JULY 2025

NEWSLETTER ISSUE 6

Director's summary

The last six months has seen a period of great activity from Maths4DL in the areas of research, workshops, industrial collaboration, engagements with policy makers and public engagement. The team (which if we include the investigators, PDRAS, PhDs and domain experts numbers about 30), has worked closely together, with monthly themed brainstorming sessions, joint papers and joint conference publications.

We have seen significant advances in research by the team in the analysis and application of Scientific Machine Learning to differential equations, inverse problems and generative methods. We have also developed applications of Scientific ML in the geosciences, medical imaging and energy sectors. In all cases our work has been characterised by the use and development of fundamental mathematical methods to shine light onto the operation of machine learning algorithms, as well as the development of new and effective algorithms for a multitude of applications. These can all be seen on the updated research page on the Maths4DL website.

We have run several workshops on the general theme of inverse problems, and have launched a working group (ML4IP) in this area of scientific ML. The differential equations working group (ML4DE) ran a very successful two day hackathon which addressed some challenges proposed by Prof Nathan Kutz, as well as coming up with some new challenges. Read on for further details of these events.

Our links with industry have been consolidated by growing projects, and publications, with the Met Office, BT, GE Healthcare and the National Grid. We have also received funds from the Ada Lovelace Centre at STFC to work on advanced algorithms for PET reconstruction.

A combined team from Maths4DL and the IMI at Bath visited parliament for Evidence Week in January to promote the role of mathematics in AI. For this we developed a policy document, made a video and spoke to many MPs and Lords. This visit was followed by another one to the House of Lords, with more planned for the future. This visit was covered by a report and podcast on the Plus Maths website.

We have enjoyed welcoming visitors to Bath, as well as getting out and about ourselves. I'm writing this having just returned from a visit to the University of Washington, where I delivered eight talks on Scientific Machine Learning to a graduate camp, exhibiting the work of Maths4DL in this rapidly growing field.

Some of you will soon be joining us in Bath for our third conference - a full report on this in the next edition. Whether you are attending our conference, or other meetings and events across the world, we wish you all a productive summer.

Chris Budd OBE, PI

Maths4DL research news

Our postdocs have been busy attending various workshops and seminars.

Alex took part in the G-StAI workshop in Greece, and attended the SSVM conference at Dartington Hall in Devon.

Davide taught a Part III graduate course in Cambridge titled "Geometric Numerical Analysis and Deep Learning". In April, he visited the Gran Sasso Science Institute in Italy to collaborate with some researchers there and present his work on symplectic neural networks.

Hok Shing attended and presented at the 22nd Conference on Advances in Continuous Optimization held at the University of Southampton in late June.

We have been fortunate to welcome some visitors to Maths4DL in Bath who have collaborated with researchers and given talks. These have included Benjamin Tapley from SINTEF Digital, Janek Gödeke from the University of Bremen, and John Stockie from Simon Fraser University in Canada.

New publications include:

Fast PET Reconstruction with Variance Reduction and Prior-Aware Preconditioning describes our contribution which won the 2024 PETRIC challenge.

A Guide to Stochastic Optimisation for Large-Scale Inverse Problems, published in Inverse Problems.

Stochastic Primal-Dual Three Operator Splitting Algorithm with Extension to Equivariant Regularization-by-Denoising, published in the Proceedings of Scale Space and Variational Methods in Computer Vision 2025.

Bilevel Learning with Inexact Stochastic Gradients, published in the Proceedings of Scale Space and Variational Methods in Computer Vision 2025.

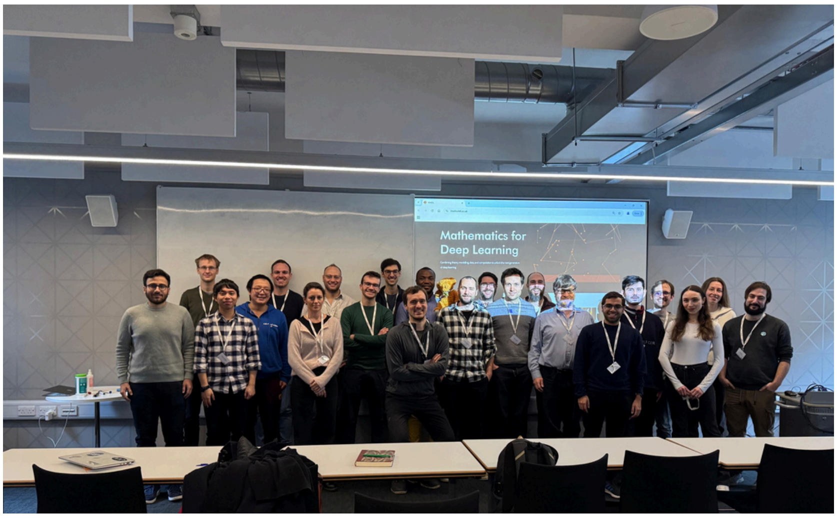
Several M4DL members have papers included in Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, volume 383 issue 2298

A full list of publications related to the grant can be found on the website: https://maths4dl.ac.uk/publications/

Maths4DL supported events

Workshop on Recent Advances in Learned Regularisation, UCL

Data-driven methods, in particular those based on Deep Learning, have become some of the most important and widely used approaches for inverse problems. Of particular note are learned regularisation approaches, which allow a synergy between data-driven approaches and theoretical framework from classical theory.



This workshop, supported by Maths4DL and held in February at UCL, brought together 33 researchers involved in this growing research area, including unrolled optimisation, learning-to-optimise, regularisation by denoising, adverserial regularisation, bilevel learning, and other learning frameworks.

Hackathon - machine learning for differential equations, Cambridge

Organised by the Machine Learning for Differential equations (ML4DE) working group, the ML4DE Hackathon 2025 brought together students and researchers from across the UK to compete in two exciting challenges focused on solving differential equations using machine learning tools.

Five teams competed for two prizes, tackling problems ranging from the accurate simulation of solution trajectories in the Lorenz equation and the Kuramoto-Sivashinsky (KS) equation using machine learning (ML) to the design of new benchmark problems for the field of scientific ML, such as the use of ML surrogates for control problems or the reliability of ML tools for held out data. The teams developed innovative insights that will form the basis for further discussions - and perhaps even future research collaborations.

Hackathon - machine learning for differential equations, Cambridge

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Our friends from Plus Maths joined the event and created a podcast to share more insights.

In this episode of *Maths on the Move*, Maths4DL members Yolanne Lee from University College London, Georg Maierhofer from the University of Cambridge, and Chris Budd OBE from the University of Bath talk about the hackathon, the science behind it, and what it was like to participate in those ambitious but exciting 48 hours.

Listen here: Brainstorming AI with Maths4DL

Outreach and public engagement

Evidence Week
22 January 2025
Houses of Parliament, London

A team from Maths4DL, joined by colleagues from Bath's IMI, took part in Evidence Week to talk about 'Opening the Black Boxes of AI'. The team met a range of MPs, Peers and advisors to brief them on their work on understanding the mathematics that underpins the algorithms powering AI technologies.

MPs who attended the session in Parliament's Jubilee Rooms included Chi Onwurah, Chair of the Science, Innovation & Technology Committee. Peers included former Defence Secretary Lord Browne of Ladyton, Lib Dem Lords Spokesperson for Science, Innovation & Technology Lord Clement-Jones, as well as leading science communicator and broadcaster Baroness Freeman of Steventon.

The team discussed AI-related questions parliamentarians are facing, helping to shed light on some of the systems which power new technologies such as ChatGPT. Conversations also considered opportunities through AI, as presented in the recent AI Opportunities Action Plan.

Our policy brief explains more about the topics discussed, while in the podcast (produced by Plus Maths), Chris Budd talks in more depth about the policy implications.

Many thanks to Sense About Science for organising Evidence Week.

Birthday celebrations!

This Spring we have celebrated two important birthdays with Maths4DL investigators Simon Arridge and Chris Budd both turning 65!

The obvious way to celebrate was of course by holding a workshop, so two events took place. “Computational Techniques and Imaging Innovations in the Age of AI” was held at UCL on honour of Simon, while the Bath workshop celebrated Chris’s commitment to taking an interdisciplinary approach to applied mathematics and explored how innovation and impact in mathematics can be achieved.

Thank you to all the friends and colleagues who joined these celebrations.