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New Emmy Noether junior research group at the University of Passau on structure and randomness in mathematics

An Emmy Noether junior research group funded by the German Research Foundation (DFG) and led by mathematician Professor Stefan Glock from the University of Passau investigates the mathematical foundations of the structures that form the basis of the digital world: Network structures that go to infinity.

The interplay of structure and randomness in mathematics could be the key to solving numerous problems that are still unanswered. One example is the problem of prime number twins, which already puzzled the ancient Greeks. These are prime numbers that have a distance of two. There are an infinite number of prime numbers per se. But does this pattern also apply to prime twins? This question remains open to this day. "Statistically speaking, prime numbers behave very randomly, although they are actually completely deterministic. If they were truly random, it would be relatively easy to prove that there are an infinite number of prime twins. Unfortunately, however, it has not yet been possible to fully capture this phenomenon mathematically," explains Professor Stefan Glock from the University of Passau.

The mathematician is one of twelve researchers from all disciplines across Germany who have been newly accepted by the German Research Foundation (DFG) into the renowned Emmy Noether Programme. With this programme, the DFG supports outstanding young researchers over a period of six years and provides funding to set up a junior research group, among other things. The Passau project is entitled "Structure and Randomness in Extremal Combinatorics" and will begin in October 2024. "I congratulate Mr Glock on this outstanding success. His work promises to shed light on fundamental mathematical problems and thus take basic research a step further," said a delighted Professor Ulrich Bartosch, President of the University of Passau.

Interactions with probability theory and theoretical computer science

In the DFG-funded Emmy Noether project, Professor Glock's team is working on unsolved problems in graph theory. Graphs are abstract mathematical models that can be used to model all conceivable networks, including road networks, chemical compounds and digital networks. Due to the increasing complexity of real networks, basic research is also focusing on very large, almost "infinite" graphs.

"In extremal combinatorics, for example, we are interested in how the structure of such large graphs looks like when certain substructures within the graph are forbidden," explains Professor Glock. Such as the question: How many connections can there be between the nodes in a large graph if 8 connections together are not allowed to form a cycle? "Surprisingly, the optimal structure of such a graph is still unknown. 8 is the smallest number for which this problem has not yet been solved".

There are also networks whose connections are subject to uncertainties. In his research, mathematician Glock analyses the abstract mathematical model for this, the so-called random graphs, using methods from probability theory.

Similar to prime numbers, there are also graphs that are deterministically defined but at the same time exhibit properties of random graphs. This includes the so-called expander graphs, whose properties are to be investigated in the project and which also play an important role in theoretical computer science.

About the researcher

Professor Glock has been Junior Professor of Discrete Mathematics at the Faculty of Computer Science and Mathematics at the University of Passau since September 2022. The junior professorship has been newly established as part of the Bavarian Hightech Agenda. Prior to this, he spent three years researching at the Institute for Theoretical Studies at ETH Zurich after completing his doctorate at the University of Birmingham with the thesis “Decompositions of graphs and hypergraphs”.

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