hausdorff center for mathematics

UNIVERSITÄT BONN

HCM NEWS 3/25

Christoph Thiele and Floris van Doorn have been awarded an ERC Synergy Grant of 6.4 million euros

Will it be possible in future to prepare proofs developed in cutting-edge mathematical research with a reasonable amount of human effort so that they can be verified by computers in real time? Christoph Thiele and Floris van Doorn from the Hausdorff Center for Mathematics (HCM), a Cluster of Excellence at the University of Bonn, want to help make this possible. The two researchers submitted a joint application for a coveted Synergy Grant from the European Research Council (ERC). Following the award of the grant, the European Union will now provide total funding of 6.4 million euros to the "Harmonic Analysis with Lean Formalization" (HALF) project over the next six years. Lean is a relatively new programming language that is increasingly establishing itself as the standard for mathematical formalization.

HALF will investigate central and long unresolved problems in harmonic analysis, whereby the main focus will be placed on multilinear and non-linear operators. These fundamental questions also have applications in other mathematical and interdisciplinary fields such as ergodic theory and quantum information processing. The new results from HALF should help mathematicians to verify proofs in the Lean language with the aid of computers.

"As the first project of its kind, HALF will mark a milestone on the path to the routine use of computer verification in mathematical research," says Floris van Doorn from the Mathematical Institute at the University of Bonn. The researchers also aim to produce urgently needed training material for applications anticipated in the field of artificial intelligence (AI), which will support the verification process in future and provide automated tools for making rigorous discoveries in mathematics.

"In principle, it is possible to carefully formulate and code a mathematical proof so that a computer can certify that it is correct," explains van Doorn's colleague at the Mathematical Institute and Project Head Christoph Thiele. However, we are still a long way from the standard application of this formalization process. "It already works really well at the level of school mathematics," says Thiele. "However, there is still too much effort required at a mathematical research level to prepare proofs for computer verification." Over the next six years Christoph Thiele will push forward with his research into harmonic analysis and formalize it in cooperation with the experts in Floris van Doorn's research group.

"Our aim is to be able to already check that submitted research results are correct before a reviewer is asked to give their opinion on the quality of the work," says van Doorn. It is possible that AI will yield mathematical proofs in the future. In order for us to be able to trust these proofs without any additional work, it is essential that the AI system can formalize them itself. Leading companies and many start-ups in the AI sector around the world are already interested in "Mathlib", a standard library of existing fundamental mathematical knowledge at a school and university level, which is being developed by van Doorn and his colleagues and will be expanded by the contributions made by HALF in the area of harmonic analysis.

"We carried out a pilot project last year to prove that our project is feasible," says Thiele. When his research group produced a new result in the field of harmonic analysis, van Doorn realized that it was particularly suitable for a formalization process. A famous classical result developed by L. Carleson in 1966, which had not yet been formalized, was also verified at the same time. The project required close cooperation between Thiele and van Doorn and their work was followed by many mathematicians around the world. It was also possible to complete the project much quicker than originally envisaged thanks to the assistance of a dozen volunteers from the international Lean community. The HALF project will allow this type of work to be completed within the research group itself. The researchers plan to improve and speed up the processes over time.

HAUSDORFF PEOPLE and RESEARCH

Catharina Stroppel appointed as new director at the Max Planck Institute for Mathematics

Catharina Stroppel, professor at the Mathematical Institute of the University of Bonn and member of the Hausdorff Center for Mathematics, has been appointed as a director of the Max Planck Institute for Mathematics (MPIM) in Bonn. She will take up her full-time position at the MPIM in March 2026.

Catharina Stroppel, born in 1971, studied mathematics in Freiburg (Germany) and received her doctorate in 2001 under Wolfgang Soergel. She was postdoc at the University of Leicester before becoming an assistant professor at Aarhus University in 2003/2004. In 2004 she moved to Glasgow University, where she became a lecturer in 2005 and a reader in 2007. In 2007/08, she was a Von Neumann Fellow at the Institute for Advanced Study in Princeton. She has been a professor in Bonn since 2008. In 2007, she received the Whitehead Prize. In 2010, she was an invited speaker at the International Congress of Mathematicians (ICM) in Hyderabad. In 2022, she gave a plenary lecture at the ICM. In 2023, she was awarded the Gottfried Wilhelm Leibniz Prize. In 2025, she received an honorary doctorate from Uppsala University (Sweden). Catharina Stroppel works on representation theory of groups and algebras with several applications in geometry, topology and combinatorics.

Christoph Thiele awarded the Bruwer Medal 2026

In 2026, the Brouwer Medal will be awarded to Christoph Thiele, professor at the Mathematical Institute of the University of Bonn, who holds one of the prestigious Hausdorff Chairs at the Hausdorff Center for Mathematics. The Brouwer Medal is awarded every three years by the Royal Dutch Mathematical Society (Koninklijk Wiskundig Genootschap, KWG) to a leading expert in a specific area of mathematics. The ceremony will take place at the BeNeLux Mathematical Congress (April 7–8, 2026, in Antwerp), where Thiele will also deliver the 2026 Brouwer Lecture.

Quoting the jury report,

"Christoph Thiele is a prominent German mathematician renowned for his profound contributions to the area of Harmonic Analysis. His work has introduced groundbreaking techniques and solved long-standing problems. His influence began with strikingly original papers on Carleson's theorem and the bilinear Hilbert transform. This work laid the foundation for what is now considered advanced time-frequency analysis, a field he has continued to shape through deep collaborations over the years. Equally extraordinary are his contributions to the mentoring and training of graduate students and postdocs. His influential summer school model, established first at UCLA and then in Bonn, has been successfully adopted by others. Recently, Thiele has demonstrated his pioneering spirit by initiating a collaboration on the LEAN formalization of a vast generalization of Carleson's theorem. The successful completion of this work will be a landmark achievement, considered the first major formalization project in the field of analysis."

The Brouwer Medal is a triennial award presented by the Royal Dutch Mathematical Society and the Royal Netherlands Academy of Sciences. It gets its name from Dutch mathematician L. E. J. Brouwer and is the Netherlands' most prestigious award in mathematics.

Christoph Thiele studied mathematics at the University of Darmstadt and the University of Bielefeld, received his doctorate from Yale University and qualified for professorship at the University of Kiel. He held the position of Professor at the University of California in Los Angeles from 1998 to 2012 and since then has been Hausdorff Chair at the University of Bonn. Thiele has received numerous awards including the Salem Prize and Humbolt Research Prize and was also invited to speak at the International Congress of Mathematicians in 2002.

Tasho Kaletha to receive 2026 Chevalley Prize in Lie Theory

Together with Zhiwei Yun (MIT), Tasho Kaletha from the Mathematical Institute of the University of Bonn, will receive the 2026 Chevalley Prize in Lie Theory, based on several recent publications. The Chevalley Prize in Lie Theory is given for notable work in Lie theory published during the preceding six years.

Tasho Kaletha is awarded the prize for two papers: "Regular supercuspidal representations" (2019), Journal of the American Mathematical Society, and, "A twisted Yu construction, Harish-Chandra characters and endoscopy" (2023), joint with Jessica Fintzen and Loren Spice, Duke Mathematical Journal; and for the book Bruhat-Tits Theory, a New Approach, joint with Gopal Prasad. The papers make striking advances towards an explicit local Langlands correspondence for a large class of supercuspidal representations, settling delicate issues around the problem, and developing character formulas compatible with requirements suggested by the trace formula (specifically, the theory of endoscopy). The book modernizes Bruhat-Tits theory, providing clear resolutions of subtleties that had been raised by the extensive use of the theory for constructing supercuspidal representations, making it accessible for current and prospective researchers.

Tasho Kaletha received his undergraduate degree from the University of Bonn in 2005, where he studied with Günter Harder, and his doctorate from the University of Chicago in 2010, advised by Robert Kottwitz. He was a Veblen Research Instructor and later Assistant Professor at Princeton and a Benjamin Peirce Fellow at Harvard before joining the faculty at the University of Michigan. In 2024, he moved to the University of Bonn and became member of the Hausdorff Center for Mathematics.

The Chevalley Prize in Lie Theory is given for notable work in Lie theory published during the preceding six years. The prize was established in 2014 by George Lusztig to honor Claude Chevalley (1909-1984). Chevalley was a founding member of the Bourbaki group who made fundamental contributions to class field theory, algebraic geometry, and group theory. This prize is given biennially to early- or mid-career mathematicians.

Henning Heller receives the Montucla Prize

Henning Heller, postdoctoral researcher at the Mathematical Institute of the University of Bonn and associate member of the Hausdorff Center for Mathematikcs, receives the prestigious Montucla Prize from the International Commission for the History of Mathematics (ICHM) 2025. The ICHM is composed of representatives from around 55 nations in which the history of mathematics is taught and/or actively researched. The Montucla Prize is awarded every four years to the author of the best article by a early career scholar published in Historia Mathematica in the four years preceding the International Congress of History of Science and Technology.

One aspect of new developments in modern mathematics that is sometimes overlooked is the manner in which the ideas become incorporated into the mainstream of university teaching. In his article “Felix Klein's teaching of Galois theory” (Historia Mathematica, vol. 63 (2023), 21-46), Henning Heller recounts the path by which Klein introduced the topic at Göttingen. Henning Heller identifies three interconnected aspects of Klein's 1886 lecture course on algebra: organizational, historical, and didactical. The laudatory speech states: "Heller’s study is impressive not only because of his thorough familiarity with the primary literature, but also because of his sound interpretations and the clear presentation of his ideas".

Henning Heller has been a postdoctoral researcher in the Mathematics Education Group at the University of Bonn (headed by Rainer Kaenders) since 2023. He received his PhD in philosophy from the University of Vienna with a thesis entitled “Integrating history and philosophy of mathematics: The case of modern algebra” under the supervision of Georg Schiemer.

Collaborative Research Grant for Michael Friedman

Michael Friedman (HCM, University of Bonn) and Deborah Kent (University St. Andrews) won a Collaborative Research Grant on “On Proofs and Partnerships: How AI, Big Data, and Proof Assistants are Transforming Mathematical Practices” (2026-2027). The project starts on January 1, 2026.

The confluence of big data sets, technologies of Artificial Intelligence, and proof assistants are revolutionizing modern mathematical practice. While these modern tools are reshaping current mathematical research, many underlying technologies emerged in prior centuries. Through both historical investigation and contemporary interviews, the project will establish how such developments represent both continuity with and rupture from earlier attempts to mechanize mathematical reasoning. The scientists intend to show that various historical examples share with large data sets, proof assistants and AI a common ambition and related result: they automate mathematical operations and drive transformations of mathematical intuition. By examining this trajectory, the researchers aim to contextualize current developments within the longer arc of debates about the relationship between human cognition and computational aids in mathematical discovery. Alongside historical research, the project will engage with mathematical communities currently navigating these technological changes. It will contribute to current debates about the nature of scientific reasoning in the age of AI; the project’s significance further extends to broader questions about human-machine collaboration in knowledge production.

The Collaborative Research Grants program of the University of St Andrews fosters international research broadly. Applicants from all schools and disciplines are encouraged to submit funding applications for innovative and sustainable projects built around collaborative research linking staff at the University of St Andrews and the University of Bonn. The research may take place in any country or regions as long as it is done collaboratively. The expectation is that these initial projects will lead to longer-term collaborations, institutional and research relations, and when applicable, generate publications, exhibitions, or external funding.

Solveig Tränkner receives the Ada Lovelace Prize from the INS

For the 2024/25 academic year, Solveig Tränkner was awarded the Ada Lovelace Prize for Female Mathematicians by the Institute for Numerical Simulation (INS) for her Bachelor's thesis, entitled "Data Visualisation with t-SNE in Theory and Practice", which was supervised by Jochen Garcke.

Solveig Tränkner's bachelor's thesis focused on mathematical and numerical analyses of the t-SNE method. t-SNE is currently one of the most widely used tools for visualizing high-dimensional data, for example in bioinformatics, computer security research, and geology. Solveig Tränkner's outstanding work exemplifies the contribution of numerical mathematics to machine learning and artificial intelligence. Particularly noteworthy is her critical examination of an existing result on clustering guarantees. The prizewinner impressively demonstrates that its assumptions prove questionable when applied to real data. Her investigation of the influence of various process parameters on the calculated visualization and its often limited reproducibility is also relevant for practical application. In her work, Solveig Tränkner demonstrates her methodologically strict approach with a noticeable understanding of the bridge between theory and algorithms.

The Ada Lovelace Prize for female mathematicians was established in 2010 by the Institute for Numerical Simulation at the University of Bonn and has been awarded annually ever since. The award serves to promote young female talent in numerical analysis.

Welcome to our new Bonn Junior Fellows!

Marvin Weidner

Marvin Weidner joined the Institute for Applied Mathematics as a Bonn Junior Fellow in September 2025. He obtained his PhD from Bielefeld University in 2022 before spending three years at the University of Barcelona, where he was a postdoctoral researcher in two ERC projects led by Xavier Ros-Oton. Marvin Weidner's research is concerned with the regularity theory for partial differential equations with a particular emphasis on free boundary problems and nonlocal equations. Recently, he has focused on nonlocal models arising in kinetic theory, such as the Boltzmann equation. In the winter semester, he is teaching an advanced topics lecture on free boundary problems and he is excited to be part of the vibrant and international mathematics community in Bonn. Outside of mathematics, he enjoys traveling to new places, hiking in nature, and going for a run.

Merlin Christ

Merlin Christ joined the Hausdorff Center for Mathematics in October 2025 as a Bonn Junior Fellow. He completed his Ph.D. at the University of Hamburg in 2023 under the supervision of Tobias Dyckerhoff, who was himself a Bonn Junior Fellow. After that, Merlin Christ joined the Institut de mathématiques de Jussieu – Paris Rive Gauche (IMJ-PRG) for a two year postdoc with mentorship by Bernhard Keller. Merlin Christ's research concerns higher category theory and its applications, particularly in representation theory. A central object of his research are so-called perverse schobers, which are a notion of categorified perverse sheaf. He is loking forward to becoming part of the lively mathematical community in Bonn. He hopes that he will learn about new areas in which higher categories can be used. Besides mathematics, Merlin Christ enjoys drinking green tea. During his time in Paris, he co-organized a tea seminar. Other people with an interest in tea are welcome to reach out to him.

Tudor Padurariu

Tudor Padurariu joined the HCM as a Bonn Junior Fellow on October 1, 2025. He obtained his PhD from Massachusetts Institute of Technology in May 2020, and has spent time as a postdoc at the Institute of Advances Studies, Columbia University, and Max Planck Institute for Mathematics in Bonn. Starting January 2024, he was chargé de recherche at CNRS. Tudor Padurariu is interested in problems in algebraic geometry and representation theory motivated by physics. Most of his research is concerned with refinements of counts of BPS states, and their connections with moduli spaces of sheaves on curves, surfaces, and threefolds, and with quantum groups via Hall algebras.

University of Bonn and IBM intensify cooperation for more powerful processors

IBM and the Research Institute for Discrete Mathematics at the University of Bonn have maintained a close and productive collaboration since 1987. This cooperation was originally initiated by the institute's long-time director, Bernhard Korte, who sadly passed away in April of this year. The partners have now expanded and intensified their cooperation.

Under this collaboration, Stephan Held, Stefan Hougardy, and Jens Vygen — along with a team of approximately 30 researchers and students — have developed foundational algorithms known as BonnTools. These algorithms are essential to the design of today's most advanced processor chips. Thanks to the mathematical innovations from Bonn, it is possible to route kilometers of wiring within an area no larger than a thumbnail, minimizing detours and avoiding interference between wires.

Despite decades of success, many challenges remain — especially as technological advances continue to push the boundaries of chip design. To address these evolving demands, IBM and the University of Bonn are deepening their collaboration through an expanded cooperation. This next phase aims to enable even denser chip layouts, resulting in more powerful and energy-efficient processors.

Institute Director Jens Vygen expressed his enthusiasm: "This expansion allows us to continue to add students to our team, giving them early exposure to applied mathematical research. Many of them go on to make significant contributions."

Leon Stok, Vice President, IBM Electronic Design Automation: "I have had the privilege of collaborating with the Bonn team for over 25 years. The Institute for Discrete Mathematics consistently attracts and educates some of the most talented students in the field. Many of these individuals have made significant, often groundbreaking, contributions during their Master's and doctoral research, and have gone on to pursue successful careers at IBM and within the broader Electronic Design Automation industry."

Rector Michael Hoch says: "The cooperation with IBM stands as a model of how pioneering research and effective knowledge transfer can drive technological innovation. Ideas developed in Bonn continue to have a global impact! I am therefore especially pleased that this cooperation is now being renewed and further deepened, reinforcing our shared commitment to excellence in both research and application."

Birgit Schwarz, Director Hardware Development, IBM Germany Research & Development, Böblingen: "Our engineers work closely with Bonn researchers to tackle some of the toughest challenges in chip design. It's incredibly rewarding to see how quickly ideas move from theory to impact. We're proud of what we've achieved together and incredibly excited about the breakthroughs this next phase could unlock for IBM and the industry."

Four decades of transfer into practice

The cooperation between the University of Bonn and IBM, established by Bernhard Korte (1939–2025), has been in place for almost four decades and is a prime example of the successful transfer of know-how from basic research into practical application. Numerous microprocessors have already been developed using the "BonnTools"; there is hardly a high-quality chip in today's electronic devices that does not contain expertise from Bonn. Bonn's expertise is also found in other sectors of the economy, such as the real-time optimization of routes for parcel and delivery services.

HAUSDORFF EVENTS

YAM Network Meeting

At the fourth Young African Mathematicians Network Meeting, we welcomed seven current YAM Fellows to the Hausdorff Center for Mathematics for two days of exchange and networking. The network meetings are designed to bring together a cohort of YAM Fellowship recipients from the four institutions of the YAM Network Germany and to give them the opportunity to learn from experts, to present their own ideas, and to connect with each other to make the best out of their research visits to excellent German mathematical institutions. We were especially happy to also welcome Mama Foupouagnigni, President of AIMS Cameroon and Chief Academic Officer of the AIMS Global Network, our main cooperating partner, as well as the founder of the YAM Program in Bonn, Franca Hoffmann (currently at Caltech, formerly a Bonn Junior Fellow at the HCM), and two successful alumni of the YAM Program: Kevine Meugang Toukam (now PhD student at the Max Planck Institute for Mathematics in the Sciences in Leipzig) and Leolin Nkuete (now a doctoral researcher in mathematics at the University of Luxemburg) to Bonn.

The two days combined mathematical talks by Franca Hoffmann and Mama Foupouagnigni, practical information sessions on career planning and on pursuing a PhD in Germany, and ample time for getting to know each other and for having informal conversations and fun at the Bonn Christmas Market. The program included a variety of input and voices: Mama Foupouagnigni impressively demonstrated the development of the African Institute for Mathematical Sciences in providing advanced graduate education to students from all over Africa to the Bonn math community. Kevine Meugang Toukam and Liza Schonlau, one of our PhD students, presented their new initiative to connect African and European early-career researchers working in analysis and related field during online working sessions. Stefan Hartmann, HCM's outreach coordinator, showed the impact of collaborating with educators from Kenia to bring his Math Club digitally to schools in Africa. And Franca Hoffmann, two of our experienced Bonn math professors, Jan Hasenauer and Martin Rumpf, the organizer of the YAM Network meeting and current coordinator of the YAM program, Magdalena Balcerak Jackson, and the two alumni hosted a lively round-table discussion on how to best approach the YAM research visit to Germany, make decisions about future academic goals, and prepare for what comes next.

The liveliness and openness with which the participants engaged with each other makes us optimistic that the YAM Network Meeting will not only provide the YAM Fellows with valuable insight, but also inspire them to get involved in some of the activities they learned about. And we have also made plans to expand the collaboration between HCM and AIMS to include visits of German lecturers to AIMS.

Young African Mathematicians Program

Our Young African Mathematicians Program is collaboration with the African Institute for Mathematical Sciences (AIMS). AIMS is a pan-African network of five centers in Cameroon, Ghana, Rwanda, Senegal and South Africa providing high-level graduate education in the mathematical sciences to students from all over Africa. The YAM Fellowship Program provides selected excellent and motivated graduates of AIMS with the opportunity to immerse themselves for one academic year in the research community of the HCM. YAM fellows spend one semester taking lectures and seminars, and a second semester working on a research project under the mentorship of an experienced professor. They become part a research group working not merely with their mentors but also with the other early career researchers and they are invited to take part of in all activities of Bonn Mathematics. Since 2023, the YAM Program has been expanded to three other German mathematical institutions, who have joined forces and formed the YAM Network Germany.

Researchers from around the world honor Bernhard Korte

With the passing of Bernhard Korte, the University of Bonn has lost one of its most influential figures. The founding director of the Research Institute for Discrete Mathematics and founder of the Arithmeum died in April 2025 at the age of 86. In his honor, the Research Institute for Discrete Mathematics and the Arithmeum at the University of Bonn hosted two high-profile conferences. At the center of both workshops is a joint academic memorial ceremony, to which a total of around 200 guests attended. Here, numerous former colleagues and friends of Bernhard Korte remembered his life's work. In this context, a bronze bust of Bernhard Korte was be unveiled, which found a permanent place in “his” Arithmeum.

Together with William Cook (Waterloo), Michel Goemans (MIT), and László Lovász (Budapest), Institute Director Jens Vygen hosted a “Bonn Workshop on Combinatorial Optimization” with more than 100 participants. Bernhard Korte shaped combinatorial optimization, the core area of algorithmic discrete mathematics, in many ways over decades; the world's best scientists came and went at “his” Bonn institute for decades. Many were now returning to Bonn, in memory of Bernhard Korte, but also to exchange new scientific ideas. The conference brought together renowned scientists in the field in Bonn, as well as many young talents.

The workshop was framed by overview presentations by Stephan Held on chip design and by László Lovász on Greedoids — two of Bernhard Korte's most important research topics. Numerous other presentations addressed the most important current research questions in combinatorial optimization, some with surprising new results: from the traveling salesman problem and network design to matchings and matroids to polyhedral, geometric, and graph-theoretical questions. In addition, many open problems were discussed that will inspire further research. The feedback was over-whelmingly positive. For example, one participant (who has organized many workshops himself) wrote: “Congratulations on this scientifically spectacular, masterfully organized workshop!”

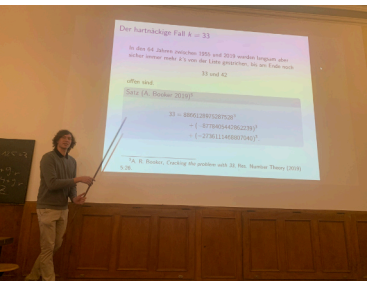
At the same time, the director of the Arithmeum, Ina Prinz, together with the director of the Museo Galileo in Florence, Roberto Ferrari, organized the “Symposium on Scientific Mathematical Instruments,” which was attended by directors and curators of the most important international museums with collections of mathematical instruments and calculating machines.

Lecture: Julia Robinson and the Limits of Mathematical Provability

In November, Gunther Conelissen (Utrecht University) gave a public lecture as part of the Trimester Program “Definability, Decidability, and Computability“, titled “To Boldly Go Where No (Wo)man Has Gone Before: Julia Robinson and the Limits of Mathematical Provability.” He discussed Diophantine equations and Hilbert’s Tenth Problem. To outline the idea behind the proof, he talked about the halting problem and presented Turing’s argument showing that there is no algorithm capable of solving the halting problem for all programs. It can be shown that every computable question — including the halting problem — can be encoded as a Diophantine equation. This leads to a negative answer to Hilbert’s question.

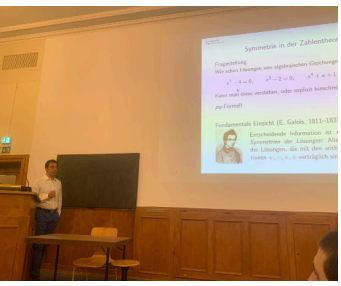
One particularly engaging part of the talk was that Gunther placed other participants of the trimester program in the audience as Julia Robinson and Alan Turing and had them deliver quotations, bringing the entire story to life. After the lecture, the film Julia Robinson and Hilbert’s 10th Problem was shown. The lecture was recorded and the video has recently been uploaded .

Dies Academicus

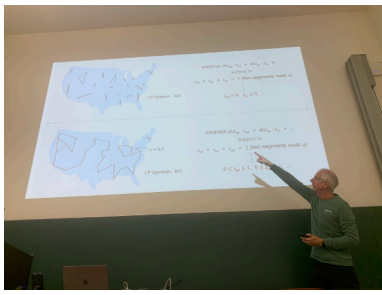


In his inaugural lecture, **Edgar Assing** reported on the representability of 33 as the sum of three cubes. The problem goes back to Louis Joel Mordell. This led to an intensive search using the most powerful computers of that time for the more general problem with k: x^2 + y^3 + z^3 = k, with 0 < k <= 100, in which the search was restricted to the box [-3164, 3164]^3. Based on investigations into the density of the solutions, Heat-Brown proposed in 1992 the conjecture that for k not equal to 4, 5 mod 9, there are infinitely many integer solutions. After while, only the cases 33 and 42 remained to be open. It was not until 2019 that A. Booker found a solution for k=33. Edgar Assing presented the essential ideas of the newly found, more effective algorithm, which works “in almost linear time”.

Koen van Den Dungen gave his inaugural lecture on Jones knot invariants, i.e., the Jones polynomials. Its discovery stemmed from operator algebraic considerations and took knot theorists completely by surprise at the time. The discovery revolutionized knot theory, earning Vaughan Jones the Fields Medal in 1990. Roughly speaking, the Jones polynomial is a Laurent polynomial in root(t) (or, in other words, a polynomial in root(t) and 1/root(t)) with integer coefficients. Iteratively, the Jones polynomial of a given knot or link can be calculated from the skein relation. Koen van Den Dungen demonstrated how to iteratively calculate the Jones polynomial for the Hopf link. For those in the audience with a particular interest in mathematics, he then introduced the braid group and its connection to this topic.



Tasho Kaletha's inaugural lecture focused on “The Symmetry of Numbers.” Symmetry was presented as a central concept in mathematics in various facets: in number theory, in geometry, and as a connecting element. In number theory, a central question is what can be said about the solutions of algebraic equations. The important insight that crucial information is contained in the symmetry of the solutions comes from Galois. Felix Klein studied symmetries in geometry. The bridge between arithmetic and geometric symmetries is given by L-functions and the Langlands Program: There should be a correspondence between Galois representations and automorphic representations. Tasho Kaletha briefly presented his own contributions to the Langlands Program.



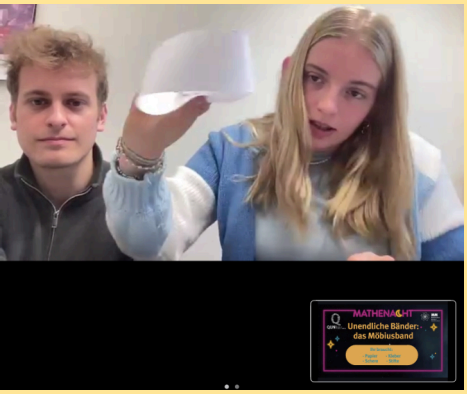
Bill Cook, who is currently a guest researcher at the Research Institute for Discrete Mathematics in Bonn, outlined the historical development of the Traveling Salesman Problem (TSP). A number of optimized exact algorithms are available in the meanwhile. In fact, we now know techniques that can be used to determine the shortest route to 81,998 pubs in Korea with precise optimality and to find approximate solutions for visiting over 100,000,000 stars. The big step forward for effective approximation algorithms for the TSP in polynomial time was Nicos Christofides' approximation from 1976, a combination of a spanning tree, matching, and an Eulerian tour. This algorithm provides a solution that is guaranteed to cost no more than 1.5 times the optimal solution. The current best algorithm for another variant of the TSP approximation where the direction of travel matters comes from Bonn: It is a 17-approximation by Vera Traub and Jens Vygen.

Another inaugural lecture, titled “How I learned to stop worrying and love NP-complete problems!”, was given by **Giles Gardam**. The main topic was the famous P versus NP problem, one of the seven Millennium Problems in mathematics. In defiance of this, there exists software that can in practice solve many problems faster than it should be able to. After an introduction to SAT modeling, Giles Gardam showed in live coding how to write a program that formulates the verification of the Boolean Pythagorean triple problem as SAT. This SAT problem could then be verified for the largest possible number 7824 in a few seconds. The fact that 7825 no longer works takes a little longer, but was also solved with a SAT solver. Finally, he came to his main result: He was able to show that the so-called unit conjecture for group rings is false. He had also reduced this problem to SAT and then proved it with computer assistance.

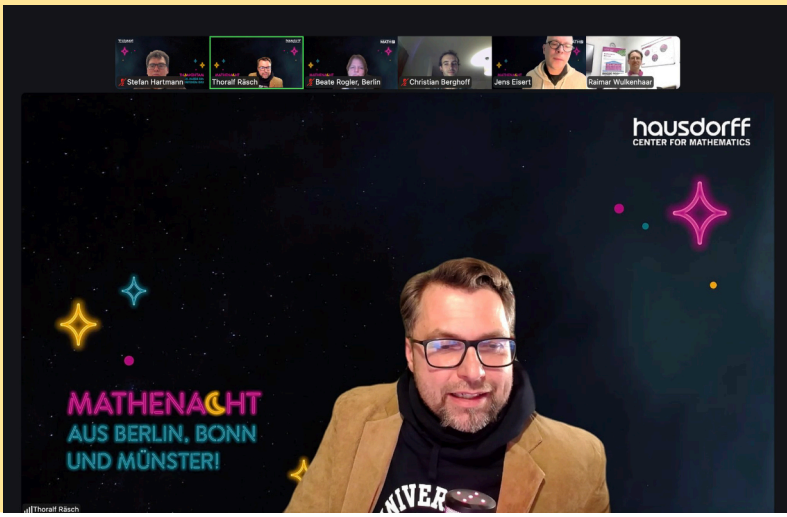
As a Persian intellectual of his time, Omar Khayyam (1048-1131) was a mathematician, astronomer, astrologer, philosopher, and poet. Mathematically, for example, his transition from Eudoxus' concept of magnitude to a modern concept of numbers represents an achievement that Gottlob Frege attributed to Isaac Newton. **Rainer Kaenders** introduced this interesting intellectual, a wise man devoted to sensual life, who inspired and continues to inspire generations in the West with his wisdom and poetry in his Robāʿıyāt (“quatrains”). Chayyām was the first to show the equivalence of the pharetically defined equality of proportions with the famous definition attributed to Eudoxus in Book V of Euclid – still a viable basis for the concept of real numbers today.

You can find more detailed descriptions of the lectures on the HCM LinkedIn channel.

Math Night



We held our fourth joint Online Math Night with the two mathematical clusters of excellence “Münster Mathematics” and “MATH+” (Berlin). In the afternoon, elementary school children and high-school students learned about exciting math questions in online workshops. Under the guidance of students Lukas Degroot and Daniela Klümper, the very youngest children learned about the Möbius strip, among other things, and discovered that there is no “outside“ or “inside“. Building the “world's largest fence” using polyforms was the task set for fifth-grade students in the workshop led by Erika Roldan and Alexis Langlois-Rémillard from Leipzig and Bonn. Mathematically, this is part of so-called extremal topological combinatorial problems. In the third workshop, Stefanie Winkelmann from the Zuse Institute in Berlin presented the well-known Parrondo paradox. Here, the combination of two losing games can result in a winning game. In the subsequent math quiz, all interested parties — children, students, and everyone else — solved mathematical puzzles and knowledge questions from the three clusters of excellence. In the panel discussion “Quantum Technology – Opportunities and Risks,” Christian Berghoff (Bonn), Jens Eisert (Berlin), and Raimar Wulkenhaar (Münster) spoke to an audience of around 100 people about the opportunities and risks of quantum technology, particularly in terms of the vulnerability of cryptographic methods, and the role mathematics plays in this context. The highly entertaining discussion was moderated by Thoralf Räsch from Bonn. In the evening, the program featured classic mathematical lectures: Among other things, Angela Stevens from Münster presented mathematical modeling related to the Notch signaling pathway, which plays an important role during embryogenesis and cell differentiation. Philipp Hieronymi (Bonn) impressively demonstrated that mathematical logic is anything but dull, using the “Chicken McNugget Theorem” and the development of intelligent cruise control as examples for how logical results can also be put to practical use. In the concluding lecture, Hanno Gottschalk (Berlin) chose a completely different, data-driven approach that enables machine learning. He presented the mathematical principles behind the algorithms that make autonomous driving possible — neural networks, measurement of uncertainties, and self-monitoring. A wonderful Math Night came to an end around 11 p.m., with everyone tired but enthusiastic about the many new insights and impressions.



Mathematischer Salon

In the „Mathematischer Salon“ in October, Sebastian Hensel (LMU, Munich) gave us an introduction to the Poincaré conjecture, the only solved of the seven Millennium Problems. First, the difference between geometry and topology was explained to the audience and classification problems were discussed. But what works for two-dimensional surfaces no longer works in three dimensions! And anyway, you first have to find ways of imagining three-dimensional structures without the surrounding four-dimensional space. Sebastian explained this - one dimension less - using the example of the torus. What are feasible classification problems in dimension 3? How did the Poincaré conjecture come about? And what ideas did Perelman have for solving this problem, which was hardly considered technically solvable? It was incredibly exciting and entertaining to learn this from an expert, with excellent illustrations!

A young and very talented ensemble from the Academy of the Gürzenich Orchestra Cologne completed the wonderful evening with the "Prussian Quartet" by Haydn and a less well-known but beautiful string quartet by Borodin.

"Mädchen machen Mathe" (MMM) seminar - Girls Do Math

This year, we at HCM organized the four-day seminar “Mädchen machen Mathe" (MMM; "Girls Do Math”) together with the Max Planck Institute for Mathematics. The 39 most mathematically gifted girls of grades 9 and 10 in Germany who had qualified through their success in math competitions and were selected by Bildung & Begabung took part. The seminar will now take place every year in Bonn and will be organized by the HCM. In addition to mathematical workshops on “Ebert's Hat Problem and the Hamming Code” (Stefan Hartmann, HCM, scientific associate and organizer of MMM), “Quadratic Residues - Legendre and Reciprocity” and “An Introduction to the Proof Assistant Lean” (both by Ruth Plümer, student), “Arithmetic Sequences, van der Waerden's Theorem, and Tic-Tac-Toe” (Lisa Sauermann, professor), “Coloring proofs” (Susanne Armbruster, PhD student), “Finding rational points” (Oana Padurariu, MPIM, postdoc, organizer of MMM), and “An excursion into the world of groups” (Hannah Boß, PhD student), a pub quiz was organized on Saturday evening, where the winning team received the yellow HCM shirts as a first prize . On Sunday, the girls could choose between a hiking trip to the Drachenfels, a visit to the "Haus der Geschichte", and activities at the youth hostel. On Monday, they had the opportunity to ask Fields Medalist Gerd Faltings personal questions at the Max Planck Institute for Mathematics. The aim of MMM is to establish a cross-generational mathematical network for gifted girls and women over the years. We had a lot of fun at the seminar and are looking forward to next year!

Math is Fun in Vienna

An international math camp was held in Vienna, organized by the initiative Projekt MmF (“Mathematik macht Freude”, Math is Fun), founded by Michael Eichmair (University of Vienna). The participants were high-school students from the winning teams of the (parallel organized) math tournaments in Bonn (Germany), Leuven (Belgium), and Nijmegen (The Netherlands). The program included math workshops, cultural activities, and international exchange between the four participating European countries. The students learned about mathematics in three interactive lectures on various facets of modern mathematical research. It was a great prize trip, during which the students had wonderful experiences in an international context. Our warmest thanks go to Vienna!

IMPRINT

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