Homepage:

I am a mathematician currently working as a doctoral student at the University of Bristol. This site is a hub for my work and productions, as well as providing a platform for me to discuss my interests.

My mathematical work currently centres on the application of functional analysis, geometry and topology to problems in quantum mechanics and quantum field theory. Beyond this my mathematical interests span many fields including, but not limited to, quantum information and dynamical systems.

In addition to my academic work, I have undertaken many of my own projects which can be found on this site. Since my time as an undergraduate student, I have produced YouTube videos explaining topics in mathematics and physics, as well as discussing life and university and science more generally. These videos have a combined view count of over 20,000. I also have several of my own programming projects, developing new systems to overcome interesting technical challenges.

The painting of Durham in the header is by Stephen Ward Art, whose work can be purchased at https://www.stephenward-art.co.uk/. I believe the view over Durham city centre to be one of the most beautiful and inspiring anywhere in the world.

Biography:

Until 2022, I studied mathematics and physics at St John’s College, Durham. During my degree I studied many broad areas and attained a high level of knowledge in quantum mechanics, analysis, particle physics, general relativity, condensed matter physics and continuum mechanics. My master’s dissertation described mathematical models for the mechanics of the violin. I maintain strong connections with my old college.

After completing my studies in Durham, I moved to the School of Mathematics in Bristol to work under the supervision of Professor Jonathan Robbins (currently Head of School) and Dr Tomasz Maciazek (currently Vice Chancellor’s Fellow). Our work focuses on the mathematical description of a class of particles called anyons which exist only in two-dimensional systems and their quantum behaviour on networks of nanowires. We have worked in collaboration with researchers at other institutions around the world. I have also assisted in the teaching of first year and third year modules.

Research:

My research toward my PhD is in the field of mathematical physics, specifically in the study of anyons in quantum mechanics While in three dimensional quantum systems there are two classes of particles, being fermions and bosons, when two dimensional systems are studied it is known that particles may fall into a more general classification. These particles are know as anyons because they can hold any quantum statistics, and their behaviour is characterised by a parameter between zero and one known as the fractional statistics parameter. If this parameter is set to zero or one then bosonic or fermionic behvaiour is recovered respectively. The worldlines of anyons form braids through 2+1-dimensions, and the exact braiding of these particles effects their quantum state.

Anyons have been used as a model for particles in order to describe a mysterious physical phenomenon called the fractional quantum Hall effect, and have been proposed as a route to fault-tolerant quantum computing due to their topological nature. Architectures for topological quantum computers often involve the exchange of anyons around junctions in a network of nanowires. The goal of my PhD project is to develop the quantum theory for anyons on wire networks.

Recent additional research in my group has studied the natural orbitals and occupation numbers in anionic systems. The natural occupation numbers can be thought of as the amplitudes of orbitals when the ground state of a many-particle quantum system is approximated with single-particle orbitals. We found that these occupation numbers decay more slowly for two-dimensional anyons than for three-dimensional electrons, establishing a greater correlation for particles in two-dimensions.