

Daniel Han

+44 737 592 9966 | hansmnc@gmail.com | <https://personalpages.manchester.ac.uk/staff/daniel.han/>

Experience

PhD research in Biology and Mathematics

Sep. 2017 - present *Dept. of Mathematics and Sch. Of Biological Sciences, The University of Manchester*

At the intersection of Mathematics and Biology, I perform experiments of live cell microscopy; analyse the resulting videos using statistics and machine learning techniques; and model biological processes using non-Markovian random walks. I modelled the motion of different endosomes, lysosomes and other intracellular vesicles within the cell. From culturing different eukaryotic cell lines, immunofluorescence protocols and wide-field microscopy to image feature detection, particle tracking and neural networks, I aim to quantify properties of the cell. Then using fractional calculus and random walks, I model the observed dynamic processes and formulate the random walks from microscopic principles to governing partial or ordinary differential equations. From mean ensemble or time average statistics, I compare models with Monte Carlo simulations, often requiring CPU/GPU parallel processing, and the experimental data.

Collaborator on Joint UoM-FAPESP Brazil Grant

Sep. 2018 - present *Facul. of Pharmaceutical Sciences, The University of Sao Paolo, Brazil and
Dept. of Mathematics, The University of Manchester*

We are currently developing non-stationary, non-homogeneous velocity walk models for application in Cell Biology. These models are hyperbolic velocity random walks with strong memory. Statistical quantities were calculated and compared with simulations and experimental results from the movement of intracellular cargo.

Graduate Teaching Assistant

Jan. 2019 - present *The University of Manchester*

With changing roles over semesters, I was responsible for:

- Assisting two tutorials per week for 'Mathematical Modelling in Finance' with 150 students. (2018)
 - Leading two supervision classes per week for 'Calculus and Vectors' with 12 students per class. (2019-2021)
 - Leading one tutorial per week for 'Vectors and Probability' with 20 students per class. (2020)
 - Assisting two tutorials per week for 'Introduction to Python programming' with 300 students (2021)
 - Marking exam scripts and mid-term assessment scripts.
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Participant in DSTL Data Study Group

Dec. 2019 *Alan Turing Data Science Institute, UK*

This week-long workshop involved working with biological data from the Defence Science and Technology Laboratory (DSTL). As a group we used supervised and un-supervised machine learning techniques for semantic and instance segmentation on brightfield microscopy videos of cells.

Visiting Researcher

Nov. 2019 *The Basque Centre for Applied Mathematics, Spain*

This visit was to begin a collaboration on the generation of fractional Brownian motion from ensembles of Langevin equations with a stochastically activated harmonic potential using analytical and computational methods. The project aims to apply this theory to experimental data to explain the movement of intracellular cargo.

Summer Internship

Jun. 2016 - Sep. 2016 *Particle Physics Group, The University of Manchester*

This project involved a sensitivity study on the possible monotop quark-dark matter production at CERN. Monotop events were simulated with a BSM dark matter model. I learned to produce the hypothetical ATLAS detection signals that these particles would leave behind.

Summer Internship

Jul. 2016 - Aug. 2016 *Particle Accelerators Group, Cockcroft Institute, UK*

I designed an ultra-relativistic cavity of a X-band VHEE medical LINAC. The cavity was a tuned 55-cell structure with tapered irises so that a constant accelerating field was achieved whilst keeping the cells within the RF breakdown constraints.

Korea Undergraduate Science Program

Jul. 2015 - Aug. 2015 *Centre for Axion and Precision Physics, KAIST, South Korea*

Attending lectures on axion searches, our team generated and tested various hypothetical axion signals that would be detected inside a resonant cavity due to dark matter interactions.

Summer Placement

Jul. 2014 - Aug. 2014 *Applied Nuclear Sciences Division, Lawrence Berkeley National Lab, USA*

I analysed data gathered by LiDAR and HPGe gamma ray detectors mounted on a truck. Then, the data was presented using Google Earth KLM. I was able to find a correlation between locations and gamma radiation from Potassium (K-40).

Publications

- Fedotov, S., **Han, D.**, Zubarev, A. Y., Johnston, M., and Allan, V. J., 2021. Variable-order fractional master equation and clustering of particles: non-uniform lysosome distribution. arXiv, 2101.02698 (Accepted in Philosophical Trans. Royal Society A)
- Biga, V., Hawley, J., Soto, X., Johns, E., **Han, D.**, Bennet, H., Adamson, A. D., Kursawe, J., Glendinning P., Manning, C. S. and Papalopulu, N., 2020. A dynamic, spatially periodic, micro-pattern of HES5 underlies neurogenesis in the mouse spinal cord. *bioRxiv* (under peer review in Molecular Systems Biology EMBO)
- **Han, D.**, da Silva, M. A. A., Korabel, N. and Fedotov, S., 2021. Self-reinforcing directionality generate Lévy walks without power-law assumption. *Physical Review E*, 103, pp. 022132
- Ciofani, J. L., **Han, D.**, Allahwala, U. K., Asrress, K. N. and Bhindi, R., 2020. Internet search volume for chest pain during the COVID-19 pandemic. *American Heart Journal*, 231, pp. 157-159
- **Han, D.**, Korabel, N., Chen, R., Johnston, M., Allan, V. J., Fedotov, S. and Waigh, T. A., 2020. Deciphering anomalous heterogeneous intracellular transport with neural networks. *eLife*, 52224
- Fedotov, S. and **Han, D.**, 2019. Asymptotic behavior of the solution of the space dependent variable order fractional diffusion equation: Ultraslow anomalous aggregation. *Physical Review Letters*, 123(5), pp. 050602
- Fedotov, S., Korabel, N., Waigh, T. A., **Han, D.** and Allan, V. J., 2018. Memory effects and Lévy walk dynamics in intracellular transport of cargoes. *Physical Review E*, 98(4), pp. 042136

Education

PhD in Applied Mathematics

2017 - present *Dept. of Mathematics, The University of Manchester, UK*

Wellcome Trust Four-year PhD Studentships in Science | University Bursary from the Faculty Support Fund

Supervisor: Prof. Sergei Fedotov

Co-supervisors: Prof. Victoria Allan and Dr. Thomas Waigh

Thesis title: 'Anomalous Intracellular Transport: Theory and Experiments'

Master of Physics with Theoretical Physic (Hons. Class I)

2013 - 2017 *Dept. Physics and Astronomy, The University of Manchester, UK*

International Excellence Scholarship | Physics Entrance Scholarship

Dissertation title: 'Chaotic Particle Trajectories near Three Dimensional Magnetic Null Points'

Supervisor: Prof. Philippa Browning

Presentations

- Speaker and organizer of 'Applications of Neural Networks in Biology' workshop at the University of Manchester, UK (Jan 2021)
- Invited to attend 'Fractional Differential Equations' Program at the Isaac Newton Institute for Mathematical Sciences, UK (2021)
- Invited Speaker at the IOP Advanced photonics techniques in biology: cutting edge, open source and AI Conference, UK (2020)
- Speaker at the SIAM UKIE National Student Chapter Conference, UK (2019) [NAG Best Presentation Prize]
- Invited Speaker at the Royal Society Bilateral International Meeting, Kavli Royal Society Center, UK (2019)
- Flash-talk at the 3rd Course on Multiscale Integration in Biological Sciences, Institut Curie, France (2018)

Computing Languages

- C++/C, Python and Matlab (mostly used for data analysis/statistical simulations)

Public Outreach

- Invited seminar speaker for 'Science for All' Series at U3A Hale (June 2019)
- Co-organizer of 'Random Walks and Intracellular Transport' International Workshop (April 2019)
- Volunteer for 'Stem Cell Fate Game' (2019) and 'Nerve Cell Derby' (2018) in British Science Week