Paul Druce

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EDUCATION

PhD in Mathematical Physics, *School of Mathematical Sciences, University of Nottingham* 2015 — 2020

Thesis Title: Spectral Geometry of Fuzzy Spaces *Supervisor: Prof. John Barrett*

I developed the understanding of finite non-commutative geometries and how they might be useful in the theory of quantum gravity.

Key skills developed: independent working, public speaking, data analysis using the language Python, knowledge of Monte Carlo simulations.

Mathematical areas: Differential geometry, noncommutative geometry, quantum gravity, representation theory.

BSc MMathPhys (Mathematics and Physics) — First Class, *University of Warwick* 2011 — 2015

Masters Project Title: Multiferroicity Emerging from Frustrated Spin Interactions

Supervisors: Prof. J Staunton and Dr. J Lloyd-Hughes Year 1: 69.3%, Year 2: 82.8%, Year 3: 82.9%, Year 4: 83.0% Overall grade: 81.6%

During my time at Warwick, I studied a wide range of mathematics and physics topics. My interests were in both the abstract mathematics and the physics of matter and its constituents. I became proficient in the programming language C and its use in high-performance computing. I learnt how to implement parallel computing by making use of OpenMP and MPI frameworks.

A Levels: *King Edward VII School, Sheffield, UK: A* A A* 2009 — 2011

GCSE: *GCSEs, Birley Community College, Sheffield, UK: 9 A's, 2 B's and one C.* 2004 — 2009

ACADEMIC ACTIVITIES

Research Interests

My research interests span a wide area within Mathematical Physics. I am deeply interested in the mathematical description of the universe with emphasis on the precise nature of spacetime. With my recent work investigating the use of noncommutative geometry to model spacetimes with a high energy cutoff. I also interested in any novel use of mathematics in physical situations, such as the use of topology and algebraic methods in condensed matter studies.

Outreach

I am an enthusiastic advocate for mathematics and science. I was on the organisational committee for the international festival Pint of Science 2019. I helped organise the Nottingham branch where academics from the University of Nottingham go to the pubs of Nottingham to explain their current research to the public in an understandable manner. I am always looking for ways to bring mathematics and science out of the universities and into public view.

Research Projects

PhD Research Project - Spectral Geometry of Fuzzy Spaces 2015-2020

Keywords: Noncommutative geometry, Monte Carlo simulations, spectral geometry, quantum gravity, symmetries in physics

My PhD research was concerned with the use of finite noncommutative geometries as candidates for quantum spacetimes. These so-called 'fuzzy spaces' possess an energy cutoff whilst retaining Lie group symmetries. My PhD research was to investigate the dimension and volume of these spaces by analysing the spectrum of the Dirac operator. I also investigated the role of Lie group symmetries in restricting the possible fuzzy spaces possible.

Masters Research Project - Multiferroicity Emerging from Frustrated Spin Interactions 2014-2015

Keywords: Solid-state physics, Theoretical physics, mathematical modelling, frustrated systems, quantum mechanics.

During the Masters' year of my undergraduate degree, I undertook a research project, supervised by Prof. J. Staunton and Dr. J Lloyd-Hughes, in which we investigated the various spin configurations of materials with a multiferroic phase. We aimed to identify what was special about these materials spin configurations that caused them to possess a multiferroic phase. This project was conducted with the aim of aiding the design of high temperature multiferroic devices. We specifically studied Cupric Oxide (CuO) which has a multiferroic phase between 213K and 230K, primarily by using mean field model. This project resulted in a functional model which predicted a multiferroic phase at a temperature which is in reasonable agreement with the experimental values.

Undergraduate Summer Research - Knotted Nematics August 2014-September 2014

Keywords: Condensed Matter, Mathematical Physics, Liquid Crystals, statistical physics

This was funded under the Undergraduate Research Scholarship Scheme and was supervised under G P Alexander at The University of Warwick. The main aim of this research was to develop a construction for describing knotted liquid crystals, specifically knotted nematics. We improved upon existing ideas that used Milnor's Fibration Theorem and developed a method to construct the necessary complex polynomial for Milnor's theorem, for a given knot.

Publications

- *The Spectral Geometry of Fuzzy Spaces*, Druce, P.: PhD Thesis (2020).
- *Spectral estimators for finite non-commutative geometries.* Barrett, J., Druce, P., Glaser, L.: J Phys Math Theor. 52, 275203 (2019). doi:10.1088/1751-8121/ab22f8

Grants and Awards

- *Non-commutative Geometry and Quantum Gravity* EPSRC Studentship, funding my PhD studies, hosted by the University of Nottingham (September 2015 - September 2018)
- *Knotted Nematics* - funded as an Undergraduate Research Scholarship Scheme by the University of Warwick, and supervised by Dr G. P. Alexander (August-September 2014).

Talks

— *Noncommutative Geometry and Gravity Models* - given at Collabor8.2 meeting at Lancaster University, UK, May 2018
— *Fuzzy Geometries and Spectral Zeta Functions*- Invited by Lisa Glaser at Radboud University, Netherlands, April 2017
— *Algebraic Knots and Liquid Crystals* - given at the Warwick Imperial Autumn Meeting, 2014 (University of Warwick, UK, November 2014)
— Poster presented at Quantum Gravity on the Computer conference March 2018.

Conferences Attended

— Gauge Theories and Noncommutative Geometry - Nijmegen, April 2016, `http://www.noncommutativegeometry.nl/ncg2016/`
— Quantum Structure of Spacetime - Belgrade, August 2016, `http://qssg16.ipb.ac.rs/`
— Quantum Spacetime - Porto, January 2017, `https://www.fc.up.pt/quantumspacetime17/`
— Talking Maths in Public - Bath, September 2017, `http://talkingmathsinpublic.uk/`
— Quantum Spacetime and Physics Models - Corfu, September 2017, `http://www.physics.ntua.gr/corfu2017/qg.html`
— Quantum Structure of Spacetime - Sofia, February 2018, `http://theo2.inrne.bas.bg/~dobrev/QST-18.htm`
— Quantum Gravity on the Computer - Stockholm, March 2018, `https://agenda.albanova.se/conferenceDisplay.py?confId=6242`
— Collabor8.2 - Lancaster, May 2018, `http://www.collabor8research.com/`
— Physical Applications of Fuzzy Spaces - Brussels, January 2019

Miscellaneous

PhD Reading Groups: I have participated in and co-organised many reading groups on topics including Loop Quantum Gravity, Characteristic Classes and C* algebras.

TEACHING EXPERIENCE

— *Academic Tutor and Mentor* Aug 2017 - Current

I am an experienced tutor in mathematics and physics at the levels of university, A level and GCSE. I also mentor students for various mathematical entrance exams and the UKMT mathematical competitions. I have vast experience in both face-to-face tutoring and online tutoring via shared online whiteboards. I prepare lessons and question sheets at appropriate levels for my tutees. My role is to build the confidence and the abilities of my students and provide them with a comfortable environment to ask any questions they may have.

— *Official UKMT Volunteer Mentor* Oct 2020 - Current

I am a volunteer for the UK Mathematics Trust. My role involves mentoring the students who are entering the advanced UKMT competitive mathematics exams. I am also involved in various outreach projects that the UKMT organise. I aid with the creation of appropriate questions and aid in the distribution via social media.

— *PhD Demonstrating and Marking* Oct 2015 - Jul 2019

I was employed to aid students with their studies for various undergraduate mathematics modules. I catered for students from the mathematics, physics and engineering departments. The courses I assisted with are:

- Introduction to Mathematical Physics (2nd year) 2015-2019
- Mathematics for Physics and Astronomy (1st year) - 2015-2019
- Calculus and Linear Algebra (1st year for Natural Science students) 2018-2019
- Applied Mathematics (1st year) 2017-2018
- Mathematical Analysis (2nd year) 2018-2019
- Differential Equations and Fourier Analysis (2nd year) 2016-2017
- Fluid Dynamics (3rd year) 2015-2016

— *Noncommutative Geometry Seminar Series for Master Students* Oct 2016 - Apr 2017

I organised and delivered a two-semester long seminar on the topics surrounding my research to masters students at the University of Nottingham. This voluntary course was popular and regularly attended by around 10 masters' students and resulted in two of the students pursuing the area further outside of the seminar.

— *Undergraduate Revision Classes* 2012-2015

As part of the Warwick Physics Society, I updated and maintained revision guides and, I organised and ran revision lectures on various topics. I also provided workshops for the course in C programming, for first time programmers, to help them understand the language and develop the programming mentality.

PROFESSIONAL EXPERIENCE

— *Academic Tutor, self employed at MyTutor* Aug 2017 - Current

I am a self employed academic tutor for mathematics and physics for all levels of schooling. I prepare lessons and question sheets at appropriate levels for my tutees. My role is to build the confidence and the abilities of my students and provide them with a comfortable environment to ask any questions they may have. I have an Enhanced DBS check and I am trusted by schools to give one-to-one tutorials to their students via the company MyTutor, see my profile `https://www.mytutor.co.uk/tutors/58270`.

— *Postgraduate Demonstrator at the University of Nottingham* Sep 2015 - Jul 2019

Throughout my PhD I was an assistant in many of the courses ran by the School of Mathematical Sciences. I was entrusted to run small group tutorials (typically around 10 people) for courses in mathematical physics as well as aiding in the running of problems classes for many of the courses. I also helped mark coursework for the courses as well as marking the end of year exams of some of the courses.

— *Open Day Assistant at the University of Warwick* Sep 2012 - Jul 2015

Throughout my undergraduate degree I was part of the open day team for the Physics department at Warwick university. My role included taking the prospective students on tours of the campus, informing them of important and interesting aspects of the university. I was also given the responsibility to present experiments to prospective students, engaging them with thought provoking questions. I was also part of the team to inform the prospective students about the courses available by the Physics department and answer any questions they may have about life at university.

— *Administrative Worker at Split The Bills Ltd.* Aug-Sep 2012

My roles in this temporary role was to communicate with the student registering for the service and then contact utility providers to setup the new accounts. Handling any issues that would arise in a timely and professional manner.

— *Warehouse Operative at River Island* 2010-2011

I was part of the team that unpackaged new deliveries of clothes and prepare clothing to be presented on the store floor. This required adaptability as each delivery changed in size. As well as good team work and communication as the unpacking procedure was split in to various stages, with a separate person per stage. As well as working in an efficient manner. I was also responsible for searching and retrieving clothing requested by the store front.

— *Voluntary Sale Assistant at British Heart Foundation* 2010-2011

My role at the British Heart Foundation included assisting customers in finding items, informing them about the charity and maintaining the store. As the British Heart Foundation has a wide range of customers and staff, I had to quickly learn to adapt my communication and sales approach to fit their needs and situation.

Skills

— Experienced using LaTex (including TikZ and beamer) and the Microsoft Office suite to produce high quality documents.
— High performance computing in C, data analysis in Python and Mathematica, experienced using Git and Github/Bitbuckets for collaborative development.
— Experience using Linux, macOS and Windows environments.
— Experience using online mathematical education software such as STACK, Moodle, Maxima.
— Basic knowledge of web development and mathematical software for online mathematical content (MathJax, p5js and manim animations etc).
— Enhanced DBS check and full drivers license
— Internet of Things development using ESP8266/ESP32 and other devices i.e. Arduino framework, ESP-IDF framework, Micropython as well as how to use PlatformIO.