Subject: SLMath Spotlight: Geometric Representation Theory with Lucien Hennecart + Tau Day 2024 Winners
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Date: 21/08/2024, 15:42
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SIMONS LAUFER MATHEMATICAL SCIENCES INSTITUTE

Dear Lucien,

The Simons Laufer Mathematical Sciences Institute (SLMath) continues our Spotlight interview series below, featuring Lucien Hennecart. Dr. Hennecart spoke to us about his work at the interface between algebraic geometry and representation theory.

We are also pleased to announce the winners of the 2024 Tau Day puzzle competition. Thank you to all who entered! (You can still try your hand at this year's crossword puzzle, just for fun.)

2024 Tau Day 6.28 Crossword Puzzle Contest Winners

Yuval Wigderson (ETH Zürich) - Grand Prize Winner
Katherine Paur (The Nueva School)
Daniel Ruberman (Brandeis University)

And a big thank you to MSRI-UP 2024 scholars **Javier Garcia, Kimberly Lopez,** and **Russell Martinez**, who observed correctly that in the Blob problem, the critical fence-building speed is at most tau (in fact it is at most 2, but its exact value is still unknown). Proofs are still being accepted, and you can take another look at the problem here.

Thank you to everyone who made SLMath's Tau Day 2024 a success — in 24 hours, we raised over $54,000 towards our Annual Fund, which supports all aspects of our mission.

Your generosity allows us to continue to welcome gifted young scientists who will, in the span of their careers, transform mathematics. Please read on for an interview with Lucien Hennecart.

Best regards,

Tatiana Toro
Director, Simons Laufer Mathematical Sciences Institute (SLMath)
Professor of Mathematics, University of Washington

SLMath Community Spotlight

Meet an SLMath Postdoc | Lucien Hennecart

Interviewed by Evelyn Lamb and Uta Lorenzen

Lucien Hennecart is a postdoctoral researcher at the University of Edinburgh. He spent Spring 2024 at the Noncommutative Algebraic Geometry program at SLMath. After his postdoc, he will start a position at the National Center for Scientific Research (CNRS) in France.

Can you describe your field of research and some of the motivating questions?

My field is a combination of algebraic geometry and representation theory called geometric representation theory. It goes in two directions: one direction is trying to give geometric constructions of some algebraic objects; the other is to apply representation theoretic methods to understanding the geometry of some spaces. This is the general philosophy of the field.

A lot of motivating questions concern the second direction, understanding geometry using representation theory. I'm thinking about questions regarding the geometry and topology of moduli spaces. In algebraic geometry, a moduli space is a space parametrizing different kinds of objects. An old example is

parametrizing lines in space, from which we can obtain what we call projective spaces. Now we have fancier, more modern versions of these, like moduli spaces of sheaves on manifolds. You start with a manifold, then you consider some objects called sheaves, and you can produce a new space, called the moduli space of sheaves, on this manifold. We want to understand the geometry of this new space. There are some motivations from physics. Sheaves can be understood as states of some physical space. We want to parametrize all possible states.

Is there a research result that you've been particularly proud of or that has been particularly important in moving your career forward?

I would say the last two papers I have in collaboration with Ben Davison and his former PhD student, Sebastian Schlegel Mejia. This is a structural result. We have some geometric context, and from the geometric situation we constructed (following work of Kontsevich-Soibelman, Schiffmann-Vasserot and Kapranov-Vasserot) some algebras, which are called cohomological Hall algebras. (An algebra is a vector space with a multiplication rule.) People had been trying to describe these algebras in a more explicit way, with generators and relations, and that is what we did. We want to find the smallest possible subset generating the whole thing, to find the bricks from which you can build the whole space. We did this for the cohomological Hall algebra associated to 2-Calabi-Yau categories.

It was a difficult question because we started with geometry, and from there we built an algebra, and then we ended up being able to describe a generating space for it explicitly. A priori, there is no reason we should expect to be able to do that. If I gave you any abstract, geometrically defined multiplication on some vector space, and I asked you to find a generating subspace, it would probably be very, very hard. There are similar situations for which we can’t do it for now, but we can do it in this case.

The way I said it was very abstract, but it has applications in algebraic geometry and representation theory, and in particular in enumerative geometry. Enumerative geometry is about counting objects, and people have been trying to understand independence phenomena. When you build a moduli space, it depends on some discrete parameters, and sometimes when you vary the parameters a little bit, you expect invariance, so what you can build from the geometry would remain the same. Using these cohomological Hall algebras, we have been able to prove some independence

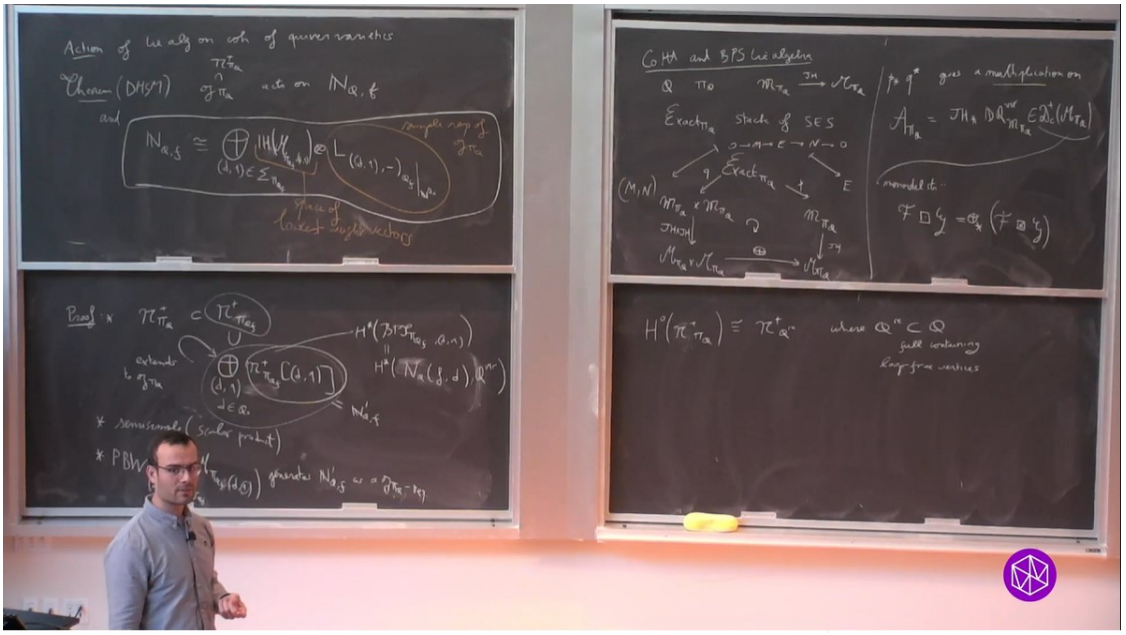
phenomena like this.

Do you have any advice for your previous self, when you were just starting out?

When I started my PhD, I was a bit shy about traveling. It felt like a lot of organization was needed to go to conferences and so on. So I would advise myself to travel more as a PhD student. Take advantage of the knowledge of the other people there. You don't know much when you start your PhD, and for me it was difficult to imagine that people could help me. So I was trying to do everything by myself. Another piece of advice I would give is that in pure mathematics, it's very easy to keep learning things because you have the impression that you never know enough to do research. You learn, you learn, and you learn. And a lot of people get burned out at the beginning of the PhD because they learn a lot of different subjects without starting to do research. I think you need to start with some small, easy questions or computations to start understanding things yourself. Learning can be a passive thing, but to do research, you need to understand how to create something, and it's impossible to do it if you never start doing even some small computations. I would recommend to start as early as possible and find some small questions to answer.

What do you love about being a mathematician?

I like thinking by myself for a few hours, trying to answer a question, but in the end that's only a small part of my work. I also like organizing things. Everywhere I go, I try to organize a seminar, or a lecture series, or a workshop. I like the social aspect of research, which one shouldn't forget. I like talking with people and trying to find new ideas, or explaining my research to them. I have to admit I also like traveling. It's probably not the most important part — the most important part is to do research and prove theorems — but then when you do this, you have to communicate, and I like traveling to different places and communicating my results. When we travel to different places, we can see that in other countries, people do math differently. In France, there is a certain way of doing math, and in the US, it's slightly different. We can see how people communicate with each other and work. Doing research is tough. It's a lot of work. Travel is one of the advantages. I can't imagine doing research by myself in my room forever. I like that you can travel a little bit and meet nice people everywhere.



Lucien Hennecart: *BPS sheaves and Kac-Moody Lie algebras*

A heartfelt thanks to our generous 2024 Tau Day friends. We could not accomplish our goals without their support, involvement, and enthusiasm. We look forward to Tau Day 2025!

- **Michael Hartl**
- **David Hoffman & Joan Sarnat**
- **Bob Palais, Richard Palais & Chuu-Lian Terng**
- **Sejongmall Co., Ltd, makers of Hagoromo Chalk**

Tau Day is a time to celebrate and rejoice in all things mathematical.
- Michael Hartl

Support Scientific Research at SLMath

The mission of the Simons Laufer Mathematical Sciences Institute (SLMath), formerly MSRI, is to foster and communicate mathematical research in a broad range of fundamental topics and applications, develop mathematical talent and cultivate a sense of belonging and engagement, and inspire an appreciation of the power, beauty, and joy of mathematics.

The generosity of our donor community allows us to fund scientific programming and workshops, outreach projects, and support for individuals including SLMath Postdoctoral Fellows.

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