



HCMNEWS 3/24

Angkana Rüland receives Leibniz Prize

In recognition of her excellent research, **Angkana Rüland** receives the Gottfried Wilhelm Leibniz Prize, which is endowed with 2.5 million euros. She is being recognized for her outstanding work in mathematical analysis, particularly on models for microstructures in phase transitions in solids and inverse problems with non-local operators.

“Completely speechless” - that was Angkana Rüland's reaction when she received the call from the DFG informing her that she had been awarded the Leibniz Prize. “I had only just walked through the door into my office when the phone rang, and it was the DFG,” says the mathematician, who is also a member of the Transdisciplinary Research Area “Modelling” at the University of Bonn. Angkana Rüland would like to use the prize money to further develop her research group. “The research environment here in Bonn is already excellent. The Leibniz Prize will strengthen this immensely.” In her research on microstructures, she is particularly interested in a class of alloys that have shape-memory properties. This means that, for example, a severely bent paper clip made of such a material will return to its original state, as if by magic, when it is heated up. The secret lies in special lattice structures that are combined in different ways, just like individual building blocks, and thus influence the material's

behavior. The mathematician also studies what is known as inverse problems, which are about reconstructing information from indirect measurements - such as is done with X-ray tomography or ultrasound scans, for instance. This indirect information lets infer information on someone's body without having to take any tissue samples. Phenomena like this can also be found in nature, such as in the ultrasound echolocation of bats.

20 Leibniz Prizes at the University of Bonn, 9 for Bonn Mathematics

Angkana Rüland's award is already the ninth Leibniz Prize for mathematicians from the Hausdorff Center for Mathematics; Catharina Stoppel received the prize as recently as in 2023. The University of Bonn now has a total of 20 Leibniz Prize winners among its faculty, making it the university with second most award winners in Germany since the prize was established in 1986. The award is endowed with 2.5 million euros. The Leibniz Prizes will be presented on 19 March 2025 in Berlin.

Congratulations!



HAUSDORFF PEOPLE and RESEARCH

Wolfgang Lück receives the von Staudt Prize

Wolfgang Lück, professor at the Mathematical Institute of the University of Bonn and member of the Hausdorff Center for Mathematics, has been awarded the Karl Georg Christian von Staudt Prize by the Otto and Edith Haupt Foundation at the University of Erlangen-Nuremberg. The award ceremony will take place on June 6, 2025. The foundation honors his outstanding contributions to topology. This deals with abstract structures and properties of spaces that are preserved under deformation, so-called topological invariants. Such invariants are important factors in the classification of topological spaces. In particular, Wolfgang Lück researches invariants of closed manifolds, special geometric objects that look the same locally but can be different globally. In his pioneering research, Wolfgang Lück proved, among other things, the Lück approximation theorem named after him and special cases of the famous Farrell-Jones conjecture. The Karl Georg Christian von Staudt Prize is presented every three to six years by the Otto and Edith Haupt Foundation. The prize is awarded to one or more mathematicians working at a

German university or research institution, unless the stay is temporary. The prize honors “outstanding, pioneering and published research results in the field of theoretical mathematics” and is endowed with 25,000 euros. Of the nine previous prize-winners, six - Stefan Hildebrandt, Don Zagier, Günter Harder, Gerd Faltings, Michael Rapoport and now Wolfgang Lück - have a very close connection to the University of Bonn and have taught and researched in Bonn for several decades.



Alessia Nota receives the Fubini Prize 2024

Alessia Nota, former postdoc at the Institute for Applied Mathematics at the University of Bonn and former member of the Hausdorff Center for Mathematics, was awarded the Fubini Prize 2024, together with Bozhidar Velichkov. The Fubini Prize endowed with 10,000 euros was funded by the Fubini-Jacobs family with the contribution of the Compagnia di San Paolo Foundation, in memory of Guido Fubini (1879-1943). The prize supports young mathematicians under 40 years old who reside in Italy (or temporarily abroad) and who have obtained results in the fields of pure or applied mathematics that are recognised by the international scientific community. Alessia Nota's research is focused on the field of kinetic theory of gases and plasmas. She studies problems which naturally arise from physics and can be analyzed with a rigorous mathematical approach. Alessia Nota is currently Associate Professor at the Gran Sasso Science Institute (GSSI), an

international PhD school and a center of advanced studies in Applied Mathematics, Astroparticle Physics, Computer Science, and Regional Science located in L'Aquila, Italy.



Don Zagier elected to the Accademia Nazionale dei Lincei

Don Zagier, Director emeritus of the Max Planck Institute for Mathematics in Bonn and associate member of the HCM, was elected a new member of the Accademia Nazionale dei Lincei. The Accademia Nazionale dei Lincei was the first private institution to promote the natural sciences in Europe. It was founded in Rome in 1603 and is now Italy's national

academy of sciences. The most famous member was Galileo Galilei, who became a member in April 1611. According to the 1986 statutes, the Academy has 180 full Italian members, 180 foreign members and 180 Italian correspondents.



Ana Caraiani to receive the 2025 AMS Satter Prize

Ana Caraiani, former Bonn Junior Fellow and Hausdorff Chair at the HCM and now professor of pure mathematics at the Imperial College London, has been awarded the 2025 Ruth Lyttle Satter Prize in Mathematics by the American Mathematical Society (AMS). She has been honored for contributions to arithmetic geometry and number theory: in particular, the Langlands program. Ana Caraiani's work is characterized by a combination of novel ideas and a fearlessness in the face of technical obstacles that would daunt almost any other researcher. This has enabled her to prove several fundamental theorems in the Langlands program. In the joint paper with Peter Scholze, director of the Max Planck Institute for Mathematics in Bonn, Caraiani proved very general results about the torsion cohomology classes in non-

compact Shimura varieties, strengthening the early results in their 2017 paper in the compact case. The proof is a tour de force, combining perfectoid spaces, a mastery of the trace formula, and a new theory of perverse sheaves in p-adic geometry.



László Végh is new Hertz Professor

The University of Bonn has once again made a top-notch reinforcement. Professor László Végh has been appointed to a Hertz Chair, which connects up different disciplines in a unique way. László Végh will be based in the Transdisciplinary Research Area "Modelling", where he will help to strengthen the links between different departments in the fields of algorithms and optimization problems in particular. In addition, László Végh is a member of the Research Institute for Discrete Mathematics, a member of the Hausdorff Center for Mathematics and a member of the Department of Economics within the Faculty of Law and Political Science.

Whether it is about finding the optimum solution for resource allocation, medical simulations or training neural networks, digital applications are necessitating increasingly complex calculation methods based on mathematical principles. And it is these kinds of optimization problems that Professor László Végh will be studying at the newly established Hertz Chair for Mathematics, Modelling and Simulation of Complex Systems. "The University of Bonn enjoys an exceptional reputation in mathematics," says Professor Végh, who is looking forward to his new responsibilities. "But there are also some outstanding groups here working in related fields, such as mathematical economics."

Discrete optimization problems are about finding the best option from among a finite but very large number of possibilities. "Although you can't hope to find an optimum solution to your problem, you can identify a solution that's guaranteed not to be far off that optimal state," Végh explains. One of the best-known optimization problems is the traveling salesperson problem, which involves finding the shortest possible route for a traveler to visit multiple cities one after the other without passing the same one twice. "As well as routing problems for

vehicles, this particular problem is also relevant to areas that seem unconnected to it, such as chip design," László Végh says. "And the Research Institute of Discrete Mathematics at the University of Bonn has some major longstanding industry partnerships in place in this field." At the University, he is currently focusing on coming up with new approaches to general mathematical optimization models such as network flows, convex programs and linear complementarity problems. The latter is a general model that also encompasses questions of calculating equilibrium in games and markets. "I've also been looking at questions of optimization posed by problems of fair distribution and the allocation of resources as well as at how machine-learning methods can be applied to the design of mechanisms."



HAUSDORFF EVENTS

The tenth Math Night

The late autumn Math Night, once again organized jointly with Berlin and Münster, began in the afternoon with workshops on coloring problems, modeling and graphs. For the first time in the Math Night's history, we staged a math quiz with knowledge questions, puzzles and estimation questions from the three clusters' research. Among other things, the audience had to guess or to know what kind of math Peter Scholze deals with: crazy math, condensed math, connected math or twisted math? The panel discussion with Steffen Dereich and Anne Driemel, moderated by Thoralf Räscher, dealt with artificial intelligence and the role of mathematics in it. What significance do mathematical concepts and methods have for the basis of machine learning and for the application of AI technologies? Ethical aspects were also discussed. Three exciting lectures by Gabriele Steidl on generative neural networks in image processing, Vera Traub on algorithms for network design problems and Gustav Holzegel on the mathematics of black holes were the highlights of the program. In total, over 300 children and adults attended the Math Night and even at 11 p.m. almost 100 people were still online.

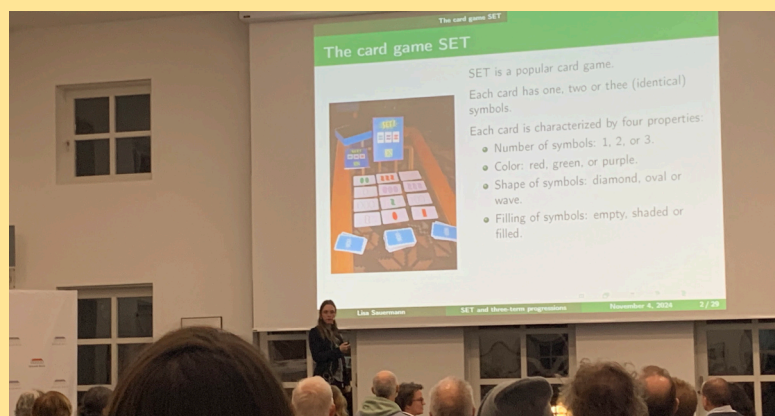
This was the 10th edition of the Math Night, which was initiated in Bonn in March 2020. The next Math Night will take place on March 14, 2025 in Bonn, in hybrid mode. We are already looking forward to it!



Hirzebruch lecture by Lisa Sauermann

Lisa Sauermann gave the traditional Hirzebruch Lecture in November. This Lecture Series was launched in 2007 to celebrate the 80th birthday of Friedrich Hirzebruch, the great post-war mathematician from Bonn and founding director of the Max Planck Institute for Mathematics. The lectures are aimed at a general audience. The lecture was entitled "The card game SET and three-term arithmetic progressions". Lisa Sauermann explained how the question of the maximum number of cards that can be chosen without getting a SET is related to the famous cap set problem. Both problems are completely identical for $n=4$. We know that this number is between $2,2203^n$ and $2,576^n$. Later, similar problems were considered, e.g. that of arithmetic triple progression in integers. Lisa Sauermann presented classical results on upper and lower bounds. This year, together with numerous co-authors, she was able to significantly improve the lower bound. Lisa roughly explained the idea of her proof in the lecture and also showed how the result could possibly be further improved. This was followed by generalizations of the

cap set problem for general primes p (instead of $p=3$) and again the search for bounds is fascinating. Until now, not much was known about lower bounds. Here Lisa Sauermann together with co-authors recently found new results. At the end, she presented some related problems, including the very exciting Erdős-Ginzburg-Ziv problem. Many thanks to Lisa for the great insights!



Mathematical salon with a magic show

We had another magical Mathematical Salon at HIM - and this time we took this very literally. Ehrhard Behrends, professor emeritus for Mathematics (FU Berlin) and certified magician, enchanted us with mathematical magic. The tricks included some elementary mathematical invariants, but also more complex mathematics from number theory and group theory such as quadratic residues, normalizers, and much more. The musical part of the evening was performed by Pauline Trottin (bassoon) and Jaume Cerdà-Martí (clarinet).



Public lecture by Galyna Livshyts

"High-dimensional phenomena" was the title of Galyna Livshyts' public lecture, which took place at HIM in December. Galyna Livshyts, associate professor at the School of Math at the Georgia Institute of Technology, was a guest at our Hausdorff Research Institute for Mathematics (HIM) as part of the trimester program "Boolean Analysis in Computer Science".

Everyone knows the book or the movie "Flatland". But how do the inhabitants of a four-dimensional world see our world and why is a pair of shoes consisting of a left and a right shoe the same as a pair of two left shoes in our world? Möbius recognized as early as 1827 that a four-dimensional rotation is required to bring two enantiomorphic bodies into alignment. This idea was illustrated by H. G. Wells in "The Plattner Story".

How does the volume of the n -dimensional unit ball change as n increases? And how is the volume distributed within the ball? The volume increases up to $n=5$ and then decreases again until it converges to 0 for n towards infinity.

The volume of a high-dimensional unit ball is concentrated near its surface and is also concentrated at its equator. If we consider a cube in dimension 1000,000 with a side length of 2, then the distance from the center of the cube to its faces is 1, but from the center to the corners is 1000. The high-dimensional cubes are therefore "spiky".

These and other high-dimensional phenomena have shaken our intuition.



First Bonn Integration Bee

In November, we hosted the first Bonn Integration Bee. It was organized by math students from Bonn. Well over 150 people took part - as participants or as spectators. The students from MIT came up with the idea for this competition. It started with a Kahoot quiz for the whole auditorium, in which the integrals could still be solved using elementary methods, symmetry arguments, trigonometric Pythagoras and so on.

The best 8 participants then qualified for the knockout round, in which there were 1:1 duels with five difficult integrals on the blackboard that had to be solved in five minutes. Some required more difficult approaches: Series expansions, clever re-arrangements to double integrals with a change in the order of integration and even the residue theorem for meromorphic functions. In the end, the following math students came out on top:

1st place: Samuel Meyer
2nd place: Giorgio Di Bella
3rd place: Nicolò Vallini



Congratulations to the winners and many thanks to all the volunteers from the mathematics student council!



Dies Academicus with Markus Hausmann

At this winter semester's Dies Academicus, Markus Hausmann from the Mathematical Institute gave his inaugural lecture on "Dimensions, Betti numbers and symmetry". Betti numbers assign a natural number β_k to a topological space X for each natural number k , which measures the "complexity" of X in the dimension k . For the two-dimensional torus, for example, the Betti numbers are $\beta_0 = 1$, $\beta_1 = 2$ und $\beta_2 = 1$. However, the result depends on the number range over which the Betti numbers are calculated. The two classic cases here are the field of rational numbers \mathbb{Q} and the field $\mathbb{Z}/2\mathbb{Z}$ with two elements. Markus Hausmann showed what Betti numbers can tell us about the symmetry of a topological space, focused on fixed point-free involutions and presented theorems on this. Closely related to Betti numbers are the cell decompositions of a topological space into k -dimensional cells. Although the cell decomposition is not unique, the Betti numbers are invariant. In the "Brave New Algebra" we now consider an infinite family of number ranges $K(n)$ between \mathbb{Q} and $\mathbb{Z}/2\mathbb{Z}$, whose elements are in a certain sense continuous mappings between spheres. The Betti numbers can also be calculated using this new number range $K(n)$, and we obtain a monotone sequence $\beta^{\mathbb{Q}} \leq \beta^{K(1)} \leq \beta^{K(2)} \leq \dots \leq \beta^{\mathbb{Z}/2\mathbb{Z}}$. Markus Hausmann

discussed how his own research is related to this: he is exploring a "Brave New Algebra" for more general symmetry groups, using moduli spaces of formal groups and complex bordisms. Many thanks to Markus for these great and vivid insights into such an abstract field.

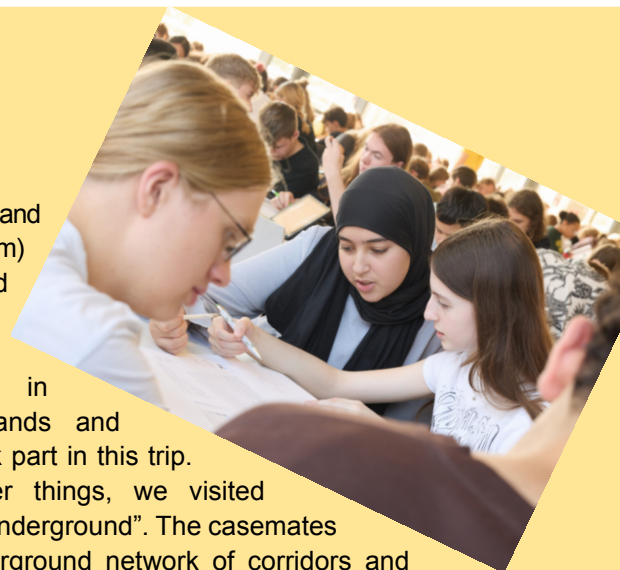
We wish him many successful years in Bonn and many great research results!



Bonn math tournament with the first title defense in history

Schools from all over North Rhine-Westphalia took part in this year's Bonn Math Tournament in teams of five. The topic of the preparatory material and the first part of the tournament was game theory. Parallel to this first part of the competition, the teachers received a training course from Marc Sauerwein. After the lunch break, it was time for the "relay", a series of 20 simple to very difficult math puzzles. The tasks in both parts of the competition had to be solved cooperatively in teams. Before the award ceremony, there was a rock concert by the band "Toxic Youth" from Niederkassel. The tournament was won (as in 2023) by Schiller-Gymnasium from Cologne, which was also ahead in both parts of the competition separately. This was the first time in the history of the Bonn Math Tournament, a school has defended its title. Congratulations to them! Only the HCM Dream Team, consisting of Susanne Ambruster, Lars Becker, Iris Hebbeker and Viktoriya Ozornova, had more points in the relay. It was a special honor for us that the Mayor of Bonn, Katja Dörner, took part in the award ceremony. Katja Dörner has been closely committed to Bonn mathematics – and in particular to the Bonn Math Tournament and the Bonn Math Club – for a long time. Our special thanks go to the many volunteers - students, teachers, pupils and parents - without whom such a tournament would not be possible. A few weeks later, the two best-placed school teams from the Bonn Math Tournament were on the European prize trip to Maastricht. In addition to the German teams, the three

(Netherlands) and one (Belgium) best-placed teams from the parallel tournaments in the Netherlands and Belgium took part in this trip. Among other things, we visited "Maastricht Underground". The casemates are an underground network of corridors and tunnels that run beneath the city of Maastricht.



High-School Student Research Group at the HCM

From school to research: this is possible at the Hausdorff Center for Mathematics. Recently, mathematically talented and interested young people have been meeting here every Monday afternoon under the supervision of Regula Krapf and Henning Heller to conduct research together. The group is dedicated to questions relating to elementary mathematics and mathematics education. The results should lead to scientific publications and give high-school students an authentic insight into how mathematical research works. The current research project is concerned with so-called "arrow chasing", with which identities for recursively defined sequences (such as the binomial coefficients) are to be proven in a new way. Valid mathematical proofs already exist for these identities - some of which have been proven for centuries. But the alternative method of proof is much more visual than the classical methods. Mathematically gifted pupils were invited to apply for this first research project with a letter of motivation.

The research group currently consists of Hannah Julia Gajdecka, Felix Göbel, Calum Kessler, Lorenz Röhler and Lisa-Sophie Theemann - all 14 to 16 years old and attending secondary schools in Bonn and the surrounding area. The group is enthusiastic about the new experience, as Hannah

describes on behalf of the group: "These are meetings with mathematical inspiration. I'm always happy to have the opportunity to exchange ideas with people interested in mathematics and experience joint successes." After the "arrow chasing", further research projects are planned, perhaps from completely different areas of mathematics. There will be further calls for participation in the future.



FEMO Winter Round 2024

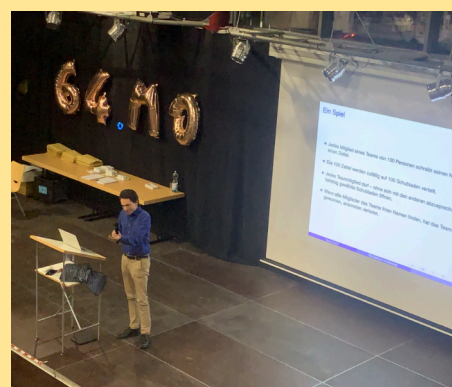


Once again, we took part in the Fizmat Elementary Math Olympiad (FEMO), which is organized centrally in Kazakhstan. 25 children took part on-site in Bonn and a further 8 children took part online.

Numerous students helped out on a voluntary basis. The competition was covered in detail in the local newspaper (Bonner General-Anzeiger) and on television (WDR, Lokalzeit Bonn). The results are not yet known.

Regional Math Olympiad round

At the end of November, the award ceremony for the regional round of the Mathematical Olympiad took place in Bonn. As every year, the HCM participated in various ways. We helped with correcting the exercises and organized – in good old tradition – the keynote lecture of the ceremony. Our HCM spokesperson Valentin Blomer presented the famous 100 prisoners problem. We congratulate all the winners, in particular the children from the Bonn Math Club, and wish them much success in the next round!



Excursion to the Marksburg



The joint excursion for all members of Bonn Mathematics has become a wonderful tradition. This year, it was organized by Antje Kiesel and Alev Erişöz-Reinke. Employees from the institutes and HCM made their way to Marksburg Castle in Braubach. After a steep climb, there was an exciting guided tour through the castle, during which we learned a lot about castle life. In addition, the origins of some German idioms were explained.

Afterwards, the group refreshed in the „Marksburg Schänke“. Many thanks to the institutes for approving and funding this annual excursion, and many thanks to the organizers, too!



Visit by former (PhD) students

In September, a group of Manfred Schäl's former (PhD) students visited the Bonn Math Center. In the '80s and '90s, they had studied probability theory and/or statistics in his classes or completed their PhD under his supervision.

After studying or working as an assistant at the University of Bonn, they all went on to work in the German insurance industry for various insurance and reinsurance companies. Their training or studies at the Institute were an important (the most important) prerequisite for their later very successful careers. One thing they had in common was actuarial work, in which both probability theory and statistics play a major role. Most of this group have now retired. They visited the Math Center and drew comparisons with their own student days, when Bonn Mathematics was still housed in the old building in Wegelerstrasse. The visitors were very impressed by the current variety of courses and opportunities offered to students by the mathematical institutes in Bonn, including the HCM. After a guided tour of the library and a walk around the

Poppelsdorf campus, the afternoon was concluded in a café where the visitors exchanged vivid memories of their student days.



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