BARINDER SINGH BANWAIT

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ABOUT

Research mathematician with industry experience in surgical robotics and quantitative finance. 10+ articles in peer-reviewed pure mathematics journals. Expert in isogenies for elliptic curves over number fields. Has worked on machine learning projects involving sensor data as well as mathematical data.

SKILLS

Number Theory | Python | C/C++ | Modelling | Research | Teaching | Machine learning | Robotics

CURRENT POSITION

Postdoctoral researcher

Boston University

Sep 2022 – present — Boston, MA, USA

My research is in **computational number theory**: how computer software systems can be used to solve open problems about the whole numbers. I have worked mainly with **elliptic curves** over number fields, and the maps between them ('isogenies'), proving results that generalize classical results from the 60s. See my list of publications below for more.

Recently I have become interested in **formal verification** of mathematics, and using strongly-typed functional programming languages to build a database of mathematical statements and proofs that a computer can understand, and that an AI can one day be trained upon. My latest research paper is an effort in this direction.

FORMER INDUSTRY POSITIONS

Quantitative Analyst

Quantile

Sep 2019 – Mar 2020 — London, UK

- Linear, mixed-integer, and multi-objective optimisation for compression of interest-rate derivative portfolios using Gurobi.
- Visualisation of FX trading datasets across several client investment banks.
- Modelling of reset risk and PV01 for swaptions.
- Git code management with Bitbucket.

Research Engineer

CMR Surgical

Jan 2018 – Sep 2019 — Cambridge, UK

- Research and optimisation of robotic control algorithms, including inverse kinematics and mass-spring-damper models.
- Path planning for collision-free end-effector motion.
- Mathematical modelling in Matlab, with Robotics and Control Systems toolboxes.
- Writing production-level, safety-critical embedded C code, compliant with MISRA C and International Standard IEC 62304.
- Time-series telemetry processing of sensor data in Python, using pandas, numpy, and matplotlib.
- Analysis and visualisation of system log messages with Elasticsearch and kibana.
- Development with Amazon Web Services, including Lambda, S3, and Athena.
- Implementing machine learning algorithms for robot arm condition monitoring, using scikit-learn and Tensorflow.
- Unit and Regression tests in C, C++, and Matlab, including Google Test framework, continuously integrated with TeamCity.
- Agile software development with SVN and Git.

FORMER ACADEMIC POSITIONS

Ruprecht-Karls-Universität Heidelberg

Oct 2021 – Apr 2022 — Heidelberg, Germany

Harish-Chandra Research Institute
Feb – Sep 2021 — Prayagraj, India

Max-Planck-Institut für Mathematik
Oct 2016 – Nov 2016 — Bonn, Germany

Universität Duisburg-Essen
Jan 2015 – Jan 2017 — Essen, Germany

Institut national de recherche en informatique et en automatique (INRIA)
Jan – Dec 2014 — Bordeaux, France

In the above positions, also lectured the courses: Abelian Varieties, Computational Number Theory, Prime numbers and Cryptography, Algebraic Surfaces, Binary quadratic forms, Linear Algebra.

EDUCATION

PhD Mathematics
University of Warwick
Jan 2010 – Sep 2013 — Coventry, UK

Supervisor: Prof. John Cremona

BA and MMath Mathematics
University of Cambridge - Christ's College
Oct 2005 – June 2009 — Cambridge, UK

MMath (*Part III of the Mathematical Tripos*) - Distinction

PAPERS AND PREPRINTS

1. **Machine Learning Approaches to the Shafarevich-Tate Group of Elliptic Curves**, with A. Babei, A. Fong, X. Huang and D. Singh. To appear, *Advanced in Theoretical and Mathematical Physics* (2025).
2. **Torsion subgroups of elliptic curves over quadratic fields and a conjecture of Granville**, with M. Derickx. To appear, *Algorithmic Number Theory Symposium XVI* (2024).
3. **Towards strong uniformity for isogenies of prime degree**, with M. Derickx. Submitted, *arXiv:2302.08350* (2024).
4. **Computing nonsurjective primes associated to Galois representations of genus 2 curves**, with A. Brumer, H. J. Kim, Z. Klagsbrun, J. Mayle, P. Srinivasan and I. Vogt. *Contemporary Mathematics 796* (2023).
5. **Modularity over $\mathbb{C}$ implies modularity over $\mathbb{Q}$**. To appear, *Modularity and the Generalised Fermat Equation*, *arXiv:2212.14412* (2022).
6. **Explicit isogenies of prime degree over number fields**, with M. Derickx. To appear, *Algebra and Number Theory*. *arXiv:2203.06009* (2022).
7. **Cyclic isogenies of elliptic curves over fixed quadratic fields**, with F. Najman and O. Padurariu. *Mathematics of Computation* (2023).
8. **Explicit isogenies of prime degree over quadratic fields**. *International Mathematics Research Notices*. 2023(14):11829–11876 (2023).
9. **Examples of abelian surfaces failing the local-global principle for isogenies**. *Research in Number Theory*. 7(55) (2021)
10. **Correction: Examples of abelian surfaces failing the local-global principle for isogenies**. *Research in Number Theory*. 8(98) (2022)
11. **Del Pezzo surfaces over finite fields and their Frobenius traces**, with F. Fité and D. Loughran. *Mathematical Proceedings of the Cambridge Philosophical Society*. 167(1) (2019) 35-60.
12. **Tetrahedral Elliptic Curves and the local-global principle for isogenies**, with J. Cremona. *Algebra and Number Theory*. 8:5 (2014) 1201-1229.
13. **On some local to global phenomena for abelian varieties**. PhD Thesis, University of Warwick (2013).

OPEN SOURCE SOFTWARE CONTRIBUTIONS

Member of the *L-functions and Modular Forms Database*. 15 pull requests merged since October 2020 across the codebase, including Classical and Bianchi Modular Forms, Testing utilities, and Dirichlet Characters.

Absolutely simple endomorphism rings - Sage

2021

- First functionality to check for geometric simplicity of Jacobians of genus 2 curves over $\mathbb{Q}$. Released in sage-9.5.

REFEREE DUTIES FOR JOURNALS

Mathematics of Computation | International Journal of Number Theory | Algebra and Number Theory | Research in Number Theory | Acta Arithmetica | International Mathematics Research Notices | Algorithmic Number Theory Symposium

LANGUAGES

English | ਪੰਜਾਬੀ (Punjabi) | Deutsch | हिंदी (Hindi) | Français