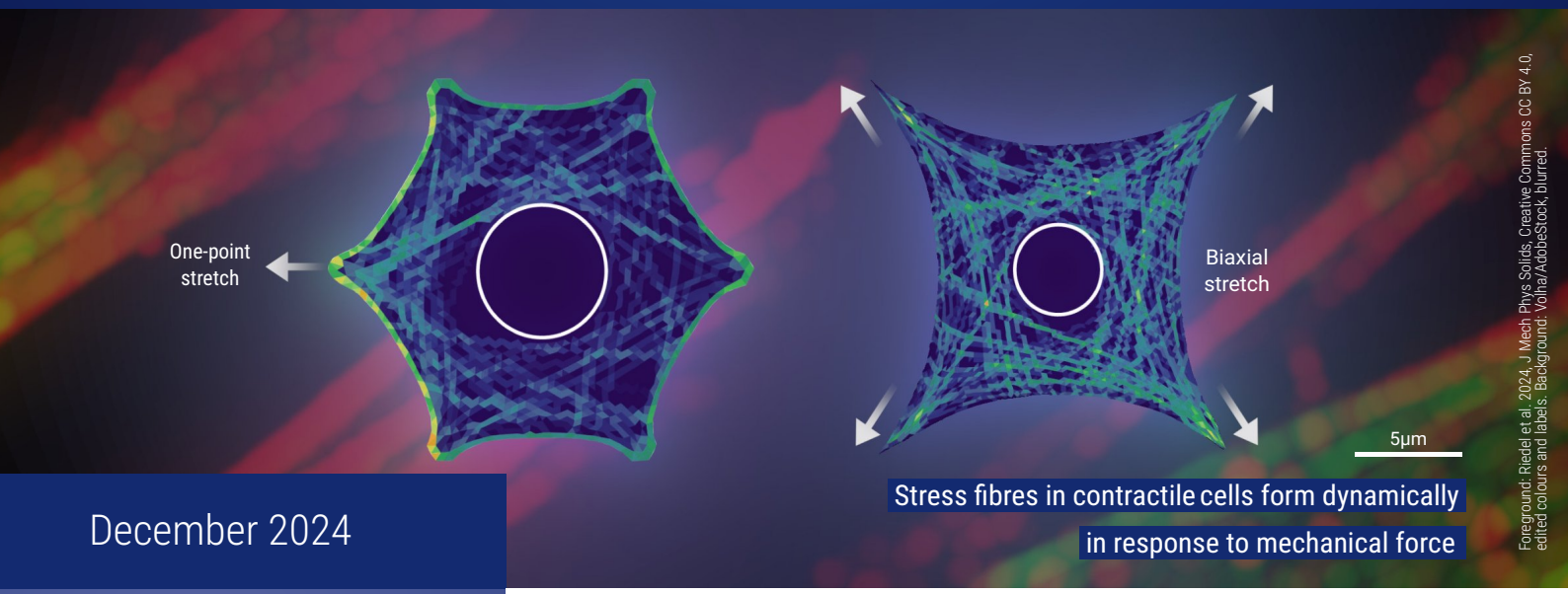
STRUCTURES | NEWS

STRUCTURES CLUSTER OF EXCELLENCE

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386



Stress fibres in contractile cells form dynamically in response to mechanical force

Foreground: Riedel et al. 2024, J Mech Phys Solids, Creative Commons CC BY 4.0, edited colours and labels. Background: Volha/AdobeStock, blurred.

December 2024

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Happy Holidays!

We wish all our readers and colleagues a joyous holiday season and a prosperous new year!

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RESEARCH

New Simulations Reveal That the Positioning of Stress Fibres in Cells Follows a Minimization Principle

Stress fibres are essential for protecting adherent cells from mechanical damage. They form dynamically in response to extracellular cues. However, the molecular mechanisms underlying their formation are complex, and their spatial distribution not well understood.

In collaborative research between the groups of Prof. Peter Bastian (Applied Mathematics) and Prof. Ulrich Schwarz (Biophysics), a special variant of the *finite element method (FEM)* was combined with *genetic algorithms* to efficiently simulate how contractile beams are formed in an elastic medium. Implemented in the advanced FEM-software environment *DUNE*, the simulated outcomes closely match experimentally observed stress fibre patterns and suggest that the positioning of stress fibres in contractile cells minimizes internal mechanical stress.

This result became possible through the close interdisciplinary collaboration of scientists within STRUCTURES. The study provides new insights into stress fibre positioning, with potential applications ranging from biomedicine to materials science.

Original Publication

L. Riedel, V. Wössner, D. Kempf, F. Ziebert, P. Bastian, U.S. Schwarz, Journal of the Mechanics and Physics of Solids, 195, 105950. doi:10.1016/j.jmps.2024.105950.

STRUCTURES COMMUNITY

Lauriane Chomaz Promoted to Full Professor

We are delighted to announce that STRUCTURES member Lauriane Chomaz has been promoted from tenure-track to full professor for experimental physics. Lauriane Chomaz is heading the *"Quantum Fluids"* group at the *Physics Institute* and has been appointed to one of the eight newly established STRUCTURES Professorships.

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STRUCTURES Professor Lauriane Chomaz

We congratulate Lauriane Chomaz on this well-deserved promotion, which highlights her excellent work and leadership.

To introduce Lauriane Chomaz and her work, we present a brief profile featuring six questions she answered already in a previous issue and has kindly revisited now:

What are you working on? *I work on ultracold quantum gases, and, in my new experiment, more particularly on gases made of atoms with strongly magnetic properties. The atoms therefore interact as magnets. What I am interested in are the quantum states that this gas of magnets can form at ultra-low temperature, when playing with their interactions and confinement.*

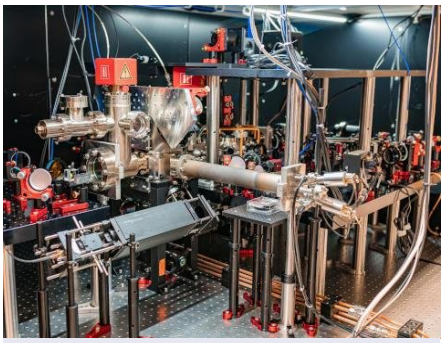
What fascinates you about this area? *I like that we are studying things that are so simple and basic, in a sense — I mean it is just a bunch of atoms — and yet the system is so rich that we can realize many different conditions and in particular implement textbook models from which we can try to help understand effects in more complex systems.*

What research question would you like to answer most? *For now, what I would like to understand better is how complex orders and structures can form from relatively simple constituents, like identical atoms.*

Why did you choose to study physics? *I was born into it, actually. I tried a few somewhat different things, but eventually came back. I like how physics tries to describe things in a universal and apparently simple way, and how it connects simple things from our daily life to deeper effects that underlie our universe.*

Any advice for young researchers on their career path? *If I take inspiration from my case for this advice, it would be: do what you like, have good mentors, and most importantly, stay open to what you think you will not or cannot do.*

What is your connection to STRUCTURES? *STRUCTURES constitutes the full background for the development of my current research. I developed the concept of my apparatus in strong connection with STRUCTURES' project, in particular with the "Heidelberg Quantum Architecture". The questions we ask connect us to the broad STRUCTURES community.*



Ultracold quantum gas experiments: Lauriane Chomaz and her group at STRUCTURES study the complex behaviour of ultra-cold quantum gases confined to two dimensions. Their research examines superfluidity, transitions between different states of matter, and the unique processes that govern these changes. *Image credit: Maurice Rieger*

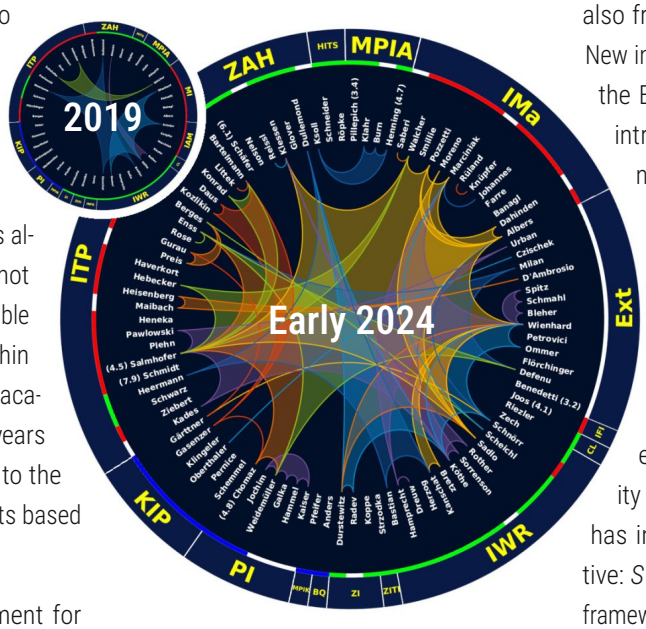
RESEARCH

The Exploratory Projects of STRUCTURES – A Five Year Success Story

In our newsletter, we regularly highlight the latest research advances and breakthroughs within the STRUCTURES cluster. Several of these were possible only thanks to STRUCTURES' *Exploratory Projects (EPs)* and their flexible format.

Complementary to the seven *Comprehensive Projects (CPs)* that define the cluster's main research lines, EPs allow for proposals of ideas that are not (yet) represented in CPs, create possible new research directions or links within the cluster or even to other parts of academia. EPs have a duration of two years and may be proposed twice a year to the steering board, which selects projects based on a peer review process.

As such, EPs are a crucial instrument for innovation, development and novelty in the cluster. Between 2019 and now, more than 60 EPs have been granted, resulting in new collaborations within the cluster and thus further linking our community together. These new collaborations are visualized as coloured polygons in the graphic at the centre of this article, with each polygon representing an EP connecting the people named in the circle. The abbreviations in the outer circle denote their institutes.



The success of the EP programme is evident not only from its substantial research output and breakthroughs across cluster areas, but also from its lasting impact on the cluster. New insights (and follow-up questions) from the EPs have significantly supported the intrinsic development of CPs and driven new ideas proposed for a second funding period of STRUCTURES, such as the newly proposed CP *"Molecules: Conformational and electronic structure"*. Beyond pioneering research, one of the EPs, *Mathematics & Data*, has created a dedicated platform for exchange and joint community activity on the method of data analysis. This has inspired the proposal of a new initiative: *STRUCTURES Crowds*, an institutional framework for methodological interest groups organizing joint activities, events and teaching programmes. Meanwhile, several new EP proposals have been submitted for 2025, allowing for the success story to continue.

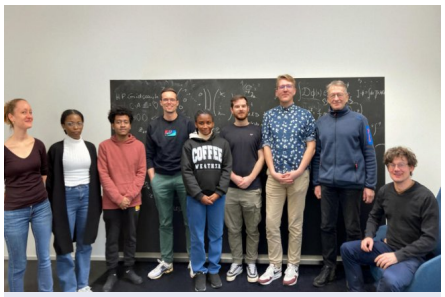
OPPORTUNITIES & FELLOWS

STRUCTURES Welcomes New YAM Fellows

STRUCTURES welcomes its three new fellows through the *Young African Mathematicians (YAM)* programme: Mina Chavelle Tchoua Tchoua, Mickaya Aimé Razanaparany, and Eunisse Nzetchuen Mangaptche, all from the *African Institute for Mathematical Sciences (AIMS)*.

Over the course of their two-semester research stay, the fellows will engage in a rich and dynamic academic programme including courses, seminars and research projects. Their work will be supervised by professors Jakob Zech, Christoph Schnörr, Jan Pawlowski and Johannes Walcher. In addition, support is provided by early-career researchers Josephine Westermann, Maximilian Siebel, Fabio Schlindwein. The research stay is co-organized by Hans Knüpfer, May-Britt Becker and the STRUCTURES office.

YAM is a collaborative initiative between the five AIMS centres and four German Clusters of Excellence (Bonn, Münster, Berlin and Heidelberg). The programme aims to empower talented AIMS students and foster international exchange with the Global South, offering research fellowships in Germany, enabling the students to enhance their skills and expand their academic network.



The YAM fellows 2024/25 together with some of their supervisors, mentors and the YAM organizers.

We warmly welcome the new YAM fellows to STRUCTURES, wish them a good start, a rewarding and inspiring experience filled with many new insights, growth, and new opportunities!

AWARDS & HONOURS

Astrid Eichhorn Receives ERC Consolidator Grant

STRUCTURES Professor Astrid Eichhorn

We are delighted to announce that STRUCTURES Professor Astrid Eichhorn has secured one of the prestigious *Consolidator Grants* by the *European Research Council (ERC)* to support her pioneering research into the quantum nature of gravity. Her project, *Probing the Quantum Nature of Gravity at All Scales (ProbeQG)* aims to explore how to test fundamental theories on the quantum structure of space-time through experiments and observations. The central challenge: quantum properties of space-time manifest on tiny length scales – about 17 orders of magnitude below the scales that can be directly examined experimentally. The main idea of ProbeQG is to identify "lever arms" – systems that translate the effects of quantum gravity into effects that are experimentally accessible. Over a period of five years, her project will receive two million euros in funding.

Astrid Eichhorn is a STRUCTURES Professor at the *Institute of Theoretical Physics* since 2024, where she heads the *Quantum Gravity* group. Prof. Eichhorn's contributions to quantum gravity have earned her recognition as a leading voice in the field.

AWARDS & HONOURS

Ruprecht-Karls Prizes for YRC Members Friederike Ihssen and Lynton Ardizzone

We warmly congratulate Friederike Ihssen and Lynton Ardizzone on receiving the *Ruprecht-Karls Prize*. This annual award by the Heidelberg University Foundation, endowed with €3,000, recognizes outstanding scholarly works from all fields. It is primarily awarded for exceptional doctoral dissertations.

Dr. Friederike Ihssen wrote her doctoral thesis on the subject of *Resolving the QCD phase structure* under supervision of Prof. Jan Pawlowski at the *Institute for Theoretical Physics*. In her work, she develops advanced methods to quantitatively describe the phase structure of quantum chromodynamics, offering insights into fundamental questions on the strong interaction and the nature of matter under extreme conditions.

Dr. Lynton Ardizzone wrote his doctoral thesis on *Conditional Invertible Generative Models for Supervised Problems* under supervision of Prof. Ullrich Köthe at the *Interdisciplinary Center for Scientific Computing*. His work introduces new methods to extend invertible neural networks, enabling them to solve supervised tasks and real-world problems from different branches of science, while offering improved trustworthiness.

Award ceremony 2024. From left to right: Dr. N. Benz, Dr. I. Sarropoulos, Dr. F. Ihssen, Dr. P. Mai, Dr. N. Ullmann, Dr. L. Ardizzone. *© Photo: Christoph Bastert*

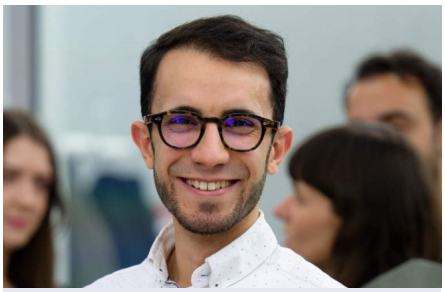
AWARDS & HONOURS

YRC Member Malek Alhajkhouder Receives Rhodes Scholarship

We warmly congratulate Malek Alhajkhouder, a member of the STRUCTURES *Young Researchers Convent (YRC)*, on receiving the prestigious *Rhodes Scholarship*, a fully funded postgraduate award that enables talented young people worldwide to study at the *University of Oxford*. The scholarship aims to develop public-spirited leaders and foster international understanding.

Originally from Damascus, Syria, Malek is a physicist and former *Heinrich Böll Foundation* scholar. After completing his undergraduate studies at *Leibniz University Hannover* and *La Sapienza University* in Rome, he pursued a master's in physics at *Heidelberg University*, writing his thesis under supervision of Prof. Jan Pawlowski at the *Institute for Theoretical Physics*.

Growing up in the Middle East and North Africa has profoundly shaped Malek's perspective. At Oxford, he plans to seek answers to questions of particle physics and hopes to inspire more students – especially from the Levant – to pursue fundamental research. Reflecting on the scholarship application process, Malek shared, *"the rigorous application process, while selective, was a valuable learning experience. It helped me to reflect on my achievements and connected me with passionate peers. I encourage other students to seize all opportunities."*



Malek Alhajkhouder *(Image credit: Heinrich Böll Foundation)*

EVENTS

Recap: Schöntal Workshop 2024

Under the theme *"The (Classical) Geometry of Physics"*, 17 early-career researchers and two invited experts gathered once again this year for the annual *Schöntal Discussion Workshop* of the *STRUCTURES Young Researchers Convent (YRC)* at the idyllic location of Schöntal Abbey.

This year, the workshop centred on the geometric nature of Einstein's General Relativity, with discussions on topics such as the geometrization of gravity, symmetries, gravitational waves, black holes, and singularities. The two invited experts, Valdo Tatitscheff (Postdoc, *Institute for Mathematics*) and Matthias Bartelmann (Professor, *Institute for Theoretical Physics*), contributed their valuable expertise to the discussions.

The Schöntal Discussion Workshop is organized and funded by the YRC, and open to all of its members. It is centred on participant-led discussions, giving early-career researchers a chance to discuss and connect with experts. The topics focus on the intersection of mathematics and physics. Past topics have included, *e.g.*, renormalization, effective theories, entropy and chaos.

Participants and impressions from this year's Schöntal Discussion Workshop.

We thank this year's organizers, in particularly Carlos Pastor Marcos, as well as the invited experts and all participants for four insightful days with many vibrant discussions! We look forward to 2025's Schöntal Discussion Workshop. Stay tuned for the next registration call!

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