Bogdan Toader

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Research interests

I am an applied mathematician working on inverse problems, optimisation and machine learning for scientific imaging. My current work is on algorithms and learning-based methods for cryo-electron microscopy and tomography that are used by structural biologists.

Professional experience

Jan 2024 - present **Postdoctoral Scientist**, **Marie Skłodowska-Curie (MSCA) Postdoctoral Fellow**
MRC Laboratory of Molecular Biology, UK
Structural Studies Division
Research topic: image processing algorithms for cryo-ET
Group leaders: Dr Sjors Scheres and Dr Tanmay Bharat

Sep 2021 - Dec 2023 **Postdoctoral Research Associate**, *Yale University,* US
Department of Statistics and Data Science and Quantitative Biology Institute
Research topic: analysis of cryo-EM methods
Group Leader: Prof Roy Lederman

Sep - Dec 2022 **Visiting Researcher,** *University of California, Los Angeles*, US
Institute for Pure and Applied Mathematics (IPAM)
Core participant of the IPAM Long Program on Computational Microscopy

Aug 2019 - July 2021 **Postdoctoral Research Associate**, University of Cambridge, UK
Cambridge Advanced Imaging Centre (CAIC)
Research topic: deconvolution algorithms for light-sheet microscopy
Group leader: Dr Leila Muresan

Aug 2013 - Sep 2015 **Technology Associate**, *Morgan Stanley,* UK
Jul 2011 - May 2012 Development of financial software for quantitative researchers and traders

Education

Oct 2018 – Mar 2019 **Enrichment Placement**, *Alan Turing Institute*, UK
6-month placement at UK's national institute for data science and artificial intelligence.

Oct 2015 – Jan 2020 **PhD in Mathematics**, *University of Oxford*, UK
Industrially Focused Mathematical Modelling (EPSRC Centre for Doctoral Training) in collaboration with the National Physical Laboratory (NPL).
Thesis title: Stability and perturbation analysis of non-negative super-resolution
Advisors: Prof Jared Tanner, Dr Andrew Thompson

Oct 2009 – June 2013 **BSc (Hons) Computer Science and Mathematics with Industrial Experience**
First Class Honours, *University of Manchester*, UK

Peer-reviewed publications

I publish in multiple fields, with different standards for ordering authors, some ordering by contributions and others ordering alphabetically. In the list below, **first authors are indicated in bold when authors are ordered by contribution; the symbol "=" indicates a manuscript with alphabetically ordered authors.**

[1] The microscope is the mask: privileged views and labels from a cryo-ET forward model
B. Toader, K. Jamali, T. Bharat, S. Scheres
Accepted to *NeurIPS 2026 Workshop on Machine Learning with Imperfect Scientific Models (Sim2Science),* 2026
arXiv preprint: https://arxiv.org/abs/2609.04325

[2] Efficient high-resolution refinement in cryo-EM with stochastic gradient descent
B. Toader, M. A. Brubaker, R. R. Lederman
Acta Crystallographica Section D, 2025
DOI: https://doi.org/10.1107/S205979832500511X. Open access: https://arxiv.org/abs/2311.16100

[3] An image processing pipeline for electron cryo-tomography in RELION-5
A. Burt, B. Toader, R. Warshamanage, A. von Kügelgen, E. Pyle, J. Zivanov, D. Kimanius, T.A.M. Bharat, S.H.W. Scheres
FEBS Open Bio, 2024
Open access DOI: https://doi.org/10.1002/2211-5463.13873

Top cited article in *FEBS Open Bio* among work published in 2024.

[4] On manifold learning in Plato's cave: remarks on manifold learning and physical phenomena
= R. R. Lederman, B. Toader
Proceedings of the International Conference on Sampling Theory and Applications (SampTA), 2023 DOI: https://doi.org/10.1109/SampTA59647.2023.10301403. Open access: https://arxiv.org/abs/2304.14248

[5] Methods for cryo-EM single particle reconstruction of macromolecules having continuous heterogeneity
B. Toader, F. J. Sigworth, R. R. Lederman
Journal of Molecular Biology, 2023
DOI: https://doi.org/10.1016/j.jmb.2023.168020. Open access: https://arxiv.org/abs/2211.10744

[6] Integrating molecular models into cryo-EM heterogeneity analysis using scalable high-resolution deep Gaussian mixture models
M. Chen, B. Toader, R. R. Lederman
Journal of Molecular Biology, 2023
DOI: https://doi.org/10.1016/j.jmb.2023.168014. Open access: https://arxiv.org/abs/2211.10518

[7] Image reconstruction in light-sheet microscopy: spatially varying deconvolution and mixed noise
B. Toader, J. Boulanger, Y. Korolev, M. O. Lenz, J. Manton, C.-B. Schönlieb, L. Mureşan
Journal of Mathematical Imaging and Vision, 2022
Open access DOI: https://doi.org/10.1007/s10851-022-01100-3

[8] Sparse non-negative super-resolution – simplified and stabilised
= A. Eftekhari, J. Tanner, A. Thompson, B. Toader, H. Tyagi
Applied and Computational Harmonic Analysis, 2021
DOI: https://doi.org/10.1016/j.acha.2019.08.004. Open access: https://arxiv.org/abs/1804.01490

[9] The dual approach to non-negative super-resolution: impact on primal reconstruction accuracy
= S. Chrétien, A. Thompson, B. Toader
Proceedings of the International conference on Sampling Theory and Applications (SampTA), 2019
DOI: https://doi.org/10.1109/SampTA45681.2019.9030883. Open access: https://arxiv.org/abs/1904.01926

[10] Global air transport complex network: multi-scale analysis
W. Guo, B. Toader, R. Feier, G. Mosquera, F. Ying, S. Oh, M. Williams, A. Krupp
Springer Nature Applied Sciences (SNAS), 2019
Open access DOI: https://doi.org/10.1007/s42452-019-0702-2

[11] Non-negative super-resolution is stable
= A. Eftekhari, J. Tanner, A. Thompson, B. Toader, H. Tyagi
Proceedings of the 2018 IEEE Data Science Workshop (DSW), 2018
DOI: https://doi.org/10.1109/DSW.2018.8439120

Preprints

[12] The dual approach to non-negative super-resolution: perturbation analysis and ℓ_1 data fidelity
= S. Chrétien, A. Thompson, B. Toader
Under review, 2026
arXiv preprint (2020): https://arxiv.org/abs/2007.02708

Technical reports

[13] Computational Microscopy
White paper, IPAM Long Program, Fall 2022.
Link: https://www.ipam.ucla.edu/wp-content/uploads/2023/01/CMS2022-White-Paper.pdf

[14] Data Study Group Final Report: DSTL – Bright-field image segmentation
Technical report, Alan Turing Institute Data Study Group, 2019.
DOI: https://doi.org/10.5281/zenodo.4452761

Research funding

2025 - 2027 **Marie Skłodowska-Curie Actions (MSCA) Postdoctoral Fellowship**
Fast and comprehensive structure identification in cryo-ET using deep learning and tomogram optimisation
European Commission, Horizon Europe (HORIZON-MSCA-2024-PF-01-01)
Grant agreement no. 101212334. DOI: https://doi.org/10.3030/101212334
Host: MRC Laboratory of Molecular Biology, UK. Value: € 260,348.
Proposal written and submitted as sole author, with Dr Sjors Scheres as host supervisor.
Ranked in the top 3% of applicants, with a score of 99.2% and a perfect score in the "Excellence" section.

Prizes and awards

2022 **IPAM Long Program Housing and Travel Grant**
University of California, Los Angeles (UCLA), US

2018 **Enrichment Scheme Placement Award**, *Alan Turing Institute*, UK

2016 **IMA Best Team Performance Prize**
InFoMM Graduate Modelling Camp, UK

2015 - 2019 **EPSRC InFoMM Centre for Doctoral Training Studentship,** *University of Oxford*, UK

2010 **Golden Anniversary Prize** for excellence in year 1 studies, *University of Manchester*, UK

2007 - 2009 **Bronze Medal at the National Mathematical Olympiad**, Romania (in 2007, 2008, 2009)

Invited presentations

Jun 2026 *SIAM Conference on Optimization*, mini-symposium presentation, Edinburgh, UK

Apr 2026 *CCP-EM Spring Symposium 2026,* Nottingham, UK

Mar 2025 *Image Reconstruction at Scale: Challenges and Collaboration (ExCALIBUR Workshop)*
University of Cambridge, UK

Nov 2024 *Machine Learning and Data Science Seminar,* Mathematical Institute
University of Oxford, UK

Sep 2023 *11th Applied Inverse Problems Conference,* mini-symposium presentation
Göttingen, Germany

Feb 2023 *SIAM Conference on Computational Science and Engineering*, mini-symposium pres. Amsterdam, The Netherlands

Nov 2022 *Institute for Pure and Applied Mathematics Seminar,* UCLA Los Angeles, US

May 2022 *PIMS Workshop on Mathematical and Computational Challenges in Cryo-EM* Vancouver, Canada

Jun 2018 *6th IMA Conference on Numerical Linear Algebra and Optimization*, mini-symposium pres. Birmingham, UK

Conference and seminar presentations

Nov 2026 *Crick BioImage Analysis Symposium 2026*, London, UK - poster

Jun 2024 *MRC LMB Tomography Seminar*, Cambridge, UK – oral presentation

Apr 2024 *CCP-EM Spring Symposium 2024*, Nottingham, UK – poster

Oct 2023 *The 10th New England Cryo-EM Symposium*, Yale University, US – oral presentation

Jul 2023 *International Conference on Sampling Theory and Applications (SampTA 2023)* Yale University, US – oral presentation

Jun 2023 *CryoEM Summer Workshop*, Flatiron Institute, New York, US – poster

Sep 2022 *SIAM Conference on Mathematics of Data Science (MDS22)*, San Diego, US – poster

Mar 2021 *Focus on Microscopy 2021 Online Conference* – oral presentation

Sep 2020 *Virtual 12th Light Sheet Fluorescence Microscopy Conference 2020* – oral presentation

Jul 2020 *SIAM Conference on Imaging Science (IS20)*, online – poster

Jan 2020 *Quantitative BioImaging Conference (QBI 2020)*, Oxford, UK – poster

Aug 2019 *International Conference on Continuous Optimization (ICCOPT)*, Berlin, Germany – oral presentation

Jul 2019 *13th International Conference on Sampling Theory and Applications (SampTA)*, Bordeaux, France – oral presentation

Jul 2018 *Curves and Surfaces Conference*, Arcachon, France – oral presentation

Jun 2018 *IEEE Data Science Workshop (DSW)*, Lausanne, Switzerland – poster

Mar 2018 *Numerical Analysis Seminar*, Oxford, UK – oral presentation

Feb 2018 *Research Workshop on Optimization and Big Data*, KAUST, Saudi Arabia – poster

Jan 2018 *SIAM UKIE Annual Meeting*, Southampton, UK – poster

Teaching experience

- **Applied and computational mathematics**

2020 - 2021 Supervisor: **Numerical Analysis** (3rd year undergraduate), *University of Cambridge*

Responsible for marking and running fortnightly supervisions (small-group tutorials) for pairs of students from Cambridge colleges.

2016 - 2018 Teaching assistant: **Continuous Optimisation** (4th year undergraduate), **Integer Programming** (3rd year undergraduate), *University of Oxford*

Responsible for marking weekly assignments and leading problem-solving classes for groups of up to 15 students, with the class tutor. Ran revision classes independently to groups of 30 students.

2016 - 2017 Lab demonstrator: **Computational Mathematics** (1st year undergraduate), *Univ. of Oxford*

Presented new material in the form of live computer demos to groups of up to 20 students.

- **Lectures and practical sessions on Cryo-ET image processing**

Gave lectures and designed and led hands-on practical sessions for PhD students and postdocs, mostly from biological backgrounds; tailored the materials, pace and examples to each cohort and to the computing resources available.

Aug 2026 **EMBO Practical Course,** Advances in cryo-EM and 3D image processing, *Heidelberg* — practical sessions

July 2026 **Dutch Cryo-EM School,** *Leiden and Delft* — lecture and practical session

Sep 2025 **EMBO Practical Course,** Image processing for cryo-electron microscopy, *London* — practical session

Jun 2024 **Dutch Cryo-EM School**, *Leiden and Delft* — lecture and practical session

Supervision and mentoring

2025 - 2026 **MSc Systems Biology**, *University of Cambridge*
Supervised student project on cryo-ET tomogram reconstruction using SGD.

Jun - Aug 2022 Mentor for **Yale Summer Undergraduate Research Fellowship Program**, *Yale Univ.*

Mar 2021 **UK Graduate Modelling Camp**, *Newton Gateway to Mathematics,* Cambridge, UK
Week-long programme where I proposed a mathematical modelling and computational problem and mentored a group of 6 PhD students on reaching a solution as a team.

Participation in industrial innovation

Dec 2019 *Data Study Group*, Alan Turing Institute, London, UK
Implemented deep learning solution for image segmentation of bright-field microscopy.

Jun 2019 *Mathematics in Industry New Zealand Workshop*, Auckland, New Zealand
Implemented optimal transport solution for decomposing the spectrum of cheese samples into different components (fat, protein, etc).

Jun 2018 *142nd European Study Group with Industry*, Palanga, Lithuania
Predicting the sustainable income of loan applicants according to central bank rules.

Dec 2016 *Data Study Group*, Alan Turing Institute, London, UK
Implemented network model to solve an air traffic prediction problem proposed by Airbus.

Jul - Sep 2016 *Deflating Magnetic Oscillations*, Culham Centre for Fusion Energy, Abingdon, UK
Used deflation to find periodic solutions to a system of ODEs describing plasma behaviour. In collaboration with Dr Wayne Arter (CCFE) and Prof Patrick Farrell (Oxford).

May – Jul 2016 *Source Reconstruction from Hydrophone Data*, National Physical Laboratory, London, UK
Analysed how compressed sensing can be applied to the problem of ship localisation from measurements of the sound in the shipping lane.
In collaboration with Dr Peter Harris (NPL), Dr Stéphane Chrétien (NPL), Prof Jared Tanner (Oxford) and Dr Andrew Thompson (Oxford).

May 2016 *116th European Study Group with Industry*, Durham, UK
Implemented mixed integer programming solution to field trials scheduling problem proposed by Syngenta.

Public engagement

2017 - 2018 *Lord Williams's School*, Thame, Oxfordshire, UK.
Organised and led two outreach sessions (in 2017 and 2018) for high-school students about doing research in applied mathematics.

Peer review

2017 - present Acted as a reviewer for the following journals:

- *Applied and Computational Harmonic Analysis, SIAM Journal on Imaging Sciences, Information and Inference: a Journal of the IMA*
- *Nature Methods, eLife, Nature Communications, Journal of Structural Biology, Structure*