Alexis Langlois-Rémillard

Research interests

Algebra, mathematical physics, representation theory of algebras, diagrammatic algebras, cellular algebras, Lie (super)algebras, Dunkl operators and Temperley–Lieb algebras.

Education

2019– exp. 2023	**Ph. D. in Mathematics**, Universiteit Gent Thesis subject: *The representation theory of the total angular momentum algebra* Advisors: Profs Joris Van der Jeugt and Hendrik De Bie, and Dr Roy Oste
2017– 2019	**M. Sc. in Mathematics**, Université de Montréal Thesis: *Sur la structure cellulaire et la théorie de la représentation des algèbres de Temperley–Lieb à couture* Advisor: Prof. Yvan Saint-Aubin
2014– 2017	**B.Sc in Mathematics**, Université de Montréal *Excellence mention*

Scholarships

2019–2023	**FRQNT**[1] Doctoral Research Scholarship ($ 84 000)
2019–2023	**FWO**[2] EOS PRIMA PhD scholarship (€ 100 000)
2017–2019	**FRQNT** Master's award ($ 30 000)
2017–2018	Alexander-Graham-Bell **NSERC**[3] Master's award ($ 17 500)
Summer 2016	Undergraduate Research Awards, **NSERC** and **FRQNT**, Yvan Saint-Aubin ($ 7 625)
Summer 2015	Undergraduate Research Award, **NSERC**, Matilde Lalín ($ 5 625)

Academic work experience

2021	**Teaching Assistant** at Ghent University (in Dutch) *Mathematics for economics IA* Helped animating practical sessions for 60-80 students, invigilated exams.
2016–2018	**Teaching Assistant** at Université de Montréal (in French) *Discrete Mathematics, Analysis 1 and Fundamental Mathematics* Animation of exercises for 20-60 students, office hours, invigilated and corrected exams.

Publications and preprints List available at https://alexisl-r.github.io/publications/.

Work in progress

1. De Martino, M., Langlois-Rémillard, A., and Oste, R. (2022+) Double dihedral total angular momentum algebra

2. Langlois-Rémillard, A., Morin–Duchesne, A. and Spencer, R. A. (2022+) Jones–Wenzl projectors for the uncoiled affine Temperley–Lieb algebras

Articles

1. (preprint) Langlois-Rémillard, A., Müßig, C., and Roldán-Roa É. (2022) Computational complexity of chess domination problems. 18p. arXiv:2211.05651

2. (accepted preprint) De Bie, H., Langlois-Rémillard, A., Oste, R., and Van der Jeugt, J. (2022+) Generalised symmetries and bases for Dunkl monogenics. 18p. Accepted in Rocky Mountains Journal of Mathematics arXiv:2203.01204

3. De Bie, H., Langlois-Rémillard, A., Oste, R., and Van der Jeugt, J. (2022) Finite-dimensional representations of the symmetry algebra of the dihedral Dunkl–Dirac operator. Journal of Algebra 591, pp. 170–216. DOI:10.1016/j.jalgebra.2021.09.025, arXiv:2010.03381

4. Langlois-Rémillard, A. and Saint-Aubin, Y. (2020) The representation theory of seam algebras. SciPost Physics 8, 019. 34p. doi:10.21468/SciPostPhys.8.2.019, arXiv:1909.03499

Proceedings

1. (accepted preprint) Langlois-Rémillard, A. (2021+) The dihedral Dunkl–Dirac symmetry algebra with negative Clifford signature. *Accepted* for the proceedings of LT-XIV 2021, 7p. arXiv:2209.06599

2. (accepted preprint) Langlois-Rémillard, A. (2020+) Deforming algebras with anti-involution via twisted associativity. *Accepted* for the proceedings of SPAS II, Västerås 2019, 21p. arXiv:2106.01855

3. Langlois-Rémillard, A. and Oste, R. (2020) An Exceptional Symmetry Algebra for the 3D Dirac–Dunkl Operator. In: Dobrev V. (ed) Lie Theory and its Applications in Physics. LT Varna 2019. Springer Proceedings in Mathematics & Statistics, vol 335. Springer Singapore. pp 399–405 doi:10.1007/978-981-15-7775-8_30, arXiv:2009.13904

Talks and Workshops Complete list available at https://alexisl-r.github.io/talks/.

Invited talks:

October 2022	**Dartmouth combinatorics seminar**, Dartmouth College, Hanover.
	Sandwich cellularity and constructing idempotent in quotients of the affine Temperley-Lieb algebras
October 2022	**Integrable systems, exactly solvable models and algebras**, CRM Montréal.
	Representations and Wenzl-Jones elements of quotients of the affine Temperley-Lieb algebra
May 2021	**EOS meeting**, online *Finite-dimensional representations of the 3D dihedral Dunkl–Dirac symmetry algebra*
November 2018	**Seminar: representation theory of algebras**, Université de Sherbrooke
	Idempotence, cellularité et algèbres diagrammatiques
October 2018	**Mathematical physics seminar**, Université de Montréal
	Roots of unity and the representation theory of boundary seam algebras

Workshops:

October 2022	**Let's talk about outreach**, Les Diablerets, Switzerland
	Gamification of research (with Christoph Müßig, Érika Roldán-Roa and Peter Voran)
June 2018	**Canadian Mathematical Society Summer Meeting**, Fredericton, Canada
	Atelier d'enseignement actif (with Marie-Andrée B. Langlois)

Contributed seminar and conference talks:

July 2022	**Group34**, Strasbourg
	Monogenic representations of the algebra of symmetries of the generalised Dirac operator
May 2022	**Symmetries, algebras and physics** CRM, Montréal
	On the representation theory of a symmetry algebra associated to a generalised Dirac operator
February 2022	**Clifford research seminar**, Universiteit Gent, Online
	Bases for Dunkl monogenics by generalised symmetries
June 2021	**Lie Theory and its applications to physics XIV**, Online
	Finite-dimensional Representations of the 3D dihedral Dunkl-Dirac symmetry algebra
April 2021	**Clifford research seminar**, Universiteit Gent, Online
	Generalizing the Deligne category, Khovanov's and Sazdanovic's approach
December 2020	**CMS Winter meeting**, Canada, online
	The symmetry algebra of the Dunkl–Dirac operator: the dihedral cases
March 2020	**Clifford research seminar**, Universiteit Gent
	The symmetry algebra of the 3D dihedral Dunkl–Dirac equation.
November 2019	**SPAS**, Västerås
	Cellular structure of seam algebras and avenues for deformations
June 2019	**Clifford research seminar**, Universiteit Gent
	Representation theory and cellular structure of seam algebras
September 2018	**XXXth Meeting on representation theory of algebras**, Sherbrooke
	Cellular structure of boundary seam Temperley-Lieb algebras
June 2018	**Canadian Mathematical Society Summer Meeting**, Fredericton
	Bratteli and the morphisms of boundary seam algebras

Poster:

| May 2022 | **PhD Day meeting of the BMS**, Liège |
| | *Weavings weights: double dihedral deformation* (with Marcelo De Martino and Roy Oste) |

Graduate students advising and evaluation

Current master students

2022-2023   Stijn Dezeure. **Mentor** with S. Lazendic (UGent under Prof. A. Pizurica)
Subject: *Quantum computing with applications to image processing*

2021-2022   Régis Schulze. **Mentor** with S. Lazendic and A. Guzmán Adán (UGent under Prof. A. Pizurica)
Thesis title: *Classical and quantum approaches to belief propagation algorithms*

Past master students

2021-2022   Pieter-Jan Vandaele. **Mentored** with S. Lazendic and A. Guzmán Adán (UGent under Prof. A. Pizurica)
Thesis title: *Classical coding approaches to quantum applications*

Spring 2021   Bert Christiaens. **Jury member** (UGent under Prof. A. Pizurica)
Thesist title: *Network explainability via content based image retrieval*

Outreach   More available at https://alexisl-r.github.io/popularization/.

Popularization work for a broad audience

1. Langlois-Rémillard, A., and Senécal C. (2022) Des dames sur d'étranges échiquiers. *Accromath*, 17, 2. pp.2–7 https://accromath.uqam.ca/2022/09/des-dames-sur-detranges-echiquiers/

2. Langlois-Rémillard, A. (2022) Huit dames et un échiquier. *Accromath*, 17, 1. pp. 8–13. https://accromath.uqam.ca/2022/02/huit-dames-et-un-echiquier/

3. Langlois-Rémillard, A. (2021) Geraldine A. Coon. *Femmes en maths*. https://femmesenmaths.org/geraldine-coon/

4. Boutet, V., Godin, J. and Langlois-Rémillard, A. (2017) Excursion typographique : La matrice des fontes. *Accromath*, 12, pp. 26–29. https://accromath.uqam.ca/2017/09/la-matrice-des-fontes/

5. Langlois-Rémillard, A. (2016) Le Petit Prince et l'algèbre, *Notes from the Margin*, Canadian Mathematical Society, Vol XII, p.4. https://issuu.com/cms-studc/docs/margin-fall2016

Popularization talks

November 2022   **Imaginary**, UGent
Wiskunde en schaak: Koninginnen en rare borden

September 2022   **Club mathématique**, Université de Montréal
La domination, une histoire d'échecs

November 2021   **PRIME problem-solving avond**, UGent
Koninginnen en (bijzondere) borden

September 2020   **Club mathématique**, Université de Montréal
Des pentagones aux heptagones, une infinité de différences

November 2018   **Club mathématique**, Université de Montréal
Huit dames pour un échiquier

July 2018   **Camp mathématique de l'AMQ**, Dawson College, Montréal
Le carréousel du géomètre

November 2017   **Club mathématique**, Université de Montréal
Excursion typographique: la matrice des fontes

Outreach activities

2021–   **Chess and mathematics**. I collected a set of chess-inspired mathematical problems and created activities around them, both for general audience and university mathematics students.

2016-2018   **Institut des sciences mathématiques**. I created an activity on tatami tiling in 2016 for the *MathFest* and co-created the activity *Le carréousel du géomètre* on square wheels for the festival *Eureka!* 2018 at the Science centre of Montréal.

2018-2019   **L'Axiomatique**. *Corrector-in-chief and writer* for a mathematics student journal at Université de Montréal.

2015-2017   **JÉMUM**. *Co-created and co-edited* a student mathematical journal to showcase summer research by undergraduate students.

Leadership and implication

Research stay

August 2022	**Max Planck Instute for Mathematics in the Sciences**, Leipzig, one-week visit, invited by Érika Roldán-Roa

Conference organizer

2022-23	**Doctoral course, UGent** Mini-course on p-Kazhdan-Lusztig combinatorics to be given by Chris Bowman and Maud De Visscher in April 2023. *Co-organiser*
2019	**SAMARI**. One-day conference on possibilities after graduation in mathematics. *Co-initiator and co-organizer*
2016-18	**Seminars in Undergraduate Mathematics in Montréal**. Annual provincial undergraduate weekend conference. *President for 2016–2017 and member of the organizing committee in 2018*
2018	**SAPHARI**. One-day conference on possibilities after graduation in physics. *Organizer of the mathematics session*
2017	**Canadian Undergraduate Mathematics Conference** Annual national undergraduate one-week conference. *President of the Montréal 2017 edition*

Session and seminar organizer

2019-present	**Kleine seminar**. Organizer for a postgraduate mathematical seminar at UGent on various algebraic subjects related to representation theory, `https://alexisl-r.github.io/kleine_seminar/`
2017-2018	**AARMS-STUDC student poster session**. Co-organiser for 2018 CMS Summer Meeting, University of New-Brunswick, Frederiction and 2017 CMS Winter Meeting, University of Waterloo, Waterloo.
2017-2018	**Séminaire étudiant en mathématiques**. Co-organizer for the graduate students mathematics seminar at Université de Montréal
2015-2017	**Club mathématique**. Co-organizer for a weekly seminar of talks aimed at undergraduate students at Université de Montréal

Community service

2020-present	**Reviewer** for zbMATH Open. [zbMATH:langlois-remillard.alexis](#)
2016-2019	**Student committee** of the Canadian Mathematical Society. *Committee member*: involved in the French translation of general activities and in the edition of French articles in the annual publication *Notes from the Margin*.
2017-2019	**AECSMS**: Graduate mathematics and statistic students association in Université de Montréal. *President* (2018-2019) and *Treasurer* (2017-2018).
2014-2019	Students representative on the **mathematics and statistic departmental assembly** at Université de Montréal: 2014-2016 for undergraduate and 2018-2019 for graduate students.

Languages

Français :	Native language
English:	Fluent
Nederlands:	Proficient (B2 CEFRL 2021-05)
Deutsch:	Basic (A1-A2)

Other Interests and Activities

Chess	I am a Canadian and Québécois expert and play with the KGSRL chess club.
Swimming	I taught swimming lessons and was a lifeguard from 2011 to 2016 and a lifeguard instructor from 2013 to 2016. I received a Commonwealth service citation for my volunteer work in 2015 and 2014.
Literature	I greatly enjoy reading, writing and discussing literary works.

Postdoc application
University of Glasgow
Angular Cherednik algebras and integrability
27th November 2022

Alexis Langlois-Rémillard
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https://alexisl-r.github.io/

Covering letter

Dear Professors Bellamy and Feigin,

I am currently a doctoral student at Ghent University under the supervision of Hendrik De Bie, Joris Van der Jeugt and Roy Oste, expecting to submit my thesis at the end of December 2022 and to defend in March or April 2023. My doctoral studies are concerned with a symmetry algebra motivated by the study of the Dunkl–Dirac operator, the deformation of the Dirac operator by Dunkl derivatives. I will extend more in what follows.

Before my doctoral studies, I did my bachelor and master degrees at Université de Montréal, the latter under the supervision of Yvan Saint-Aubin on seam algebras, a generalisation of Temperley–Lieb algebras coming from two-dimensional statistical loop models with boundary conditions in statistical mechanics. We studied the representation theory of these algebras via their cellular theory—indeed they are cellular algebra, as are the Temperley–Lieb algebras, since the seam algebras are still endomorphism algebras of tilting modules of $U_q(\mathfrak{sl}_2)$.

My research path in the last years was directed toward the representation theory of objects linked to reflection groups, mostly Hecke algebras and their deformations, always keeping in mind applications to mathematical physics. More specifically, projects I have worked on came from constructions present in statistical mechanics, conformal field theory and integrable systems, the latter via spin chains and generalisations of the Temperley–Lieb algebra.

As such, I was agreeably surprised to learn of the project you are leading as it intersects with my interests and would give me the opportunity to explore more of the geometric aspects of theses objects. I have been close to most of the concepts that will intervene in the project you propose, and even the subjects I feel less familiar with are within reasonable reach.

In the course of my studies at Ghent University, I have been organising an informal lecture group with fellows students and postdocs, the Kleine seminar. We have covered many subjects in representation theory in the last three years: Hecke algebras, categorification, category $\mathcal{O}$ for semisimple Lie algebras, tensor categories, crystal bases, Soergel bimodules, and we will close it next year with a course on p-Kazhdan–Lusztig bases. I emphasise this to show that I am willing to invest the time and effort to learn new material and keep up to date with the general progress of the field, and I would gladly continue such a reading group at your institution if wanted.

I will expand briefly on my research experience in the remaining of the letter, and try to indicate connections to the research project you are leading when relevant.

Current research projects and doctoral thesis

Master's degree research and continuation. My master's thesis was on the representation theory of the boundary seam Temperley–Lieb algebras, associative algebras parametrised by two integers and a complex number. It can be seen as a Temperley–Lieb algebra left- and right-multiplied by a smaller Jones–Wenzl projector.

The key concept we invoked for the study was cellularity. The study was an application of the tools of cellular algebras to the specific case and it also made great use of the diagrammatic calculus presents in the Temperley–Lieb category. The main result was to characterise the simple and principal indecomposable modules at roots of unity.

I am still interested in this subject and I am currently collaborating on it with Alexi Morin-Duchesne (UGent) and Robert Spencer (Cambridge) on a related project. We study a finite-dimensional quotient of the infinite-dimensional affine (or extended periodic) Temperley–Lieb algebra that we call the uncoiled affine Temperley–Lieb algebra. It was motivated by a question of Tubbenhauer coming from their recent work with Khovanov and Sitaraman, where they used representation theory of specific algebras to make cryptographic protocols.

The uncoiled affine Temperley–Lieb algebra has n one-dimensional modules. In normal Temperley–Lieb algebras, the Jones–Wenzl projector is the idempotent linked to the only one-dimensional module. In the uncoiled affine version, we are able to compute the n Jones–Wenzl-like projectors for characteristic 0 and we have linear recurrence formulas that uniquely determine their coefficients.

We also have proved that the uncoiled affine Temperley–Lieb algebra is sandwich cellular, a generalisation of cellularity extending upon the notion of affine cellularity of König and Xi. This gives ways to a study of its representation theory via its cell modules.

Relevance to the research project.   I expect a version of cell theory could appear in the algebras to encounter in the project, with maybe diagrammatics calculus similar to Webster's diagrammatic for Cherednik algebras. The methods I have worked with for those projects might be useful, and it furthermore lead me to be in contact with a lot of mathematical physics literature and integrable systems.

Timeline.   The project with Morin-Duchesne and Spencer is well advanced and our goal is to have complete formulas for the Jones–Wenzl projectors. We already have recurrence relations for the coefficients of the projector that determine them and are completing the computation for closed-forms. We plan to submit a short article in February. In the future, we would like to consider the modular characteristic cases, dive in more depths the representation theory, and to explore the relations between the representation theory of the affine Temperley–Lieb algebra and towers of uncoiled affine Temperley–Lieb algebras.

Doctoral research.   My doctoral research is aimed at an algebra, the Dunkl total angular momentum algebra. This is a subalgebra of the tensor product of a Clifford algebra and a rational Cherednik algebra linked to a reflection group and a parameter function. The research conducted considered general notions of the algebra, built spinor-valued polynomial realisation and gave classification of its finite-dimensional representations for specific groups, when the reflection group was a product of dihedral groups.

To be more precise, the total angular momentum algebra studied here can be defined abstractly by generators and relations or as the supercentraliser of an $\mathfrak{osp}(1|2)$ realisation inside the tensor product of a rational Cherednik algebra and a Clifford algebra. It contains the Dunkl angular momenta algebra of Feigin and Hakobyan as an even subalgebra.

The total angular momentum algebra depends on a reflection group W and a weight function κ invariant on W-orbits. Relatively little was known over the representation theory of this algebra, only the groups $W = \mathbb{Z}_2^d \subset \mathcal{O}(d)$ and $W = S_3 \subset \mathcal{O}(3)$ had been studied prior to the start. In my doctoral thesis, I presented the representation theory of the dihedral family in low dimensions $W = D_{2m} \times \mathbb{Z}_2 \subset \mathcal{O}(3)$ and $W = D_{2m} \times D_{2n} \subset O(4)$ and I gave a realisation as polynomial solutions to the Dunkl–Dirac equation for any group W.

At the moment, an ongoing collaboration with Marcelo De Martino (UGent) and Roy Oste (UGent) aims to extend the two first results to a stack of dihedral groups, and to consider in more details the representation theory at special values of κ. In the low-dimensional cases, the values we avoided did not result in interesting behaviour, but we expect that having many values simultaneously conflicting could allow for remarkable types of representation, as is the case for representations of rational Cherednik algebras.

Connections with the research project. The study of the representation theory of these algebras is similar in spirit to that of rational Cherednik algebras, with the added constraint of the $\mathbb{Z}_2$-grading induced by the Dirac theory. Dunkl operator are also present in Calogero–Moser–Suntherland systems and I suspect some special function realisations might be useful to begin the study of the systems with tractable examples using computational evidences.
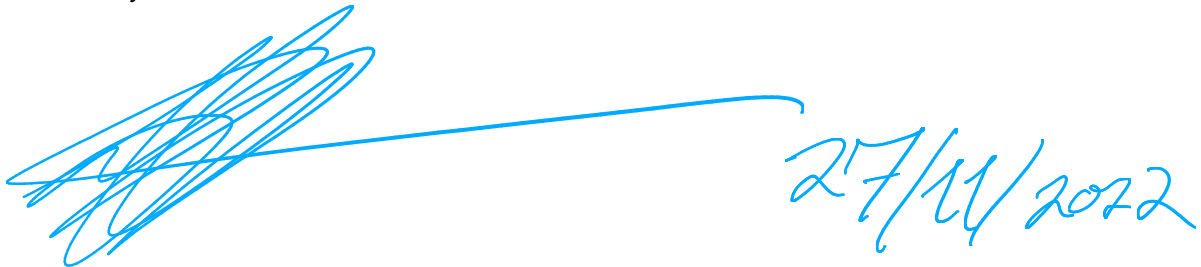
Timeline. The study of the representation theory of the Dunkl total angular momentum algebra for $W = D_{2m} \times D_{2n}$ is contained in my thesis, where the main families of representations are considered. The article version of those results, written with Marcelo De Martino and Roy Oste, is nearing completion and should be submitted in January 2023. As a follow-up, we plan then to consider different types of duality outside that of the Howe dual pair $(\mathrm{Pin}(d), \mathfrak{osp}(1|2))$ and to study the related symmetry algebras linked to them, or to try different reflection groups.

Closing words

To conclude, I would appreciate the chance to take part in your project to which I think I could contribute as it lies in the intersection of fields I have encountered during my past studies and research experiences. I would be most willing to learn more about the geometric interpretation of the objects I have known mostly algebraically and would welcome the opportunity to combine again the insights of concrete systems from mathematical physics to algebraic description of the structures they underlie.

I stay available for further queries or demands.

Cordially,

27/11/2022

Alexis Langlois-Rémillard