BARINDER SINGH BANWAIT

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RESEARCH INTERESTS

Computational Number Theory | Galois Representations | Abelian Varieties

ACADEMIC APPOINTMENTS

Postdoctoral researcher in Mathematics

Harish-Chandra Research Institute

Jan 2021 – Present Prayagraj, India

Postdoctoral researcher in Mathematics

Universität Duisburg-Essen

Jan 2015 – Jan 2017 Essen, Germany

Working in group *Algebraische Geometrie und Zahlentheorie*. Mentor: Prof. Dr. Ulrich Görtz.

Visiting Scientist

Max-Planck-Institut für Mathematik

Oct 2016 – Dec 2016 Bonn, Germany

Research visit to Dr. Alex Bartel (who himself was visiting Prof. Hendrik Lenstra).

Postdoctoral researcher in Mathematics

Institut national de recherche en informatique et en automatique (INRIA)

Jan – Dec 2014 Bordeaux, France

Working in group *Théorie algorithmique des nombres rapide et flexible*. Mentor: Dr. Andreas Enge.

PAPERS AND PREPRINTS

- **Explicit isogenies of prime degree over quadratic fields**. *arXiv:2101.02673*. 2021.
- **Examples of abelian surfaces failing the local-global principle for isogenies**. *arXiv:2007.13583*. 2020, submitted.
- **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.
- **Tetrahedral Elliptic Curves and the local-global principle for isogenies**, with J. Cremona. *Algebra and Number Theory*. 8:5 (2014) 1201-1229.

IN PREPARATION

- **On** $X_0(79)(\mathbb{Q}(\sqrt{5}))$, with M. Derickx. Appendix to **Explicit isogenies of prime degree over quadratic fields** (see 'Papers and Preprints' above).
- **Computing non-surjective primes associated to Galois representations of genus** 2 **curves**, with A. Brumer, H.J. Kim, Z. Klagsbrun, J. Mayle, P. Srinivasan and I. Vogt.

INDUSTRY EXPERIENCE

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.
- Modelling of reset risk and PV01 for swaptions.

- Analysis of trading data and software development in Python and AMPL.
- Git code management with Bitbucket.

Research Engineer

CMR Surgical

Jan 2018 – Sep 2019 | Cambridge, UK

Transforming Surgery. Developing the next-generation robotic surgical system.

- Research and optimisation of robotic control algorithms, including inverse kinematics and mass-spring-damper models.
- Key achievements include halving the control loop time of the robot arm, ensuring the joints keep away from their limits during surgical use, and preventing self-collision of the arm.
- 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 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.

EDUCATION

PhD Mathematics

University of Warwick

Jan 2010 – Sep 2013 | Coventry, UK

Supervisor: Prof. John Cremona
Thesis: On some local to global phenomena for abelian varieties

BA and MMath Mathematics

University of Cambridge - Christ's College

Oct 2005 – June 2009 | Cambridge, UK

MMath (*Part III of the Mathematical Tripos*) - Distinction
Part III Essay: Class Field Theory (Cohomological Approach), supervised by Dr. Tim Dokchitser

GCSEs and A-Levels

Langley Grammar School

Sep 1998 – June 2005 | Langley, UK

10 GCSEs, all A*. 3 A-Levels (Maths, Further Maths, Chemistry), all A

INVITED TALKS

(selected)

- *Explicit isogenies of prime degree over quadratic fields*, Zagreb Number Theory Seminar, Zagreb and online, Jan 2021
- *Tetrahedral Elliptic Curves and the local-to-global principle for isogenies*, Indian Institute of Science Education and Research, Pune, Jan 2020
- *Traces of Frobenius and an inverse Galois Problem for cubic surfaces over finite fields*, Explicit Methods in Number Theory; Conference in honour of John Cremona's 60th Birthday, Warwick, Apr 2016
- *Courbes elliptiques tétraédriques et le principe local-global pour les isogénies*, Clermont-Ferrand Number Theory Seminar, June 2014

ACADEMIC MEMBERSHIPS

Member of the *L-functions and Modular Forms Database*. 8 pull requests merged since October 2020 across the codebase, including Classical and Bianchi Modular Forms, Testing utilities, and Dirichlet Characters.

MATHEMATICAL CODING PROJECTS

available on my GitHub

Quadratic Isogeny Primes - Python, Sage, PARI/GP

2021

- Command-line tool to compute superset of isogeny primes for given quadratic field (not imaginary quadratic of class number one).
- Released under GNU General Public License version 3 and later.

Download Bianchi Modular Form Data from LMFDB - Python, Sage, Magma

2020

- Add functionality to download Hecke eigenvalues of a Bianchi modular form from its LMFDB homepage, into Sage and Magma (LMFDB Issue #4053).
- Sage code yields a dictionary of the eigenvalues, Magma code further constructs the form as a `ModFrmBianchi` object.

Integrally Closedness - Lean

2020

- Formalisation of absolute and relative definitions of an integrally closed integral domain.
- Proving equivalence of definitions (work in progress):

```
lemma equiv_int_closed_abs_rel (R : Type u) (A : Type v) [integral_domain R] [comm_ring A] [algebra R A]
(ϕ : fraction_map R A): is_integrally_closed R ↔ is_integrally_closed_in R A
```

Human Activity Classifier - Tensorflow

2019

- Training a deep neural network to classify human activity from sensor data recorded by a Samsung Galaxy SII.
- 6 categories - walking, walking upstairs, walking downstairs, sitting, standing, lying.
- 92% accuracy with model consisting of 3 densely-connected neural layers and 5 epochs of training.

Elliptic Curve Diffie-Hellman Protocol - Sage

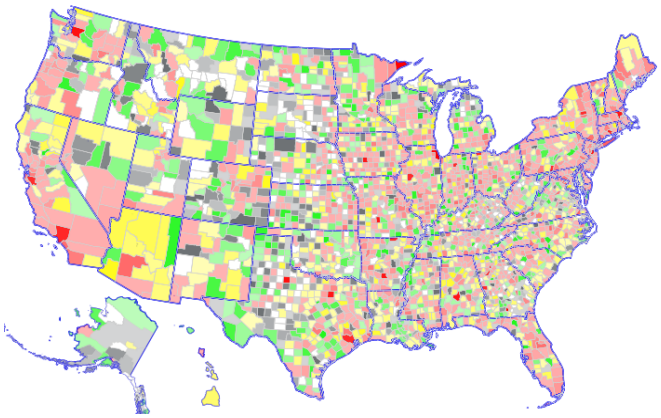
2017

- Implementation of public-key cryptosystem developed by Diffie and Hellman.
- Encryption involves randomly chosen element from a finite extension of base field.

H-1B Visa Applications - pandas, scikit-learn, Basemap in matplotlib

2017

- Cleaning and analysing US visa application data from 2014-17.
- Producing datamap of US counties according to application density.
- Predictively modelling salary and visa decision, the latter to 90% accuracy using a random forest classifier.



Filling US counties by successful H-1B visa application density

RESEARCH SEMINAR TALKS

(selected)

- *Harder-Narasimhan truncations in Vincent Lafforgue's proof of the Global Langlands correspondence*, Langlands Parameterisation over Function Fields, Essen, December 2016. Organiser: Prof. Dr. Jochen Heinloth
- *Formal Group Laws and Formal A-Modules*, The Lubin-Tate Tower and its p-adic cohomology, Essen, October 2015. Organiser: Prof. Dr. Ulrich Görtz
- *The Theorems of Bhargava-Shankar*, Ranks of Elliptic Curves, Essen, May 2015. Organiser: Prof. Dr. Massimo Bertolini

TEACHING EXPERIENCE

Course Lecturer

Vertiefung Zahlentheorie

Apr - July 2016 — Essen, Germany

Representability of primes via quadratic forms - from Fermat, Euler, Gauss, and to Artin Reciprocity. Contact time comprised three hours per week, for 15 weeks. Lectures given in German.

Einführung in das Computer-Algebra-Paket *Sage*

Sep 2015 — Essen, Germany

Introductory week-long short-course on *Sage*, aimed at final year undergraduates. First half of week devoted to overview of main features of *Sage*, the second half to programming, and to implementing their very own RSA cryptosystem. Course given in German.

Algebraic Number Theory

July 2009 — Linyi, China

Introductory course at summer-school aimed at second year undergraduates. Topics included: Rings of integers, failure of unique factorisation in some Dedekind rings, class number computations, applications to solving Pell equations.

Seminar Organiser

Algebraic Surfaces

Oct 2015 - Jan 2016 — Essen, Germany

Masters level seminar, organised with Prof. Görtz. We lectured on the foundations: Sheaf cohomology, Serre duality, and intersection theory. Students chose more advanced, specialist topics to give a 90-minute talk on, and obtained credits subject to delivering a satisfactory talk.

Teaching Assistant

A teaching assistant marks the student assignments, and organises a support class to discuss the questions and other problems.

Linear Algebra	Apr - July 2015	Vytautas Paškūnas	Universität Duisburg-Essen
Modular Forms	Oct - Dec 2012	Mehmet Haluk Şengün	University of Warwick
Algebraic Number Theory	Jan - Mar 2012	Johan Bosman	University of Warwick
Elliptic Curves	Oct - Dec 2011	Lassina Dembélé	University of Warwick
Algebraic Number Theory	Jan - Mar 2010	William Hart	University of Warwick

Undergraduate Supervisor

Oct 2010 - Apr 2013 — University of Warwick

A supervisor is assigned groups of 5 students. The supervisor marks the assignments of his/her students, meets the students twice a week for one hour each, and discusses the assignments and other material on the courses which the students are studying, across both pure and applied disciplines.

STEP Mentor

Apr 2007 – 2009 | University of Cambridge

The Sixth Term Examination Papers (STEP) are the *de facto* entrance exam for Mathematics at Cambridge University, and offers are made conditional on a satisfactory grade in STEP. Some schools can provide their students holding conditional offers help in these exams, but many cannot. The University Admissions Office considers this unfair to students from state schools.

A STEP mentor is assigned a group of 10 A-level students holding such a conditional offer, whose own schools cannot help them with preparation. The mentor's role is to prepare the students for the STEP entrance examination, by organising classes and lessons on the STEP questions, and generally helping the students mathematically. This takes place during a week in April each year. I was a STEP mentor in 2007, 2008 and 2009.

This serves to increase access to Cambridge from diverse backgrounds of students.

AWARDS

Engineering and Physical Sciences Research Council, UK

Jan 2010

- Full funding for PhD studies.

Institute for Advanced Study, Princeton NJ, USA

Jul 2008

- Full funding to attend Park City Mathematics Institute conference on Algebraic Geometry in 2008.

Whelan Prize

Oct 2007

- Awarded by Christ's College, University of Cambridge, for outstanding examination performance (top of college in mathematics).

Nuffield Trust, UK

Jul 2007

- Undergraduate Research Bursary to conduct a summer research project.
- Supervisor: Dr. Jon Bevan, University of Surrey, UK.

REFEREE DUTIES FOR JOURNALS

Mathematics of Computation | International Journal of Number Theory | Algebra and Number Theory

LANGUAGES

English	●●●●●●	**Python**	●●●●●○
ਪੰਜਾਬੀ	●●●●●○	**Sage**	●●●●○○
Deutsch	●●●●○○	**C**	●●●○○○
हिंदी	●●●○○○	**Matlab**	●●●○○○
Français	●●●○○○	**Magma**	●●●○○○
Lean	●○○○○○	**C++**	●○○○○○