Paul Druce's Curriculum Vitae

pjdruce@gmail.com

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Current responsibilities

Consulting Engineering at MachineWorks May 2021 - Current I aide commercial 3D software developers implement and use MachineWorks software for a wide variety of applications, using the languages C, C++ and C#.

I also create demonstrative applications to show case MachineWorks software in new markets.
This includes the creation of new workflows and GUI applications.
I also develop algorithms and create example code for customers to use in their products to facilitate their products to market faster.

When Covid restrictions are eased sufficiently, I will be providing direct support to evaluating developers through on-site training to ensure new evaluations and integrations are rapid and successful.

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. I also possess an Enhanced DBS check and I am trusted by schools to give one-to-one tutorials to their students via the company MyTutor. You can see student reviews and further details here: https://www.mytutor.co.uk/tutors/58270.

Official UKMT Volunteer Mentor October 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 of content via social media.

Skills

- Experienced in high performance computing and commercial software in C and C++.
- Experienced using Git and Perforce for collaborative development.
- Experience in data analysis using Python and Mathematica.
- Web development, including animations; HTML/CSS/JavaScript.
- Experienced using LaTex (including TikZ and beamer) and the Microsoft Office suite.
- Experience using Linux, macOS and Windows environments.
- Proficient in the following programming languages: C, C++, C#, Python, HTML/CSS/JavaScript and Mathematica.
- Internet of Things development using ESP8266/ESP32 and other devices, i.e., Arduino framework, ESP-DF framework, micropython as well as how to use PlatformIO.
- I have a valid First Aid Certificate (2017-2020) (planned to renew once COVID restrictions are eased). I also have a full drivers licence and motorcycle licence.

Education

PhD in Mathematical Sciences, University of Nottingham, UK: *2015 -2020 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. **Mathematical areas studied:** Differential geometry, non-commutative geometry, quantum geometry, representation theory. **Key skills developed:** independent working, public speaking, data analysis using Python, knowledge of Monte Carlo simulations

For my PhD I worked on an area of mathematics called non-commutative geometry and how it might be useful in the theory of quantum gravity. My research was to investigate the use of called *fuzzy spaces* as candidates for quantum spacetimes. I investigated 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.

In pursuit of my research I developed my knowledge of data analysis using the language Python. I also became familiar with the workings of Monte Carlo simulations and the application of machine learning to physical problems. A topic I am very interested in pursuing further.

First Class Masters in Mathematics and Physics, University of Warwick, UK: *2011-2015 Masters Dissertation: 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. Here is a list of topics I studied during my time at Warwick: Real Analysis, Differential Equations, Groups and Rings, Complex Analysis, Classical Mechanics, Statistical Physics, General Relativity, Solid State Physics, Fluid Dynamics and many more. I maintained an average grade of 81% throughout my course achieving one of the best marks in the year. I became proficient in the programming language C and its use in high-performance computing. I learnt how to implement parallel computing by making us of OpenMP and MPI frameworks.

A Levels, King Edward Vi Sixth Form, Sheffield, UK: *2009 - 2011* Maths: A*, Physics: A, Chemistry: A.

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

Teaching Experience

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

  Alongside my PhD, I was employed to help students with their questions for various undergraduate mathematics modules for Engineering students, Physics students and Mathematics students. This includes courses such as Introduction to Mathematical Physics (2nd year), Differential Equations and Fourier Analysis (2nd year), Applied Mathematics (1st year) and more. I also mark the mid-term exams and coursework for various modules.

    - Introduction to Mathematical Physics (2nd year) 2015-2019

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

- **Non-commutative Geometry Seminar Series for Master Students Oct 2016 - Apr 2017**

  I organised and delivered a seminar on topics surrounding my research over the course of two semesters. The seminar was delivered to masters students at the University of Nottingham. The was regularly attended by around 10 students despite it not being for credit towards their degree. The course resulted in two students choosing noncommutative geometry as the subject for their masters dissertation, and one of the students chose to undertake a PhD with my supervisor. Some lecture notes suitable for a UK masters student were developed on the foundational results of non-commutative geometry.

- **Undergraduate Revision Classes 2012-2015**

  As part of the Warwick Physics Society:

  - I updated and maintained revision guides
  - I organised and ran revision lectures on various topics
  - I provided workshops to run alongside a university course. These were aimed at first time programmers in C programming, to help them understand the language and develop the programming skills necessary.

Other Professional Experience

- **Open Day Assistant at the University of Warwick September 2012 - July 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-September 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.

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.

Past Research Projects

PhD Research Project - Spectral Geometry of Fuzzy Spaces 2015-2019

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

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

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