STRUCTURES | NEWS

STRUCTURES CLUSTER OF EXCELLENCE

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

Oct 2021

Contents

Upcoming

Jour Fixe Winter Term 2021/22:

- **Nov 05:** Antonio Girao + Felix Joos, Heidelberg University
- **Nov 12:** TBA
- **Nov 19:** Mihai Petrovici, University Bern

Our Jour Fixe restarts in presence as a hybrid event!

More information on the STRUCTURES web page.

Time, Space and Ideas – The STRUCTURES College

Space, time, and the best possible conditions to meet, focus and work on joint research projects – this is what the STRUCTURES College offers its members. It also bundles research-oriented teaching and outreach activities of the cluster as well as the STRUCTURES Training and Education Program for Success (STEPS).

The College is an essential unit for many activities within STRUCTURES. It will become a permanent facility at Heidelberg University, being hosted in a novel building that is currently planned for the campus Philosophenweg. Thereby, the College will become an integral part of the scientific landscape of the university, as a place for interdisciplinary research uniting physics, mathematics, and computer science. For the duration of STRUCTURES, every member of the cluster is also a member of the College. This includes the faculty members as well as the members of the Young Researchers Convent (YRC). The STRUCTURES office manages the various activities and supports projects of our members. But which opportunities and activities are actually provided by the College now and in the future?

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Congratulations! Awards and Honors

STRUCTURES is proud to congratulate:

- **Matthias Bartelmann (ITP)** for being appointed as one of eleven members of the University Council, which oversees the management by the Rectorate.

- **Gulio Beletti (MI)** for being awarded an Alexander von Humboldt Research Fellowship.

- **Dieter Heermann (ITP)** for being elected as member of the International Advisory Board of the Shanghai Jiao Tong University.

- **Fabian Schneider (HITS)** for winning the Ludwig-Biermann-Award of the Astron. Society for his work on the evolution of massive stars, binary stars and supernovae.

– Continued from page 1: Time, Space and Ideas - The STRUCTURES college –

Spacetime

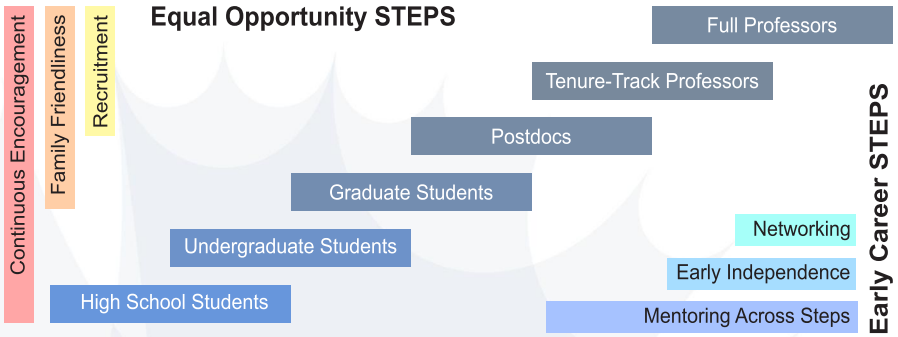
Space is currently provided for our researchers, the YRC, guests and fellows in the 3rd floor of the Mathematikon, Berliner Str. 47 (see article *"New Space for STRUCTURES"*, last newsletter). When the building for the EINC (European Institute for Neuromorphic Computing) is finished, it will provide new space for the College in the third floor. This space, which we call Oberstübchen (German colloquial for brain, literally "upper room"), provides offices and meeting facilities for visiting scientists and fellows, and hosts workshops, regular seminars, and thematic programs of the College, as well as the STRUCTURES office. Furthermore, lab space will be available in the building as well as ample space and facilities for lectures and exhibitions to inform the public about the ongoing research.

More time for research is made available by the College Fellowship program. Our recent fellows had been Matthias Bartelmann and Jan Pawlowski, both Institute for Theoretical Physics (see first newsletter). Every year, faculty members of STRUCTURES can apply for a fellowship. Fellows will be freed of most routine duties at the university for a year, to devote most of their time to research on their STRUCTURES topics, and to interact with other members of the cluster, in particular with the young scientists. In addition, office space and an individual budget is made available to support the fellows in their research, and/or to employ a teaching replacement.

If the College Fellowship program sounds attractive to you, stay tuned for the next call!

Guest Program

Interdisciplinary collaboration and scientific exchange are substantial for a vital scientific community. For this reason, the STRUCTURES College has funds for a substantial visitor program that allows scientists to visit for collaboration and discussion for periods ranging from days up to a year. With the pandemic, travelling has been basically impossible for over 1½ years now and international collaboration was possible only virtually. While during this time many of us got used to the positive aspects of online meetings and may integrate them in our regular collaborative research life, we are now very much looking forward to welcoming guests in Heidelberg again.



The STRUCTURES Training and Education Program for Success (STEPS)

For information on the guest program and funding opportunities, please contact the STRUCTURES project management office!

Research-oriented Teaching

We are happy that several STRUCTURES workshops could take place over the course of the last 1½ years, some in-person, some online or in a hybrid format. Workshops are not only essential for ongoing research but also for graduate and research-oriented education, which is another cornerstone of the College. This is realized by lectures, courses and interaction offers from the fellows of the College, courses in close collaboration with the Scientific Software Center and the graduate schools HGSFP and HGS MathComp, and by stimulating the early independence of the young researchers via their own budget to invite lecturers and speakers. Furthermore, the latter is one of the goals of STEPS, which started its mentoring program last semester.

The STEPS mentoring program continues this semester. If you want to participate as a mentee and/or mentor, please let the STRUCTURES office know!

Interdisciplinary Exchange

The weekly STRUCTURES Jour Fixe is an integral activity to foster the interaction among the disciplines at all levels and across all different career stages. Fortunately, the online version of the Jour Fixe was well frequented, where we welcomed not only faculty and YRC members as speakers, but also guests from Heidelberg and abroad. The pretalks introduced last semester were a great success, promoting the interdisciplinary discourse and integrating the young researchers into the scientific community. To combine the positive aspects of both online and in-person meetings, the Jour Fixe will take place in a hybrid format this semester.

The College will continue to be the place where scientific discourse across disciplines and research groups takes place in research and teaching, and where connections to other parts of the university are drawn. As an academical unit that operates across faculties, it embodies the spirit of STRUCTURES and will pass it on to new generations of researchers.

STRUCTURES COMMUNITY

We Are STRUCTURES

In each newsletter, we introduce three members of our Young Researchers Convent (YRC) through short interviews:

Klaus Paschek
PhD Student, ERC Origins Group, Planet & Star Formation Dept., MPIA

What are you working on? I am fascinated by understanding the origin of life on our planet and beyond. I try to understand how the key building blocks of the RNA world were synthesized in outer space and on the young Hadean Earth.

What are you an expert on? I model abiotic chemical reactions inside parent body planetesimals of meteorites. Further, I plan to understand autocatalysis as a key chemical pathway to complex molecules with mathematical models. I am an expert in connecting different research disciplines and surviving meanwhile in information overload.

What was your greatest scientific success up to now? Combining insights from all kinds of scientific disciplines such as astrophysics, chemistry, scientific computing, geology, and biology to model how prebiotic nucleobases and ribose were formed, and matching perfectly measurements in meteorites.

What is your connection to STRUCTURES? I joined STRUCTURES to get in contact with people to gain more theoretical understanding for my autocatalysis project, and to enjoy the interdisciplinarity here.

How does one recognize you? You always see me walking through the woods, staring at my GPS device, to find the next Geocache.

Christophe Pixius
PhD Student, Cosmological Structure Formation Group, ITP

What are you working on? In our group we are using a classical field theoretic approach (Kinetic Field Theory) to analytically calculate the evolution of cosmic large scale structure. I am particularly interested in different approaches to treat gravitational interactions in Kinetic Field Theory and how they influence the dark matter power spectrum.

What are you an expert on? Expert is a strong word and as of yet I would not consider myself an expert in any domain. I would say that I feel most confident in the field of cosmology and more specifically in the analytical description of nonlinear structure formation.

What was your greatest scientific success so far? Since I started studying, I developed a particular interest in communicating and sharing scientific knowledge with fellow students and with non-scientists. I therefore consider my biggest scientific success so far my contribution to a workshop that our group organized for this year's Girl's Day.

What is your connection to STRUCTURES? I joined STRUCTURES right after I started my PhD and became the deputy speaker of the YRC in the beginning of 2020. Since the beginning of this year I am the speaker of the YRC and consequently also a member of the steering board.

How does one recognize you? Since one of my great passions is bouldering and rock climbing, I am often running around in climbing pants.

Mareike Pfeil
Postdoc, Differential Geometry Group, Research Station Geometry & Dynamics, Math. Inst.

What are you working on? I am interested in hyperbolic geometry, which is the geometry of surfaces that have at least two holes. More specifically, I am working on special representations of fundamental groups of such surfaces.

What are you an expert for? I am an expert for cataclysm deformations of Anosov representations, which I constructed in my thesis. Outside of math, I strive at increasing my ornithology skills and become an expert in birding.

What is your connection to STRUCTURES? I have been a member of the YRC since the start of STRUCTURES and had the honor to give a talk about mathematical billiards at the opening ceremony in July 2019. Further, I am grateful to the YRC, since it gave me the opportunity to organize an international workshop for young researchers on “Positivity in Lie groups”, which, unfortunately, had to be postponed due to the pandemic.

What was your greatest scientific success up to now? I defended my thesis mid-September, which I consider as quite a success! Also, during my PhD, I got the possibility to participate in a program at the Mathematical Sciences Research Institute in Berkeley, which is a highly respected mathematical center for collaborative research.

How does one recognize you? When you see someone leaving the math department after work a) with a black-and-red roadbike or b) with a pink bag with swimming gear or c) in running shoes, there is a high chance that this is me.

Are you interested in shaping the future of the cluster and building a strong YRC community by contributing your own ideas? There are still free slots for the YRC brainstorming meeting from December 6-7 in the idyllic town of Trifels. Write us a mail to structuresyrc@thphys.uni-heidelberg.de with a short motivation text.

STRUCTURES COMMUNITY

New STRUCTURES Members

On July 23, the General Assembly elected four new members who are now part of our STRUCTURES community.

Dylan Nelson is Emmy Noether Research Group Leader of the Computational Galaxy Formation & Evolution Group at the Institute for Theoretical Astrophysics (ITA) within the Center for Astronomy (ZAH).

Tilman Plehn is Professor at the Institute for Theoretical Physics (ITP). With his group, he works on particle phenomenology and machine learning.

Björn Malte Schäfer is Professor at ARI (Astronomisches Rechen-Institut), ZAH, leading the Statistics & Cosmology Group.

Mihai Petrovici got elected as the second external member of STRUCTURES. He is group leader at the Department of Physiology, Bern University (Switzerland), of the research Group Neuro-inspired theory, modeling and applications.

STRUCTURES RESEARCH

New Exploratory Projects

We are happy to present the newest Exploratory Projects (EPs) from the call Summer 2021:

EP 5.1: Persistent homology for big data
Freya Bretz, Guido Kanschat, Anna Wienhard

EP 5.2: Structure formation in driven Bose-Fermi mixtures
Lauriane Chomaz, Matthias Weidemüller, Tilman Enss, Manfred Salmhofer

EP 5.3: Emergent non-equilibrium phases in driven Rydberg systems
Martin Gärttner, Razvan Gurau

EP 5.4: Learning a universal kinetic energy density functional
Fred Hamprecht, Andreas Dreuw

EP 5.5: Critical behavior of epidemic models on distinct network topologies & applications to the study of brain disease
Ana P. Millán, Nicolò Defenu, Tilman Enss

The following EPs got admitted funding to extend the project period:

EP 2.2: Bayesian parameter estimation for mathematical models of self-organization & biological pattern formation
Anna Marciniak-Czochra, Robert Scheichl

EP 3.2: Zero-Sum Evolutionary Games & Con vex Hamiltonian systems
Gabriele Benedetti, Davide Legacci

LECTURES & COURSES

Improve Your Software Development Skills

It is at the heart of STRUCTURES and element of the College's program to support you in taking new approaches to sustainable software development. Sustainable software development makes your research more reliable, transparent and enjoyable. The Scientific Software Center (SSC, https://ssc.iwr.uni-heidelberg.de/) offers several courses to help you to improve your software maintenance and development skills like proper documentation.

The ongoing Mentoring Program "Reproducible Science" started in May 2021.

Here we present an overview of the courses:

Course Program WS 2021/22

Oct 29: Start of the Seminar Series "Lunch Time Python"

Nov 10: Data Exploration with Python & Jupyter
Dr. Liam Keegan, SSC

Nov 23: The Unix Shell
Dr. Dominic Kempf, SSC

Nov 24: Version Control with Git
Dr. Dominic Kempf, SSC

Dec 04: Containers in Science: Using Docker and Singularity
Dr. Dominic Kempf, SSC

Jan 18: Advanced Topics in Version Control with Git
Dr. Dominic Kempf, SSC

Jan 20: Automated Testing with GitHub Actions
Dr. Dominic Kempf, SSC

Feb 23: Performance Benchmarking C++ Applications
Dr. Liam Keegan, SSC

Mar (TBA): Scientific Software Development
Dr. Inga Ulusoy, SSC, Mar. 2022

More information can be found online.

The SSC started as a new institution at Heidelberg University and is supported by the Excellence Strategy. Our STRUCTURES members Guido Kanschatt, Ralf Klessen and Björn Ommer are members of the SSC's Scientific Board.

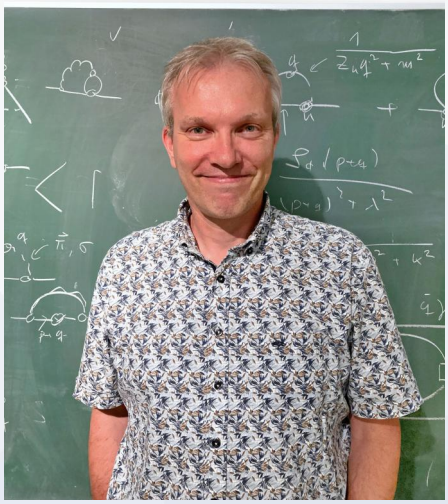
MEMBER INTERVIEWS

STRUCTURES asks: Jan Pawlowski

To give you the opportunity to better get to know the faculty members of STRUCTURES, we regularly present interviews with them. For this edition, we interviewed Prof. Dr. Jan Pawlowski, fellow at the STRUCTURES College. He leads the "Strongly Correlated Systems Group" at the Institute for Theoretical Physics. He is involved in CP5 "Quantum Systems and Neural Networks" and in EP 4.2 "Machine Learning and the Renormalization Group".

What are you working on and what is fascinating for you about this topic? Currently, in my group we are working on various aspects (phase structure, dynamics, conceptual aspects) of strongly correlated quantum systems, ranging from ultracold atoms at small temperatures and energies over QCD under extreme conditions to quantum gravity at and beyond the Planck scale. The resolution of the physics phenomena in of these systems requires a combination of analytic and numerical methods, which is part of the fun in my opinion. While being very different in nature, these systems share quite some surprising communalities/ structures, which I find very intriguing, and fits very well to our cluster.

What are you keen on doing as STRUCTURES Fellow? As a STRUCTURES fellow one has more time for specific topics that one finds fascinating and urgent. In my case this is for example the topic of the EP on 'machine learning (ML) and the renormalisation group (RG)'. There we look for similar structures in the neural design of neural network (propagation of information), and the evolution of a system within RG steps. A bit contradictory to the latter statement, the time as a



Jan Pawlowski is Professor at the Institute for Theoretical Physics (ITP), where he leads the "Strongly Correlated Systems group".

STRUCTURES fellow also allows you to freely look into completely different fresh directions; and I very much benefited from and enjoyed the weekly discussion with Matthias Bartelmann (also STRUCTURES fellow) and Manfred Salmhofer, which hopefully will go on as a very welcome legacy of this time.

Why did you choose to study physics? At the time of my choice I was very much intrigued by the combination of mathematics and the possibility of 'predicting' or rather describing physics phenomena on the basis of simple fundamental laws of nature cast into a solid mathematical form. So, little did I know, but luckily it turned out to be a great choice.

Do you have any advice for young researchers about choosing their career path? Let me start with a disclaimer: I always find it difficult to hand out advice for others. After all, what has worked for me may not work for others (and all other combinations). So, I rather like to give my opinion freely, for everyone to ignore.

In my opinion, it is predominantly important to be genuinely interested in the (research) subjects one is working on. This makes you think about it a lot, and my experience is, that it is the persistent occupation with the subject at hand, that triggers real progress. However, one also may want to avoid getting stuck in a specific topic, and keeping an open mind and positive attitude towards all directions is of paramount importance. Some of the research topics I am involved with in STRUCTURES still are or have been new to me, and they are so much fun.

What do you like best about your job? Apart from the typical bureaucracy and grant application marathon, I like it all. Evidently I like physics and thinking about it, as well as doing it in collaboration with others. I am very well aware of the luxury of doing what I like for a living and on top of this having the free choice of what to pursue in the future.

Teaching students in lecture courses and in my research group as well as in collaborations, and seeing them developing and flourishing is great. I have had the great pleasure of teaching and collaborating with very gifted students, some of them now also pursue careers in physics and computer science (without my advice but with freely shared opinions).

How do you stimulate your motivation for doing science? I do not need any stimulation there. A topic being fascinating is enough motivation.

Coffee or tea? White- or Blackboard? mac, Linux or Windows? Coffee, Blackboard, Linux (but I have a MAC, one of the many contradictions in life).

LECTURES & COURSES

Ruperto Carola Lecture Series "STRUCTURES"

We are delighted to announce that this semester term the Ruperto Carola Lecture Series (Ruperto Carola Ringvorlesung) is organized by Matthias Bartelmann, STRUCTURES member and fellow of the college, and Manfred Salmhofer, speaker of STRUCTURES.

Each semester, the Ruperto Carola Lecture Series brings a selected research topic, that is relevant for society, to a broad public audience. It aims at transferring research results into all societal levels and to open new perspectives to the scientific community. This semester, the lecture series targets the core topics of the STRUCTURES cluster of excellence. Matthias Bartelmann describes the objectives as follows: "The cluster is grounded on the insight that structures in the most diverse physical systems, in mathematics and in large data sets, can be analyzed with very similar methods. This overarching methodological relationship raises the question of which kind of structures occur in completely different areas and which concepts can be used to describe them. This lecture series is intended to (i) investigate this question, to (ii) present structures in mathematics and physics, in humans themselves, in human communities, but also in literature and music and to (iii) contrast these structures with one another."

The Ruperto Carola Lecture Series starts on Monday, November 8 with an opening talk on STRUCTURES by Manfred Salmhofer. In addition to lectures by Markus Oberthaler and Matthias Bartelmann from STRUCTURES, we are looking forward to presentations by six renowned speakers from philosophy, brain research, psychology, literature, law, and music.
Lectures take place every Monday at 7:30 pm, Aula Neue Universität. The talks will be given in German language.

Course program:

Nov 08: Strukturen in der Welt: Vielfalt und Einheit
Prof. Dr. Manfred Salmhofer
Institut für Theoretische Physik
Universität Heidelberg

Nov 15: Strukturen zwischen Mathematik und Philosophie: Neue Allgemeinbegriffe um 1900
Prof. Dr. Paul Ziche
Dept. of Philosophy & Religious Studies
Universität Utrecht

Nov 22: Strukturen des Gehirns und Sprache
Prof. Dr. Katrin Amunts
Institut für Neurowissenschaften und Medizin, Forschungszentrum Jülich

Nov 29: Strukturen im Kosmos: Einheit in der Vielfalt
Prof. Dr. Matthias Bartelmann
Institut für Theoretische Physik
Universität Heidelberg

Dec 06: Struktur im Rauschen: Was der Urknall mit dem kältesten Gas in Heidelberg gemein hat
Prof. Dr. Markus Oberthaler
Kirchhoff-Institut für Physik
Universität Heidelberg

Dec 13: Strukturen der (kranken) Seele
Prof. Dr. Hans-Christoph Friederich
Klinik für Allg. Innere Medizin und Psychosomatik, Uniklinikum Heidelberg

Dec 20: Vom Geheimnis der Wiederholung: Struktur in Literatur und Poesie
Prof. Dr. Ulrike Draesner
Deutsches Literaturinstitut
Universität Leipzig

Jan 17: Strukturen in der nationalen und der europäischen Verfassung
Prof. Dr. Peter Michael Huber
Bundesverfassungsgericht
Karlsruhe

Jan 24: Strukturen in der Musik Johann Sebastian Bachs
Prof. Dr. Dr. h.c. Andreas Kruse
Institut für Gerontologie
Universität Heidelberg

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

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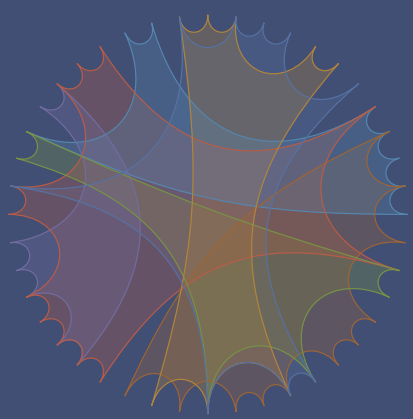
Each person depicted in the images has provided consent to the use of their pictures.



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