Ian L. Charlesworth

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Employment/Education

Lecturer, Cardiff University (UK). 2022-Present

Postdoctoral Scholar, KU Leuven (Belgium). 2021-2022

NSF Postdoctoral Scholar, University of California, Berkeley (USA). 2018-2021

S.E.W. Visiting Assistant Professor, University of California, San Diego (USA). 2017-2018

Ph.D. in Mathematics, University of California, Los Angeles (USA). 2017

M.Arts in Mathematics, University of California, Los Angeles (USA). 2014

B.Math. Honours Pure Mathematics & Honours Computer Science, University of Waterloo (Canada). 2012

Research Interests

Free probability and non-commutative information theory; regularity properties of non-commutative distributions; applications to von Neumann algebras and more generally operator algebras.

Non-commutative independences; extensions of free entropy to other settings; matrix models outside the realm of asymptotic free independence.

Connections between of quantum information theory, operator algebras, and free probability.

Publications

Journal Articles

I. Charlesworth and B. Nelson. *On free Stein dimension*. Indiana University Mathematics Journal **74** (2025), no. 4, 883-918.

I. Charlesworth, R. de Santiago, B. Hayes, D. Jekel, S. Kunnawalkam Elayavalli, and B. Nelson. *Random permutation matrix models for graph products*. Documenta Mathematica **30** (2025), no. 5, 1231-1269.

M. Bischoff, I. Charlesworth, S. Evington, L. Giorgetti, and D. Penneys. *Distortion for multifactor bimodules and representations of multifusion categories*, Documenta Mathematica **30** (2025), no. 3, 497-586.

I. Charlesworth and P. Skoufranis. *Analogues of Entropy in Bi-Free Probability Theory: Microstates*, International Mathematics Research Notices **2023** (2023), no. 1, 636-707.

I. Charlesworth and B. Nelson. *Free Stein irregularity and dimension*, Journal of Operator Theory **85** (2021), no. 1, 101-133.

I. Charlesworth and B. Collins. *Matrix models for ε-free independence*, Archiv der Mathematik **116** (2021), no. 1, 585-605.

I. Charlesworth and P. Skoufranis. *Analogues of Entropy in Bi-Free Probability Theory: Non-Microstate*, Advances in Mathematics **375** (2020), 107367.

I. Charlesworth, K. Dykema, F. Sukochev, and D. Zanin. *Simultaneous upper triangular forms for commuting operators in a finite von Neumann algebra*, Canadian Journal of Mathematics **72** (2019), no. 5, 1188-1245.

I. Charlesworth. *An alternating moment condition for bi-freeness*, Advances in Mathematics **346** (2019), 546-568.

I. Charlesworth and D. Shlyakhtenko. *Free Entropy Dimension and Regularity of Non-commutative Polynomials*, Journal of Functional Analysis **271** (2016), no. 8, 2274-2292.

I. Charlesworth, B. Nelson, and P. Skoufranis. *Combinatorics of Bi-Freeness with Amalgamation*, Communications in Mathematical Physics **338** (2015), 801-847.

I. Charlesworth, B. Nelson, and P. Skoufranis. *On Two-faced Families of Non-commutative Random Variables*, Canadian Journal of Mathematics **67** (2015), no. 6, 1290-1325.

Conference Proceedings

A. Nica, I. Charlesworth, and M. Panju. *Analyzing Query Optimization Process: Portraits of Join Enumeration Algorithms*. IEEE 28th International Conference on Data Engineering (2012).

Preprints

I. Charlesworth and D. Jekel. *The atoms of graph product von Neumann algebras*. arXiv preprint 2506.09000 (2025).

I. Charlesworth and D. Jekel. *Operator models and analytic subordination for operator-valued free convolution powers*. arXiv preprint 2501:09690 (2025).

I. Charlesworth, R. de Santiago, B. Hayes, D. Jekel, S. Kunnawalkam Elayavalli, and B. Nelson. *On the structure of graph product von Neumann algebras*. arXiv preprint 2404:081540 (2024).

I. Charlesworth, R. de Santiago, B. Hayes, D. Jekel, S. Kunnawalkam Elayavalli, and B. Nelson. *Strong* 1*-boundedness, L^2-Betti numbers, algebraic soficity, and graph products*. arXiv preprint 2305:19463 (2023); to appear in the Kyoto Journal of Mathematics.

Patents

A. Nica and I. Charlesworth. *Highly adaptable query optimizer search space generation process*. U.S. Patent no. 8,429,151 (2013).

Grants

Co-PI for NSF DMS Grant 2000335 (*Young Mathematicians in C^*-Algebras*); 2020; 31,454 USD; with M. Brannan and K. Eifler.

PI for NSF DMS Grant 1803557 (*Postdoctoral Research Fellowship*); 2018-2021; 150,000 USD.

Research Visits & Focus Programmes

Fields Institute for Research in Mathematical Sciences: Thematic Program on Operator Algebras and Applications, October - December 2023.

American Institute of Mathematics Structured Quartet Research Ensemble: *Classification of graph products from analytic and probabiistic [sic] viewpoints*, April 2022, April 2023, April 2024.

Teaching

Current Doctoral Student

Bogdan Alexandru Luchian (2025-Present)

Accreditation

Fellow of the Higher Education Academy; UK, 2023.

Courses taught

As instructor of record:

Cardiff University (2022-Present): MA2008 (Linear Algebra II), four times; MA4901 (Reading Module), with topic "Introduction to C*-algebras", twice.

University of California, Berkeley (2019-2021): Math 185 (Introduction to Complex Analysis); Math 104 (Introduction to Analysis), thrice.

University of California, San Diego (2017-2018): Math 142A, 142B (Introduction to Analysis I, II); Math 20B (Calculus for Science and Engineering II); Math 18 (Linear Algebra).

As teaching assistant:

University of California, Los Angeles: Math 170A (Probability Theory); Math 131A (Real Analysis); Math 115A (Linear Algebra); Math 32A (Calculus of Several Variables); Math 3A (Calculus for Life Sciences Students); PIC 10A, 10B (Introduction to Programming, Intermediate Programming).

Institute for Advanced Study Park City Mathematics Institute (2017): Random Matrix Theory Graduate Summer School.

Honours and Awards

Pacific Journal of Mathematics Dissertation Prize, 2017.

NSERC Postdoctoral Fellowship, 2017 (Declined).

AMS Joint Math Meetings Graduate Student Travel Grant, 2017.

University of California, Los Angeles Dissertation Year Fellowship, 2016.

NSERC PGS D3 Research Scholarship, 2013.

University of Waterloo Faculty of Mathematics Valedictorian, 2012.

NSERC PGS M Research Scholarship, 2012.

NSERC CGS M Research Scholarship, 2012 (Declined).

ACM SIGMOD Undergraduate Research Poster Competition Winner, 2010.

University of Waterloo President's Research Award, 2010.

NSERC USRA Research Scholarship, 2010.

René Descartes Scholarship, University of Waterloo, 2007.

University of Waterloo President's Scholarship of Distinction, 2007.

Canadian Computing Contest Stage 2 Bronze Medalist, University of Waterloo, 2007.

Service

Organization of meetings, conferences, and seminars

Free Probability. Special session at the 37th International Workshop on Operator Theory and its Applications. To be held at Univerité Laval, Canada. 2026. Co-organized with Serban Belinschi.

Random Matrices and Free Probability. Special session at the 35th International Workshop on Operator Theory and its Applications. University of Kent, UK. 2024. Co-organized with Håkan Hedenmalm, Torben Krüger, and Jani Virtanen.

Connes Embedding/$\texttt{MIP}^* = \texttt{RE}$ **Reading Group** at the University of California, Berkeley and Simons Institute. Winter 2020.

Advances in Operator Algebras. Special session at the AMS MAA Joint Mathematics Meetings 2020. Denver, Colorado, USA. Co-organized with Brent Nelson, Sarah Reznikoff, and Lauren Ruth.

Advances in Operator Algebras. Special session at the AMS MAA Joint Mathematics Meetings 2018. San Diego, California, USA. Co-organized with Marcel Bischoff, Brent Nelson, and Sarah Reznikoff.

Trimester Junior Seminar at the 2016 von Neumann Algebras Trimester of the Hausdorff Research Institute for Mathematics, Universität Bonn.

Refereeing

Electronic Communications in Probability

Electronic Journal of Probability

International Mathematics Research Notices

Journal of Functional Analysis

Journal of Operator Theory

Proceedings of the American Mathematical Society

Random Matrices: Theory and Applications

Other

Participation & Engagement assessment of proposals for workshop proposals at the Banff International Research Station

Presentations and Talks

Invited Talks

Atoms in ε-free probability, Conference on Free Probability, Universität des Saarlandes, June 2025.

Free Probability, Convolution, and Regularity, Pure Mathematics Colloquium, University of Southampton, May 2025.

Matricial Approximations, Algebraicity, and Strong 1*-boundedness*, Groups and Operator Algebras Seminar, University of Copenhagen, April 2025.

Regularity in free probability: an overview, and some recent results on graph products, Non-commutative Function Theory and Free Probability Workshop, Mathematisches Forschungsinstitut Oberwolfach, April 2024.

Algebraic soficity and graph products, Functional Analysis Seminar, University of California, San Diego, April 2024.

Permutation matrices, graph independence over the diagonal, and consequences, Abu Dhabi Stochastics Seminar, New York University Abu Dhabi, April 2024.

Permutation matrices, graph independence over the diagonal, and consequences, Pure Mathematics Seminar, Newcastle University, February 2024.

Permutation matrices, graph independence over the diagonal, and consequences, Functional Analysis Seminar, University of Oxford, February 2024.

Graph products and strong 1*-boundedness*, Operator algebra seminar, Fields Institute, November 2023.

Permutation matrices, graph independence over the diagonal, and consequences, Analysis seminar, University of Waterloo, November 2023.

Permutation matrices, graph independence over the diagonal, and consequences, Operator Algebra seminar, KU Leuven, May 2023.

Free Stein dimension and algebraic relations, Functional Analysis Seminar, University of California, San Diego, April 2023.

Regularity in Free Probability and Free Stein Dimension, Analysis seminar, University of Glasgow, March 2023.

Regularity in Free Probability and Free Stein Dimension, Operator Algebras in the South, Cardiff University, March 2023.

Free Probability, Regularity, and Free Stein Dimension, Operator seminar, Seoul National University, October 2022.

Recent work on free Stein dimension and regularity in free probability, Oberseminar C^*-Algebren, WWU Münster, June 2022.

Regularity and entropy of non-commutative random variables, Methusalem Colloquium & Lecture Series, KU Leuven, April-May 2022.

Recent work on free Stein dimension and regularity in free probability, Analysis seminar, TU Delft, February 2022.

Recent work on free Stein dimension, Functional Analysis seminar, University of California, San Diego, November 2021.

Recent work on free Stein dimension and regularity in free probability, Operator Algebra seminar, KU Leuven, November 2021.

Recent work on free Stein dimension, International Workshop on Operator Theory and Applications, Lancaster University, August 2021.

Free Stein Dimension and Regularity in Free Probability, KTGU Mathematics Workshop for Young Researchers, Kyoto University, February 2021.

Distortion for Multifactor Inclusions, Probabilistic Operator Algebras Seminar, University of California, Berkeley, November 2020.

An Introduction to Free Probability, Santa Clara University Mathematics Colloquium, November 2020.

Free Stein Dimension, IU (Virtual) Analysis Seminar, Indiana University, October 2020.

Free Stein Dimension, Wales MPPM Zoom Seminar, September 2020.

Free Stein Dimension, Seminar in Free Probability and Random Matrices, Queen's University, July 2020.

Free Probability, an expository talk at the Groundwork for Operator Algebras Lecture Series, Michigan State University, July 2020.

Free Stein Irregularity, Real Algebraic Geometry with a View Toward Hyperbolic Programming and Free Probability Workshop, Mathematisches Forschungsinstitut Oberwolfach, March 2020.

Asymptotic ε-independence, Probabilistic Operator Algebras Seminar, University of California, Berkeley, February 2020.

Combinatorics of the bi-free Segal-Bargmann transform, Seminar in Free Probability and Random Matrices, Queen's University, January 2020.

Combinatorics of the bi-free Segal-Bargmann transform, CMS Winter Meeting Session on Operator Algebras, Toronto, December 2019.

Matrix models for ε-independence, AMS Sectional Meeting Special Session on Advances in Operator Algebras, University of California, Riverside, November 2019.

Free Stein irregularity, AMS Sectional Meeting Special Session on Advances in Functional Analysis, University of California, Riverside, November 2019.

Matrix models for ε-independence, 17th East Coast Operator Algebra Symposium, The Ohio State University, October 2019.

Asymptotic ε-independence, Classification Problems in von Neumann Algebras Workshop, Banff International Research Station, October 2019.

Free Stein Irregularity, Analysis Seminar, University of Waterloo, July 2019.

A Stein kernel approach to regularity in free probability, Workshop on Applications to Random Matrices and Free Probability of Free Noncommutative Functions, Fields Institute, University of Toronto, June 2019.

Free Stein Information, Kyoto Operator Algebra Seminar, University of Kyoto/RIMS, May 2019.

Free Stein Information, Operator Theory Seminar, University of Virginia, April 2019.

Free Stein Information, Functional Analysis Seminar, University of California, San Diego, April 2019.

Free Stein Information, Free Probability - the theory, its extensions Workshop, Centre de Recherches Mathématiques, Université de Montréal, March 2019.

Free Stein Information, Southern Ontario Operator Algebras Seminar, Fields Institute, University of Toronto, February 2019.

A Bi-free Segal-Bargmann Transform, AMS Sectional Meeting Special Session on Advances in Operator Theory, Operator Algebras, and Operator Semigroups, San Francisco State University, October 2018.

Infinitesimal bi-free probability, Shanks Workshop: Free Probability and Applications, Vanderbilt University, September 2018.

Fisher information and conjugate variables in bi-free probability theory, Quantum Algebra & Quantum Topology Seminar, The Ohio State University, June 2018.

Non-crossing partitions and the combinatorics of free probability, Noncommutative Geometry Seminar, The Ohio State University, June 2018.

Bi-free probability and an approach to conjugate variables, Probability & Statistics Seminar, University of California, San Diego, May 2018.

Bi-free probability and an approach to conjugate variables, Probability Seminar, University of California, Irvine, February 2018.

Bi-free probability and entropy, CMS Winter Meeting Session on Operator Algebras, University of Waterloo, December 2017.

Bi-free probability and an approach to conjugate variables, Extended Probabilistic Operator Algebras Seminar, University of California, Berkeley, November 2017.

Bi-free probability, vaccine, and entropy, AMS Sectional Meeting Special Session on Advances in Operator Algebras, University of California, Riverside, November 2017.

Combinatorics in Free Probability, Combinatorics Seminar, University of California, San Diego, October 2017.

Bi-free probability, Quantum Symmetries: Subfactors and Planar Algebras, University of Hawai'i Maui College, July 2017.

An alternating moment condition and liberation for bi-freeness, Operator Algebras Seminar, University of California, San Diego, February 2017.

Bi-free probability: a new characterisation and consequences, Joint Mathematics Meetings AMS Special Session on Advances in Operator Algebras, Atlanta, Georgia, January 2017.

An Alternating Moment Condition and Liberation for Bi-freeness, Free Probability Seminar, Queen's University, December 2016.

An Alternating Moment Condition and Liberation for Bi-freeness, Analytic versus Combinatorial in Free Probability Workshop, Banff International Research Station, December 2016.

An Alternating Moment Condition and Liberation for Bi-freeness, Extended Probabilistic Operator Algebras Seminar, University of California, Berkeley, November 2016.

An Alternating Moment Condition for Bi-free Independence, 24th West Coast Operator Algebra Seminar, University of Wyoming, October 2016.

An Alternating Moment Condition for Bi-free Independence, Functional Analysis Seminar, University of California, Los Angeles, October 2016.

Free Entropy and Polynomials, Subfactor Seminar, Vanderbilt University, September 2016.

Regularity in Free Probability, Von Neumann Algebras Trimester Seminar, Hausdorff Research Institute for Mathematics, Universität Bonn, June 2016.

Regularity in Free Probability, Free Probability Seminar, Texas A&M University, April 2016.

Standard invariants of amalgamated Bisch-Haagerup subfactors, AMS Sectional Meeting Special Session on Dynamics, Inverse Semigroups, and Operator Algebras, North Dakota State University, April 2016.

Regularity in Free Probability, Operator Algebras & Related Topics Seminar, University of California, Riverside, April 2016.

Regularity of polynomials in non-commuting random variables, Free Probability and the Large N Limit, V, University of California, Berkeley, March 2016.

Regularity of polynomials in non-commuting random variables, AMS Sectional Meeting Special Session on von Neumann Algebras, University of Memphis, October 2015.

Combinatorics of Bi-free Probability, Extended Probabilistic Operator Algebras Seminar, University of California, Berkeley, May 2015.

Bi-free and Combinatorially Bi-free Random Variables, Probabilistic Operator Algebra Seminar, UC Berkeley, April 2014.

Contributed Talks

Permutations, algebraic microstates, and strong 1*-boundedness*, UK Operator Algebras Conference, Newcastle University, June 2024.

Free Stein Dimension, 48th Canadian Operator Symposium, Fields Institute, May 2020.

Free Stein Irregularity, Young Mathematicians in C*-Algebras, University of Copenhagen, August 2019.

Free Stein Information, Great Plains Operator Theory Symposium, Texas A&M University, May 2019.

Bi-free probability, Great Plains Operator Theory Symposium, Texas Christian University, May 2017.

Regularity and Entropy in Free Probability, Young Mathematicians in C*-Algebras, University of Münster, July 2016.

Combinatorics of bi-free probability, Free Probability Theory Workshop, Mathematisches Forschungsinstitut Oberwolfach, June 2015.

Languages

English – native

Welsh – beginner