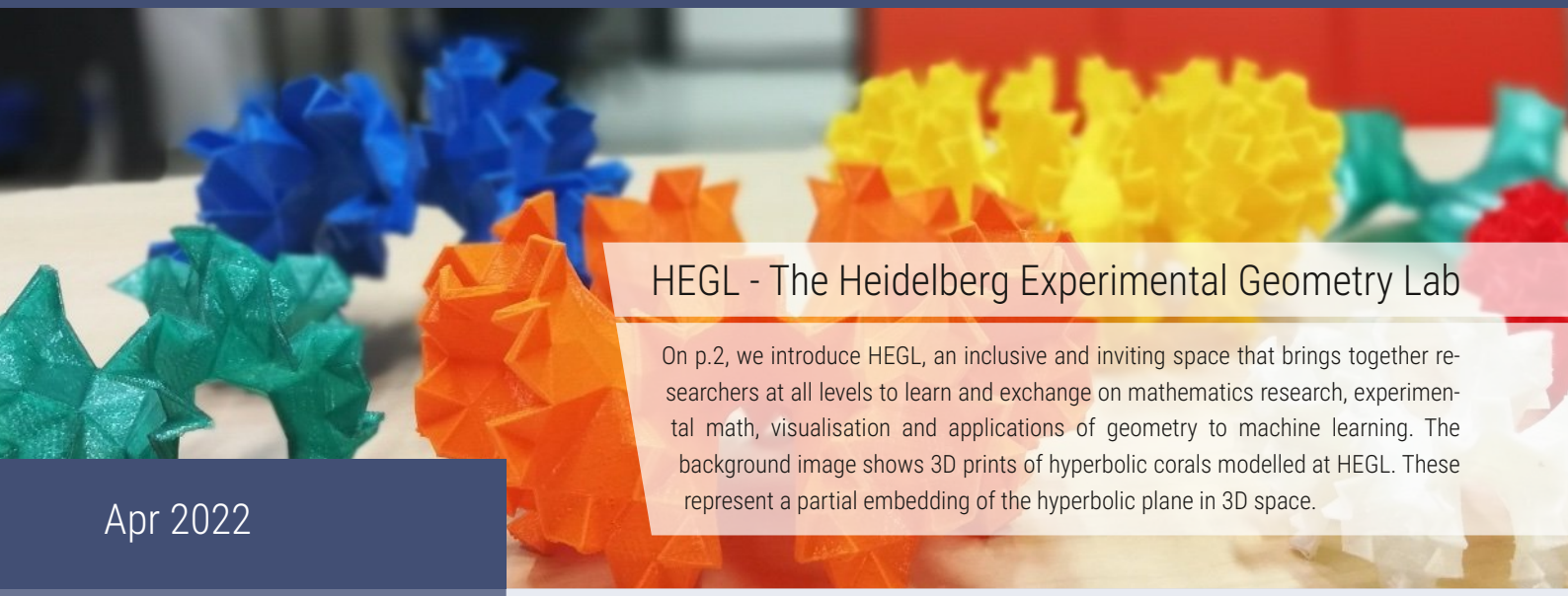
STRUCTURES | NEWS

STRUCTURES CLUSTER OF EXCELLENCE

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386



HEGL - The Heidelberg Experimental Geometry Lab

On p.2, we introduce HEGL, an inclusive and inviting space that brings together researchers at all levels to learn and exchange on mathematics research, experimental math, visualisation and applications of geometry to machine learning. The background image shows 3D prints of hyperbolic corals modelled at HEGL. These represent a partial embedding of the hyperbolic plane in 3D space.

Apr 2022

Contents

Upcoming

Jour Fixe:

- Apr 29: Hendrik Weber (Univ. Bath)

Conferences & Workshops:

- May 9: Joint workshop with FI EMS: "From Structures to Function"
- May 16-20: Conference "Random Geometry in Heidelberg"

Special Events:

- Apr 28: Girls'Day
- Jun 21, 22: EAB Mid-Term Review
- Jul 15: General Assembly + Summer Party + Talk: Millennium's Question: Poincaré conjecture

New Centre for Model-Based Artificial Intelligence

We congratulate Jürgen Hesser (Medical Faculty) and STRUCTURES member Ullrich Köthe (IWR), who received funding from Carl-Zeiss-Foundation for establishing a centre for *Physical Models & Deep Learning for Imaging & Cancer Treatment*. Starting in April 2022, the project will research on how cancer treatment can be supported with Artificial Intelligence, and is equipped with a budget of 5 million euros over six years.

New Quantum Technology Cooperation Projects

The Baden-Württemberg Foundation is funding ten projects on quantum technologies, two of which are coordinated by STRUCTURES members. The project *NeuroQuant: Neuromorphic hardware assisted characterisation of super-conducting qubit quantum simulators* is led by Martin Gärttner (PI/KIP). Philipp Preiß leads the project *NEF2D: Non-equilibrium dynamics of few fermions in 2D potential landscapes*, involving also Selim Jochim (PI).

KIDS: The New Parent-Child Offices of STRUCTURES and ISOQUANT Are Ready For You!

Do you want to bring your child to the office? Or would you like a relaxing nursing room right by your workplace? Then we have the right place for you! "*KIDS*", the new parent-child offices at Philosophenweg and Mathematikon, are open to all members of STRUCTURES and ISOQUANT. Several fully equipped workstations, a group-working space, a quiet room, a kitchenette and numerous play corners for the little ones are waiting for you. For more information, visit https://ekb.thphys.uni-heidelberg.de/ and register now to book your desired workspace any time!

If you have any questions, please feel free to contact us at ekb@uni-heidelberg.de. We are looking forward to welcoming you and your kids in our offices for our official opening on May 18, 4pm, Philosophenweg!

PROJECT REPORT

HEGL: The Heidelberg Experimental Geometry Lab

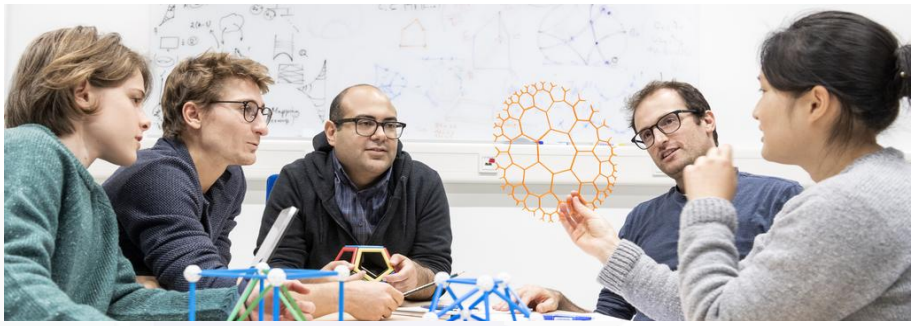
Invited article by Diaaeldin Taha

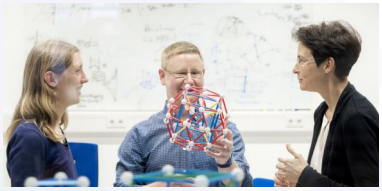
The Heidelberg Experimental Geometry Lab (HEGL) is a community of researchers and math enthusiasts who promote an experimental, experiential, and interdisciplinary approach to mathematics research, mentorship, education, and outreach. HEGL was founded by the director of the Geometry & Dynamics Research Station, Anna Wienhard, in 2021 in collaboration with HITS. The Lab lies at the crossroads of a vibrant math visualisation community in Europe and a growing network of geometry labs in North America. Read on to learn more about the Lab and its activities.

The HEGL Lab

Facilities. The Lab provides infrastructure for experimentation, visualisation, and outreach – including high-performance workstations, 3D printers, a laser engraver, VR equipment, and mathematical toys and games. The Lab facilitates opportunities for learning how to use software and hardware tools through projects, tutorials, office hours and hackathons.

Team. A dedicated team of researchers and students from the Geometry & Dynamics Research Station oversees the Lab and its activities. The team includes Nguyen-Thi Dang, Valentina Disarlo, Mathias Häberle, Fabian Lander, Brice Loustau (left in Feb 2022), Peter Smillie (will join in Jul 2022), Anja Randecker, Maurice Reichert, Diaaeldin Taha and Ricardo Weibel.





Lab Activities

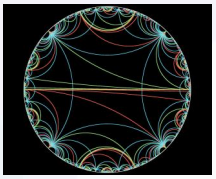
Ultimately, HEGL is a community that fosters collaboration and community engagement, and the Lab employs projects, seminars and outreach events as catalysts for fulfilling its core goals.

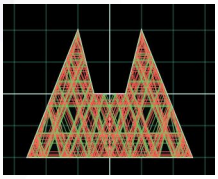
Student Projects. HEGL supports research projects by cultivating mentoring and collaboration opportunities. This includes organising semester-long projects for BA and MA students. For example, two DFG-funded projects focus on billiards in symplectic and hyperbolic geometries, aiming to study the closed trajectories and fine-scale statistics of the billiard systems. The student researchers have created useful general-purpose simulation software packages and developed interesting conjectures currently under theoretical analysis.

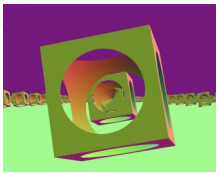
HEGL community members are also organising independent student projects covering diverse topics such as rolling knots, hyperbolic tilings, Margulis spacetimes, joint spectra of Schottky groups, hyperbolic graph embeddings, and fractals arising in complex dynamics. Finally, HEGL seminar participants will work on projects that emphasise illustrating mathematics: raymarching on translation surfaces, exploring reflection groups with mirrors, arcade games in hyperbolic geometry, a Möbius hyperbolic paint programme, and more.

Seminars. The Lab organises three seminars for students and researchers: HEGL (Pro)-Seminar, HEGL Community Seminar, and Geometric Deep Learning Seminar.

Outreach. The Lab oversees several outreach activities that target a broad audience, including national events such as Girls'Day and Millennium Prize Festival, visits, workshops, internships for students, as well as hackathons and workshops.







Top row: Hyperbolic lamination (left) and periodic symplectic periodic billiard trajectories (right) simulated with a software package created at HEGL. Bottom left: 3D model of a pseudosphere rendered at HEGL. Bottom right: Ray-marching can simulate what a being living on the 2D torus sees.

CURIOUS?

Visit our website (**https://hegl.mathi.uni-heidelberg.de**), drop us a mail (**hegl@mathi.uni-heidelberg.de**), pop in during opening hours or attend our seminars/events. We look forward to discussing your project ideas and sharing our research experience. HEGL is an inclusive space, and all are welcome. See you soon!

STRUCTURES COMMUNITY

We Are STRUCTURES

In each newsletter, we introduce members of the Young Researchers Convent (YRC) through small interviews. For this edition, we interviewed Iris Feldt, Niklas Euler and Tobi Haas.

Interview with Iris Feldt:

Iris Feldt
PhD Student, AG Bartelmann, ITP

What are you working on? I am working on applying functional renormalisation group techniques to the microscopic action of Kinetic Field Theory (KFT). My goal is to study the transition of the microscopic theory towards a more common hydrodynamical description of cosmic structure formation.

What are you an expert for? During my master's I enjoyed working on cosmology and especially studying Fuzzy Dark Matter in the framework of KFT. My recent project allows me to get more involved with statistical methods in classical field theories.

What is your connection to STRUCTURES? My PhD project is part of CP1 "Cosmic structure formation". Also, a description of cosmic structure formation via KFT allows me to use and get in touch with a vast variety of concepts more common in other fields of physics than in cosmology.

How does one recognise you? You can see me often in Philosophenweg 12 with a cup of tea and wearing a colorful hoodie.

Interview with Niklas Euler:

Niklas Euler
PhD Student, AG Gärttner, PI/KIP

What are you working on? I investigate periodically driven phases of matter in disordered spin systems far from equilibrium. Strikingly, these so called time crystals show many properties usually associated with equilibrium states and are quite robust against perturbations.

What are you an expert for? During my MSc thesis I spent a lot of time simulating many-body quantum systems. Since my current project also requires simulating many-body systems of Rydberg atoms, I can build upon my previous experience.

What is your connection to STRUCTURES? Discrete time crystals are an emergent non-equilibrium phase of matter with an intriguing spatio-temporal structure. I hope to leverage the broad theoretical and experimental expertise in the STRUCTURES community to gain new insights into this fascinating quantum phenomenon.

What was your greatest scientific success up to now? I came up with a procedure to detect the microscopic non-classical structure of highly-entangled cold atom systems, especially the entanglement dimension. This method requires only measurements in two different bases, making experimental entanglement dimension characterisation feasible, even for multipartite systems.

Interview with Tobi Haas:

Tobi Haas
PhD Student, AG Flörchinger, ITP.
May 22: Postdoc AG Cerf, QuIC ULB, Bruxelles.

What are you working on? I study the phenomena of uncertainty and entanglement for finite systems and quantum fields. Besides, I work on analog gravity models.

What are you an expert for? Hopefully the topics I mentioned before.

What is your connection to STRUCTURES? I was one of the organisers of the last Schöntal workshop on entanglement. I am part of a STRUCTURES project carried out by a team around Stefan Flörchinger and Markus Oberthaler. We are trying to simulate cosmological particle production in an expanding universe with a Bose-Einstein condensate (see also Celia Viermann's interview in the STRUCTURES Newsletter Vol. 2 / 2021, p.3 "We Are STRUCTURES").

What was your greatest scientific success up to now? I derived the first entropic uncertainty relation for a quantum field and I found a new principle of inference, both based on relative entropy.

How does one recognise you? By looking for the guy who combines sweatpants with a jacket.

STRUCTURES ACTIVITIES

Save the Date: STRUCTURES YRC Conference Oct. 4–7 2022

We invite all members of STRUCTURES, including the YRC, the faculty as well as external members and collaborators to save the date for the first STRUCTURES YRC Conference! Expect keynote talks by the STRUCTURES PIs, as well as scientific talks and a poster session by members of the YRC and STRUCTURES researchers. Time and space for collaborative work and networking included.
Abstract submission and registration will be opened in the beginning of May.

SCHÖNTAL WORKSHOP

Stay Tuned - Application for the 6th Schöntal Workshop opens on May 1st!

Topic & date: *Effective Theories, Renormalisation and Scales*. Aug 16-19, Schöntal Abbey. With Jan Pawlowski and Stefan Flörchinger.

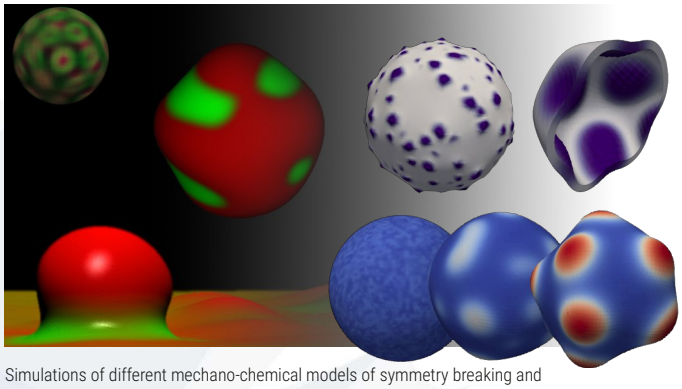
You will receive the link to the application form and further information via e-mail.

MEMBER INTERVIEWS

STRUCTURES Asks: Anna Marciniak-Czochra

We regularly present interviews with STRUCTURES faculty members to give you the opportunity to get to know them better. For this edition, we interviewed Anna Marciniak-Czochra, professor of applied mathematics at the Institute of Applied Mathematics (IAM), the Interdisciplinary Centre of Scientific Computing (IWR) and BIOQUANT Centre. She leads the research group "Applied Analysis & Modelling in Biosciences".

Anna Marciniak-Czochra, professor of applied mathematics.



Simulations of different mechano-chemical models of symmetry breaking and evagination patterns (simulations performed by Dr. Moritz Mercker, AG Marciniak-Czochra)

What are you working on? I am working on modelling and analysis of self-organisation and structure formation in biological systems. I am keen to develop models that enable mechanistic understanding of the processes underlying experimental or clinical observations. Working in a collaboration with experimentalists and clinicians, I focus on specific problems such as control of stem cell-based development and regeneration, cancer evolution or mechanisms of developmental pattern formation. Developing new models often leads to interesting mathematical problems. My analytical research includes asymptotic and stability analysis of partial differential equations and rigorous approaches to model upscaling and reduction.

What is your main fascination doing research? I am fascinated by the universality and power of mathematical description.

What research question is the most important one for you? A long-term question since my PhD concerns the mechanism of pattern formation in Wnt signalling in Hydra which is a model organism of developmental biology. Another question that currently drives my research is how to link models of cell population dynamics with the single cell data to explore the systemic control of stem cell-based processes.

Is interdisciplinarity central to your research? Yes. And it is not only close cooperation with experimentalists, but above all an inspiration for new models and problems that require new mathematical ideas. Also, cooperation between various fields of mathematics and computer science is of importance in my research.

Any advice for young researchers choosing their career path? I would advise them to work on what they feel passionate about, be keen to share, and not be discouraged by the negative comments of article reviewers.

What is your connection to STRUCTURES? For me, STRUCTURES is a source of inspiration and an opportunity to learn from very different approaches and develop new interdisciplinary concepts. I am part of CP3, concerned with partial differential equations for mechanochemical structure formation. New aspects of my research arise from interactions at the interface of data analysis and mathematical modelling. In a joint EP with Robert Scheichl, we have developed a novel Bayesian approach to model identification of a broad class of pattern formation models. EP Math and Data inspired a new collaboration bringing the topological data analysis in the stem cell research.

How would you define success? Success is when you solve an important problem or significantly influence its understanding. In an interdisciplinary research, success comes when experiments suggested by your models change the paradigm.

Imagine you get 48 hours extra as a gift. How would you use the time? I would use it to streamline the organisation of the ECMTB 2022, which will take place in Heidelberg in September.

STRUCTURES ON THE WEB
https://structures.uni-heidelberg.de

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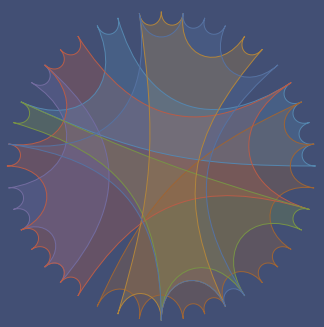

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