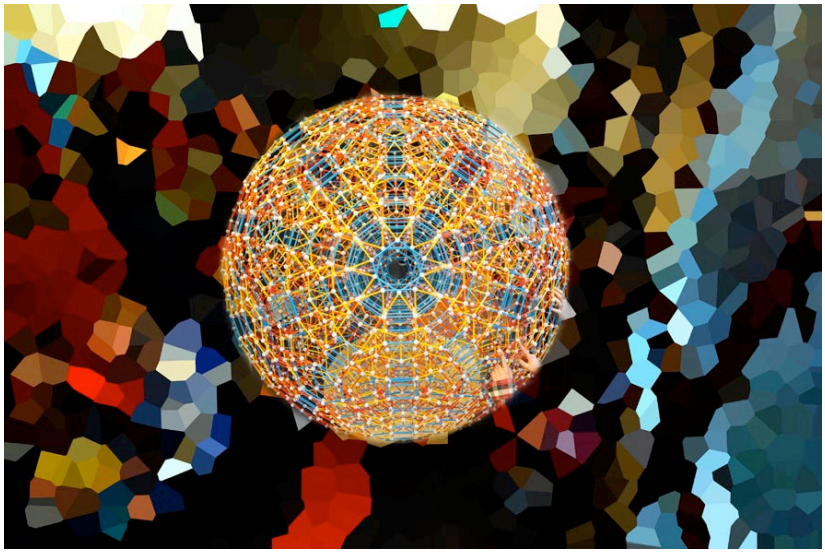


Rombicosidodecahedrische Diprismatohexacosihecatonicosachoron (Ook geheten runcitruncated 600-cel)

Paul van de Veen *entree Waaier*

Dit vierdimensionale object is halfregelmatig, het is een configuratie van rombenicosidodecaëders, afgeknotte tetraëders en zes- en vijfhoekige prisma's. In de figuur hieronder zien we een model in de derde dimensie van dit object, opgebouwd uit 8880 staafjes en 3660 witte kogels. Deze bouwkogels hebben de vorm van een rhombicosidodecahedron, het beeldmerk van NMC2011. In de aankomsthal wordt dit model gedemonstreerd.

Biografie: Paul van de Veen is docent wis- en natuurkunde aan het Stedelijk Lyceum te Enschede. Zijn interesse in toepassingen van en mogelijkheden met wiskunde is breed. Als hobbies vermeldt hij muziek en dammen op zijn website `www.vandeveen.nl`. Paul ontwerpt applets voor wiskundelessen en geeft workshops over Geogebra. Zijn fascinatie voor de vierde dimensie blijkt uit workshops Zometool constructies met leerlingen.



The mysterious equations of love

Il Cocodrillo Cante *Waaier 2, do 19:10-19:25*

Vocal ensemble *Il Cocodrillo Cante* was formed in 1990 by a number of choral music enthusiasts, who loved to sing in a small ensemble. The name of the ensemble, now consisting of well-trained singers, has been derived from the madrigal *Il Cocodrillo Geme* (the crocodile weeps) by Vecchi. In 1991, the leadership by Julia Blank, was handed over to Jeanet Bosch. Since then the repertoire of *Il Cocodrillo Cante* covers different styles: Renaissance (Josquin, Ockeghem), Baroque (Purcell, Schütz, Bach) and 20th-century repertoire (Hindemith, Stravinsky, Messiaen). *Il Cocodrillo Cante* gave several concerts abroad (Switzerland, France and Germany) and is frequently heard in the region. Every year the choir presents one or two new programs, a cappella or with a small instrumental ensemble. A few highlights are Purcell's opera *Dido & Aeneas*, the *Petite Messe Solenelle* by Rossini, *Ein deutsches Requiem* by Brahms, *Messe des Morts* by Jean Gilles and the *Mattheuspassie* by J.S. Bach translated in Dutch by Jan Rot. More details can be found at `www.cocodrillo.nl`.

11 NMC-locaties 1965 t/m 2011

Jaar	Nr.	Plaats/Opm.
1965	1	Enschede
1966	2	Heerlen
1967	3	Nijmegen
1968	4	Eindhoven
1969	5	Wageningen
1970	6	Delft
1971	7	Amsterdam (UvA)
1972	8	Groningen
1973	9	Leiden
1974	10	Enschede
1975	11	Utrecht
1976	12	Amsterdam (VU)
1977	13	Rotterdam
1978	14	Amsterdam (VU)
1979	15	Eindhoven
1980	16	Nijmegen
1981	17	Amsterdam 1e dag op UvA, 2e dag op CWI
1982	18	Wageningen
1983	19	Delft
1984	20	Groningen
1985	21	Leiden
1986	22	Enschede
1987	23	Utrecht
1988	24	Eindhoven
1989	25	Amsterdam (VU)
1990	26	Nijmegen
1991	27	Rotterdam
1992	28	Delft
1993	29	Amsterdam (UvA)
1994	30	Leiden
1995	31	Groningen
1996		Antwerpen AMS Benelux, 22-24 mei 1996 georganiseerd door de American, Belgian, Dutch and Luxemburg mathematical societies
1997	32	Wageningen
1998	33	Enschede
1999	34	Utrecht
2000	36[1]	Maastricht
2001	37	Amsterdam (VU) gezamenlijk georganiseerd door VU en CWI
2002	38	Eindhoven
2003	39	Nijmegen
2004	40	Tilburg
2005	41	Gent in samenwerking met de zusterorganisaties uit België, Frankrijk en Luxemburg
2006	42	Delft gezamenlijk georganiseerd door TUD en UL
2007	43	Leiden gezamenlijk georganiseerd door TUD en UL
2008	44	Amsterdam onderdeel van het 5th European Congress of Mathematics
2009	45	Groningen
2010	46	Utrecht
2011	47	Enschede

[1] Het congres van 1996 is aanvankelijk niet meegeteld als NMC (althans volgens het programmaboekje). In het jaar 2000 is dit gecorrigeerd.

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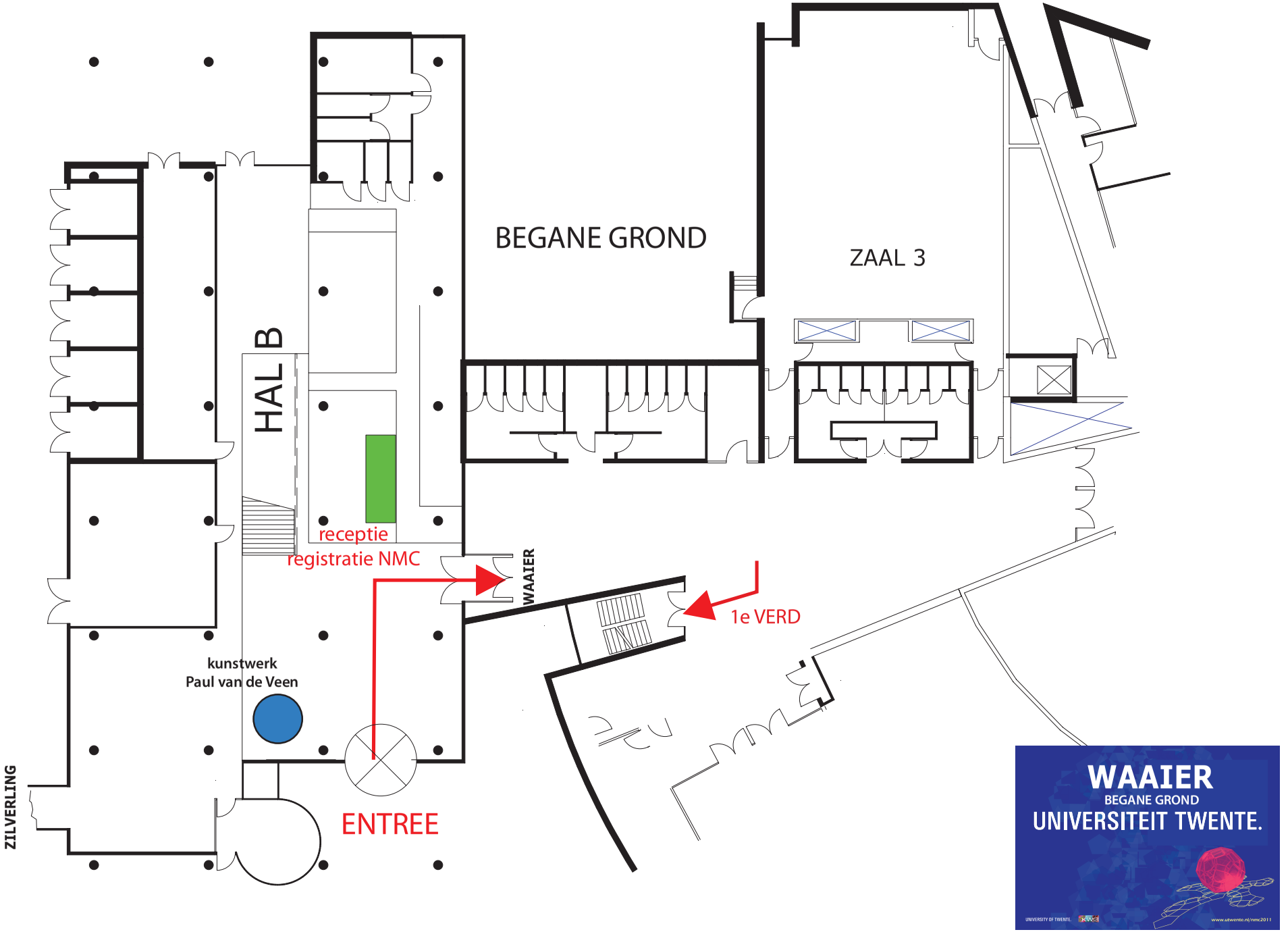
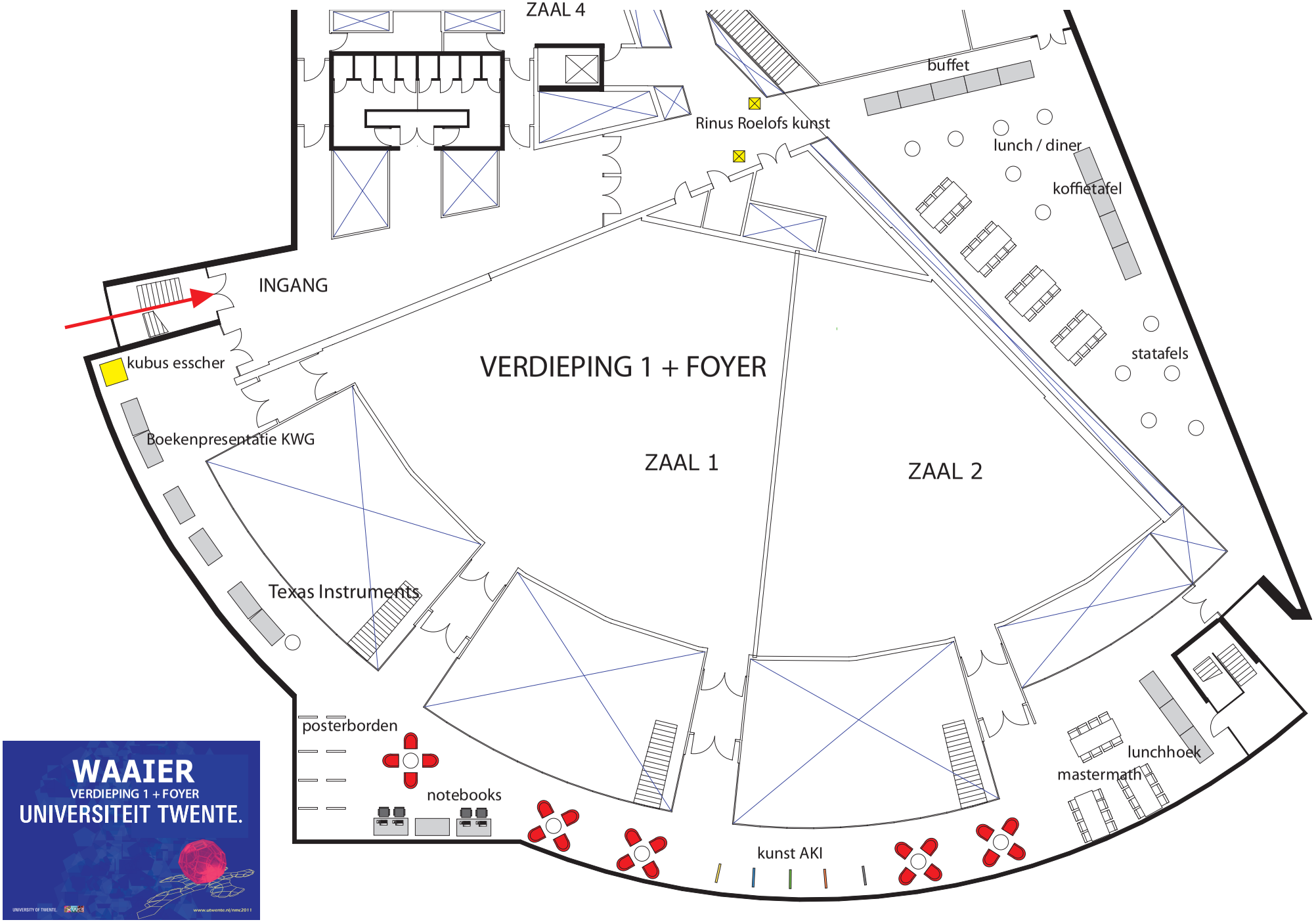

BEGANE GROND
ZAAL 3
HAL B
receptie
registratie NMC
WAAIER
1e VERD
kunstwerk
Paul van de Veen
ENTREE
ZILVERLING
WAAIER
BEGANE GROND
UNIVERSITEIT TWENTE.


ZAAL 4
buffet
Rinus Roelofs kunst
lunch / diner
koffietafel
INGANG
kubus esscher
VERDIEPING 1 + FOYER
statafels
Boekenpresentatie KWG
ZAAL 1
ZAAL 2
Texas Instruments
posterborden
notebooks
lunchhoek
mastermath
kunst AKI
WAAIER
VERDIEPING 1 + FOYER
UNIVERSITEIT TWENTE.