Atlantic Association for Research in the Mathematical Sciences

Research - Outreach - Community

Newsletter

Spring 2019

Our AARMS Outreach Postdoc

Since August 2018, I have been an AARMS outreach post-doctoral fellow at Dalhousie University. As part of my actual position, I allocate roughly half of my work time to research and the other half to organize and coordinate AARMS sponsored outreach activities.

My research is in arithmetic algebraic geometry, the branch of mathematics that studies geometric objects defined by polynomial equations that are of use to number theorists. A classical example of an arithmetic geometric object are elliptic curves, defined by cubic equations, whose arithmetic properties lead to many applications: For instance, they are an essential ingredient in the proof of Fermat's last theorem and they provide an effective approach to public-key cryptography.

In particular, I am interested in arithmetic-geometric objects endowed with the action of a group. Group actions are a very important source of methods for decoding geometries. In a broad sense, this idea has a long tradition, that can be traced back to the work of Galois and to Klein's Erlangen program. In my research, I try to adapt this philosophy to contemporary problems about arithmetic varieties. For instance, in a recent paper I have shown that finite group actions on certain arithmetic curves are classified by certain enriched graphs, that I called "Berkovich-Hurwitz graphs", as they are constructed using the theory of non-archimedean spaces introduced by Vladimir Berkovich in the early 90s.

I like the richness and complexity of the objects I study, it allows me to learn a broad range of mathematical theories, from algebraic geometry to representation theory, combinatorics, and much more. However, I wouldn't be happy with research alone: I always felt the instinct to communicate what I do and what I learn to the people I meet. With other mathematicians, I like to chat about possible common ground for our research; with my students, I like to give them a glimpse of the history of mathematics underlying what they learn; and most of all, I love the challenge of presenting mathematical notions to non-specialists and the broader public.

Since the beginning of my graduate studies, I have been involved in outreach activities, such as math exhibits, science festivals, and math clubs for high school students. I always did this in my spare time, so I was extremely happy when AARMS gave me the opportunity of organizing outreach activities as part of my job. I am impressed by the variety of AARMS sponsored initiatives and the generosity of the outreach community in Atlantic Canada. My first big project (together with Dr. Dorette Pronk) is a big STEM event in partnership with the Girl Guides of Nova Scotia on the weekend of May 11-12. We expect to greet around 500 girls and we hope to show them how STEM disciplines can be at the same time exciting and offer great career opportunities. Wish us luck!

- Daniele Turchetti

AARMS Summer School 2019

Some places still remain open for students to attend the 2019 AARMS Summer School on Dynamical Systems, Differential Equations and Special Functions, June 17-July 12 at UPEI. For further details see our website: https://aarms.math.ca/summer-school/school2019/

News

Atlantic Algebra Centre Mini Course

During the fourth week of January, Atlantic Algebra Centre at Memorial University hosted a mini-course "Representations of simple finite dimensional and affine Lie algebras", sponsored by AARMS and Memorial University. The mini-course was taught by Professor Vyacheslav Futorny of the University of Saõ Paulo, a member of Brazilian Academy of Sciences and an author of over 130 research papers on a variety of topics including Kac-Moody algebras, quantum groups, vertex algebras, and representation theory of Lie algebras and its applications in mathematical physics. Professor Futorny gave four lectures, which were attended by faculty and graduate students of Memorial University as well as two external graduate students, whose participation was made possible by financial support from AARMS. For all participants, the mini-course was an opportunity to get acquainted with cutting-edge research in a stimulating environment.

News from Richard Nowakowski

Richard Nowakowski was recently made a Fellow of the Canadian Mathematical Society at the 2018 CMS Winter meeting in Vancouver. He has also given the following recent talks:

"Boiling point: Temperature Bounds for games" at INTEGERS 2018, October in Augusta, Georgia;

"Orthogonal Graph Colouring game", 2018 CMS Winter meeting, December, Vancouver;

"Trends in Combinatorial Games" at Combinatorial Games Colloquium III, January 2019, Lisbon, Portugal;

"A matter of perspective", Recreational Mathematics Colloquium VI, January 2019, Lisbon, Portugal;

His student Svenja Huntemann defended her PhD in summer 2018 and was awarded an NSERC PDF which she will take at Carleton University.

MTA Hacks

On February 2, 2019, student organizers at Mount Allison University hosted MtA Hacks, a 1-day hackathon featuring workshops, industry booths, and social events for participants, who could choose between a 12-hour stream and a 16-hour stream. Within the designated time, teams of 2 to 4 students competed to design and implement the best piece of software focused on environmental sustainability. MtA Hacks 2019 had 24 participants from Atlantic Canadian universities and high schools, and a panel of distinguished industry judges from Canada and the United States. MtA Hacks was organized by a committee of Mount Allison students headed by Graeme Zinck. Plans are already well underway for MtA Hacks 2020.

MtA Hacks website: http://mtahacks.ca/

MtA Hacks Facebook page:
https://www.facebook.com/mtahacks19/

Winning team - 12 hour stream

Winning team - 16 hour stream

Committee members with the MTA president

An AARMS Postdoc Reports

A focus of interest for my research is the concept of renormalization in theoretical physics. Some of the ideas involved can be illustrated on a simple example, based on the well-known central limit theorem of statistics. We consider an increasing number of independent random variables $X_1, \ldots, X_N$ and evaluate their average X : in physics, this could describe how a macroscopic quantity might be computed from an increasingly detailed microscopic model. Specifically, we can think of it as a refinement process: the model at a given scale ϵ encompass a number of variables X_i^ϵ each of which captures (an approximation of) the collective behaviour of certain variables

$$X^{\epsilon'}_{K(i-1)+1}, \ldots, X^{\epsilon'}_{Ki}$$

from the more accurate model at a smaller scale ϵ'.

Under suitable assumptions, the distribution of X admits a well-defined limit, but only when X is suitably normalized: by the a priori non-trivial scaling $1/\sqrt{N}$ instead of $1/N$. Then, it converges to a normal distribution, which has the remarkable property of being a fixed point of our refinement process: if a number of random variables are normally distributed, so is their average.

A similar procedure can be followed in quantum mechanics, which constitutes a non-commutative generalization of ordinary statistics: the non-commutativity of observations encodes the fact that quantum measurements may interfere with each other, as opposed to statistical events (the intersection of which transparently describes joint occurrence). There exist rigorous, well-controlled recipes to turn (finite-dimensional) classical systems (defined on finite-dimensional symplectic manifolds) into quantum ones (a.k.a. quantize them). However, the quantization of infinite-dimensional classical systems (defined on certain functional spaces) remains poorly understood.

An indirect way to construct such quantum field theories is to truncate our classical system, generating a net of increasingly precise, but still finite-dimensional, approximations (which correctly reproduce the original theory at increasingly small scales). We can then quantize each of them using the well-established techniques available for finite-dimensional systems, and hope to recover the full quantum theory in the limit of the truncation scale going to 0 (the continuum limit). As in the case of classical statistics, the (quantum equivalent of the) normal distribution is an attractor, known as the Gaussian fixed point. It describes theories of non-interacting quantum particles.

To produce interacting theories, one has to go beyond the central limit theorem. It is done by identifying the few directions (in theory space) with respect to which the fixed point happens to be repulsive, rather than attractive, and introducing so-called (bare) coupling constants to parametrize how far the truncated theory at scale lies along these directions. By making the bare coupling constants scale-dependent, we can continuously adjust them so as to compensate exactly the flow away from the fix point (again this may require non-trivial rescalings, hence the name "renormalization"'). This allows the distribution of macroscopic quantities to converge toward a more interesting, non-Gaussian continuum limit.

A renormalization scheme of this type outputs a single (quantum) distribution: the vacuum state. But a usable quantum theory actually consists of a space of quantum states. While it is traditionally possible to use the vacuum as a seed from which the entire state space can be reconstructed, the assumptions which make this reconstruction possible tend to break down in more ambitious settings, such as non-equilibrium quantum field theory or quantum gravity. The principal goal of my work is to develop a renormalization framework which operates directly at the level of the state space, rather than on individual distributions. First, I employ a projective limit construction (a.k.a. inverse limit) to assemble a large space of candidate quantum states (the projection maps implement coarse-graining, the reverse of refinement). This provides an arena to delineate which states support the kind of convergence that will lead to well-defined continuum limit. For example, I am currently applying this strategy to a simple theory of two-dimensional quantum geometries (based on Causal Dynamical Triangulations).

- Suzanne Lanery

Recent and Upcoming Events

New Brunswick Math League
April 5, 2019
UNB, Fredericton

2019 CMS – UPEI – AARMS Math Camp
May 3, 2019 - May 5, 2019
UPEI, Charlottetown

AARMS-Girl Guides Event: “All SySTEMs Go” 2019
May 11, 2019 - May 12, 2019
Dalhousie, Halifax

Blundon Seminar Math Camp
May 15, 2019 - May 17, 2019
MUN, St. John's

STFX Math Camp
May 17, 2019 - May 19, 2019
STFX, Antigonish

PIMS Workshop on Mathematical Sciences and Clean Energy
Applications
May 21, 2019 - May 24, 2019
Vancouver, BC

Calculus Instruction in Atlantic Canada Symposium 2019
May 24, 2019 - May 25, 2019
MSVU, Halifax

Atlantic General Relativity Meeting
May 27, 2019 - May 31, 2019
UNB, Fredericton

CanaDAM 2019
May 28, 2019 - May 31, 2019
SFU, Burnaby, BC

Special Session on “Categorical Approaches to Geometry and Topology” during the 2019 Summer Meeting of the Canadian Mathematical Society
June 7, 2019 - June 10, 2019
Regina, SK

AARMS Summer School 2019: Dynamical Systems, DEs, and Special Functions
June 17, 2019 - July 12, 2019
UPEI, Charlottetown

Nonassociative algebras and geometry
August 12, 2019 - August 16, 2019
MUN, Bonne Bay Marine Station

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"Film is one of the three universal languages, the other two: mathematics and music."

-- Frank Capra