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EDUCATION & EMPLOYMENT

- Postdocs at the Institute for Advanced Study, UCL, and the University of Sheffield
- PhD in mathematics from Imperial College London
  Thesis: "On the locally reducible part of the eigencurve" `doi.org/10.25560/68086`
  I received the "president's PhD scholarship", which is a competitive scholarship that fully funded my PhD studies.
- BSc & MMath in mathematics from the University of Oxford
  I graduated with "first-class honours" in all four years. I received the "junior mathematical prize" for ranking top 3 in my generation on the final exams in mathematics; the "reach Oxford scholarship", which is a competitive scholarship (2 or 3 are awarded each year) that fully funded my undergraduate studies; and the "Clothworkers' scholarship", awarded by St. Catherine's College of the University of Oxford.

PUBLICATIONS

8 "The p-adic Kakeya conjecture"
J. Amer. Math. Soc. **37** (2024), 69–80 `doi.org/10.1090/jams/1021`

The classical *Kakeya conjecture* states that all compact subsets of $\mathbb{R}^n$ containing a line segment of unit length in every direction have full Hausdorff dimension. This article proves the natural analogue of the classical Kakeya conjecture over the p-adic numbers — more specifically, that all compact subsets of $\mathbb{Q}_p^n$ containing a line segment of unit length in every direction have full Hausdorff dimension — a conjecture which was first discussed in the 1990s by James Wright. More generally, this article proves the p-adic analogue of the *Kakeya maximal conjecture,* which is a functional version of the Kakeya conjecture proposed by Jean Bourgain in the 1990s.

This result was mentioned in Quanta Magazine in the articles "A Question About a Rotating Line Helps Reveal What Makes Real Numbers Special" and "The Year in Math". I gave a talk at the Institute for Advanced Study titled "Non-Archimedean Harmonic Analysis" discussing the history of the problem and future directions. It is available at `youtu.be/wTwNBu6nOp0`.

7 "On the Minkowski dimension of certain Kakeya sets"
Mat. Bilten **46** (2022), 77–82 `doi.org/10.37560/matbil22462077a`

An early draft of article #8 proved a special case concerning Minkowski dimension by using a more specialized combinatorial argument. The referees for #8 suggested that this is of independent interest, and that it should be published as a separate article. Thus, this article documents that argument.

6 “Limiting measures of supersingularities”
Preprint arXiv:1911.12220

This article proves that the measures of p-adic supersingularities of certain modular forms are concentrated away from the interval $(\frac{1}{p+1}, \frac{p}{p+1})$ when the prime p is regular, making progress toward a conjecture of Fernando Gouvêa from 2001.

5 “On the reductions of certain two-dimensional crystalline representations, II”
Preprint arXiv:1808.03224

This article is a continuation of #4, and it proves the Breuil–Buzzard–Emerton conjecture for *all* slopes up to $\frac{p-1}{2}$.

4 “On the reductions of certain two-dimensional crystalline representations”
Doc. Math. **26** (2022), 1929–1979 doi.org/10.25537/dm.2021v26.1929-1979

A conjecture of Breuil–Buzzard–Emerton from 2005 states that if certain representations of the absolute Galois group of $\mathbb{Q}_p$ are reducible and have even weights, they must have integer slopes. This article proves the Breuil–Buzzard–Emerton conjecture for *some* slopes up to $\frac{p-1}{2}$.

3 “On the reductions of certain two-dimensional crystabelline representations”
Res. Math. Sci. **8** (2022), #12 doi.org/10.1007/s40687-020-00231-6

A conjecture of Buzzard–Gee from 2015 states that if certain representations of the absolute Galois group of $\mathbb{Q}_p$ are reducible, they must have integer normalized slopes. This article proves that, contrary to expectations, there exist such representations with half-integer slopes, and it classifies all counterexamples for slopes up to $\frac{p-1}{2}$.

2 “Additive bases via Fourier analysis”
Combin. Probab. Comput. **30** (2021), 930–941 doi.org/10.1017/S0963548321000109

This article proves that the additive span of a small number of generating sets for a finite Abelian group contains a coset of a large subgroup, making progress toward the so-called additive basis conjecture.

1 “A proof of Snevily’s conjecture”
Israel J. Math. **182** (2011), 505–508 doi.org/10.1007/s11856-011-0040-6

This article proves a conjecture of Hunter Snevily, which states that for any positive integer k and any two k-element subsets $\{a_1, \dots, a_k\}$ and $\{b_1, \dots, b_k\}$ of a finite Abelian group of odd order there exists a permutation $\pi \in S_k$ such that all k sums $a_i + b_{\pi(i)}$ are pairwise distinct.

Snevily’s conjecture was discussed in a section of the book “Additive Combinatorics” by Terence Tao and Van Vu. At the time, the conjecture was 10 years old, and partial results had been obtained by Noga Alon (in the case of cyclic groups of prime order) and Dasgupta–Károlyi–Serra–Szegedy (in the case of cyclic groups of composite order).

I gave a talk at the University of Cambridge titled “On a Conjecture of Snevily” discussing the proof. It is available at www.newton.ac.uk/seminar/4981.