Benjamin Percival

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https://benjaminpercival.github.io/cultivatingthegrapevine

Research Summary

Building on a rigorous background in theoretical physics and mathematical modelling, I shifted my focus to applying these skills in climate science. My work now centres on developing and refining numerical models to accurately predict atmospheric processes. I have an interdisciplinary mindset and aptitude for communicating complex scientific concepts.

EDUCATION

Doctorate in Philosophy (Theoretical Physics)

10/2017– 07/2022

University of Liverpool, specialising in String Theory and Particle Phenomenology

MSc Natural Sciences (Maths and Physics) – 1st Class Honours

10/2012– 07/2016

Durham University

WORK EXPERIENCE

Postdoctoral Research Associate in Air Pollution Modelling

04/2024–Present

Manchester Metropolitan University, Department of Natural Sciences

Research achievements

Data analysis and simulations of air pollutant dispersion at airport sites:

- ★ Managed and processed **large data sets** using **SQL and Pandas** for efficient data analysis.
- ★ Utilised **QGIS and PyQGIS** for spatial mapping and visualisation of dispersion patterns and environmental impacts.
- ★ Solving systems of mass balance equations, **forecasting** expected pollutant concentration levels and presenting results to an international research consortium**,** as part of **environmental assessment to provide policy recommendations** for European aviation.

Postdoctoral, Honorary and PhD Researcher in String theory

09/2017–03/2024

University of Liverpool, Department of Mathematical Sciences

Research achievements

Spearheaded a cross–disciplinary **collaboration with AI researchers** at University of Liverpool applying advanced computing methods to fundamental physics, in particular:

- ★ Applied advanced **SAT and SMT algorithms** to solve large constraint systems to achieve orders of magnitude speed–up compared to previous techniques [2].
- ★ Applied **High Performance Computing** to efficiently enumerate solutions– **parallelisation**, **cloud computing** (AWS and Google Cloud) and **JIT compilation** with Numba in Python.

- ★ Developed **open-source Python package** for string theory model building [3].
- ★ Implemented **Autoencoder Neural Network** to reconstruct input data of string models [1].
- ★ Implemented **quantum annealing** to solve string constraints to significantly speed up classification.

Published **14 publications in top scientific journals** [1,2,4,5,6,7,8,9,10,11,12,13,14,15] tackling **mysteries in fundamental physics** for string models I constructed, including supersymmetry breaking [11,12], moduli stabilisation [13] and the cosmological constant problem [10,11]. Within this work, I have::
- ★ Developed programs to perform **numerical analysis of complex, modular integrals** in Mathematica and Python [2,3,5,10,11,12].
- ★ Analysed vast parameter space of string model potential energy and tested for stable points using **numerical analysis and calculus methods from dynamical systems** [11,12].

Teaching roles
- ★ Lecturer for 'Probability and Statistics II' (350+ students) and 'Mathematical IT Skills' (programming, simulations, mathematical models), obtaining Associate Fellow status.
- ★ Delivered PhD-level course on String Model Building at University of Liverpool.
- ★ Tutor for Brilliant Club Scholars Program, teaching particle physics to school students.

Wider academic contributions
- ★ Delivered more than 10 presentations to research groups and at conferences, including a speaker prize at Young Theorists Forum 2020 and **plenary talk** at international 'String Phenomenology 2022' conference [15].
- ★ Attended research visits and delivered talks to Osaka Met. University and IPMU, Kavli Institute theoretical physics groups.

Science Lecturer

Kaplan International College, London Bridge
09/2016 –09/2017
- ★ Lectured and developed course material for foundation courses in maths and science.
- ★ Delivered on academic targets in the Science and Engineering team.
- ★ Recruitment, interviewing, observations and onboarding of new staff.

Summer Student Researcher

CERN
05/2015 – 09/2015
- ★ Contributed to CERN's research consortium in accelerator beam dynamics, analysing **mathematical models of proton beam extraction** from the PS ring at CERN.
- ★ Ran **simulations of nonlinear dynamical systems** in Mathematica and worked closely with experimentalists to tune parameters to more accurately model the accelerator beam.

COMPUTER SKILLS
- ★ Python, Mathematica, SQL, HPC, Neural Networks, SAT/SMT Solvers, Quantum Computing.

PUBLICATIONS

[1]   A. E. Faraggi, G. Harries, B. Percival and J. Rizos (2020), J. Phys. Conf. Series 1586 vol. 1.

[2]   A. E. Faraggi, B. Percival, S. Schewe and D. Wojtczak (2021), Physics Letters B. 816. 136187.

[3]   'Free Fermioniser' Python package: https://github.com/BenjaminPercival/FreeFermioniser

[4]   A. E. Faraggi, G. Harries, B. Percival and J. Rizos (2020), Nucl. Phys. B 953 (2020) 114969.

[5]   A. E. Faraggi, V. G. Matyas and B. Percival (2020), Eur. Phys. Jour. C 80 (2020) 4.

[6]   A. E. Faraggi, V. G. Matyas and B. Percival (2020), Nucl. Phys. B 0550–3213 (2020) 115231.

[7]   A. E. Faraggi, V. G. Matyas and B. Percival (2020), IJMP A Vol. 36, No. 24, 2150174 (2021).

[8]   A. E. Faraggi, V. G. Matyas and B. Percival (2020), Phys. Rev. D 104 046002.

[9]   A. E. Faraggi, V. G. Matyas and B. Percival (2020), Physics Letters B 814:136080,

[10] A. E. Faraggi, V. G. Matyas and B. Percival (2022), Phys. Rev. D 106, 026011.

[11] A. R. D. Avalos, A. E. Faraggi, V. G. Matyas and B. Percival (2023), Phys. Rev. D 108 086007.

[12] A. R. D. Avalos, A. E. Faraggi, V. G. Matyas and B. Percival (2023), Eur. Phys. J. C **83**, 926.

[13] A. E. Faraggi, S. Groot Nibbelink and B. Percival (2023), Phys. Rev. D LG19547DR.

[14] E. Basaad, L. A. Detraux, A. R. D. Avalos, A. E. Faraggi and B. Percival, arXiv:2408.03928.

[15] L. A. Detraux, A. R. D. Avalos, A. E. Faraggi and B. Percival, Phys. Rev. D 110 (2024) no.8, 086006.

[16] Lectures on String Model Building https://youtu.be/SC7MCjOwPyk?si=qFlo6y28VX_8i4fd

[17] Plenary Talk String Pheno. 2022 https://youtu.be/EoY2QHp3pm8?si=pIXEW9r6QnWMN0Nv