Dr Laura Miller

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1. Research Interests

My research in applied mathematics focusses on poroelasticity, composite materials, viscoelasticity, and applications of continuum mechanics models to real world scenarios such as cardiac modelling (electrophysiology, perfusion, and disease) and diseases affecting the eyes. My PhD project modelled the perfusion and mechanics of multiscale biological soft tissues. The multiscale models that I derive in my work are obtained via applying homogenization techniques to fluid structure interaction problems that describe the materials at the microstructural level. This allows to obtain systems of partial differential equations that describe the effective behaviour of the tissue/material at the macroscale level. During my current fellowship, I have expanded the modelling and solution approaches that I utilise to include mixture theory, statistical sensitivity analyses and techniques to derive analytical solutions. This gives a wide range of approaches that can be selected depending upon the application or the type of information that should be encoded in the model.

2. Current Employment

EPSRC Doctoral prize research fellow – University of Glasgow, School of Mathematics and Statistics. A 2-year fellowship beginning on December 1st, 2022.

3. Education and Qualifications

3.1. University of Glasgow: PhD in Mathematics: October 2018 – October 2022

Date of Viva: October 20th, 2022

Date of Award Letter: 21st November 2022

Thesis Title: Multiscale Modelling of Perfusion and Mechanics in Poroelastic Biological Tissues

Supervisors: Dr Raimondo Penta and Professor Nick Hill

Funding: EPSRC NPIF EP/N509668/1

3.2. University of Glasgow: MSci Mathematics 2013 – 2018 - 2:1 Master in Science

Masters Dissertation: Critical Review of the potential utility of mathematical modelling in the treatment of structural heart diseases.

Supervisor: Professor Xiaoyu Luo

Honours Dissertation: The Elastic Properties of Arteries.

Supervisor: Professor Ray W Ogden

4. Prizes and Awards

I am currently the recipient of a two-year EPSRC Doctoral Prize research fellowship to investigate my own proposed research project. During my career, I have been awarded the following prizes in both research and teaching.

4.1. William Jack Prize for the best PhD thesis in Mathematical sciences 2022/2023 University of Glasgow.

4.2. Second Prize for best Early career talk titled "Investigating the effects of microstructural changes induced by myocardial infarction on the elastic parameters of the heart" at the 6th SoftMech Soft Tissue Modelling Workshop 7th – 9th June 2023.

4.3. Joint winner of the Jon Nimmo Memorial Prize for Teaching Excellence 2021 for the role of postgraduate lecturer as part of the widening participation summer school. This summer school was also highly commended by the University Vice Principal for Learning and Teaching, Moira Fischbacher.

Grants

4.4. Named as a collaborator to work on a project funded by Royal Society International Exchanges 2023 Cost Share (NSFC) scheme won by Dr Hao Gao - £12,000.

5. Publications

10 Peer-Reviewed Papers

5.1. **L. Miller** and R. Penta*, Effective double-poroelasticity derived via homogenization of two non-interacting solid phases percolated by a viscous fluid,* European Journal of Mechanics A\ Solids, 105, (2024) (doi: https://doi.org/10.1016/j.euromechsol.2023.105219).

5.2. **L. Miller** and R. Penta, *Homogenization of a Coupled Electrical and Mechanical Bidomain Model for the Myocardium*, Mathematics and Mechanics of Solids (MMS), (2024) (doi: https://doi.org/10.1177/10812865231207600).

5.3. **L. Miller**, S. Di Stefano, A. Grillo and R. Penta, *Homogenised governing equations for prestressed poroelastic composites,* Continuum Mechanics and Thermodynamics, Early online (2023) (doi: https://doi.org/10.1007/s00161-023-01247-3).

5.4. **L. Miller**, A. Ramírez-Torres, R. Rodríguez-Ramos and R. Penta, *Effective Governing Equations for Viscoelastic Composites,* Materials, 16 (14), pp. 4944 (2023) (doi: https://doi.org/10.3390/ma16144944).

5.5. **L. Miller** and R. Penta, *Investigating the effects of microstructural changes induced by myocardial infarction on the elastic parameters of the heart*, Biomechanics and Modelling in Mechanobiology, 22 (3), pp. 1019-1033 (2023) (doi: https://doi.org/10.1016/j.euromechsol.2022.104875).

5.6. **L. Miller** and R. Penta, *Micromechanical analysis of the effective stiffness of poroelastic composites,* European Journal of Mechanics A\ Solids, 98, 104875 (2022) (doi: https://doi.org/10.1016/j.euromechsol.2022.104875).

5.7. **L. Miller** and R. Penta, *Homogenized balance equations for nonlinear poroelastic composites*, Applied Sciences, 11 (14), (2021) (doi:10.3390/app11146611).

5.8. **L. Miller** and R. Penta, *Double poroelasticity derived from the microstructure,* Acta Mechanica, (2021) (doi:10.1007/s00707-021-03030-4).

5.9. S. Di Stefano, **L. Miller,** A. Grillo, and R. Penta*, Effective Balance Equations for Electrostrictive Composites*, ZAMP, 71 (5), pp. 1-36 (2020) (doi:10.1007/s00033-020-01365-x).

5.10. **L. Miller** and R. Penta, *Effective Balance Equations for Poroelastic Composites*, Continuum Mechanics and Thermodynamics, 32, pp. 1533-1557 (2020) (doi: 10.1007/s00161-020-00864-6).

1 Book Chapter

5.11. R. Penta, **L. Miller**, A. Grillo, A. Ramirez-Torres, P. Mascheroni, and R. Rodriguez-Ramos, *Porosity and diffusion in biological tissues*, in Constitutive modelling of solid continua, pp. 311-356, Springer, (2020) (doi: 10.1007/978-3-030-31547-4_11)

Current Work

5 Submitted Papers

5.12. P. Mascheroni, **L. Miller** and R. Penta, *Homogenization of solute transport in double porosity materials*, Mathematical Methods in the Applied Sciences Submitted.

5.13. H. Ashgari, **L. Miller**, R. Penta and J. Merodio*, On an isotropic porous solid cylinder: the analytic solution and sensitivity analysis*, Applied Mathematics and Mechanics, submitted.

5.14. **L. Miller** and R. Penta, *Effective Homogenised modelling of an electrical double poroelastic myocardium,* Proceedings of the Royal Society A, Submitted.

5.15. U.S. Mahabaleshwar, T. Maranna, N. Swaminathan, **L. Miller** and R. Penta, *Falkner-Skan equation for bi-viscosity nanofluid flow over a stretching wedge surface and suction/injection,* ZAMP, submitted.

5.16. **L. Miller** and R. Penta, *Homogenized Modelling of the vascularisation and electrical conductivity in the myocardium*, Royal Society Open Science, submitted.

4 Papers In preparation

5.17. **L. Miller** and H. Gao*, Mixture Theory Modelling of the Myocardium as a Composite Material with a First Application to Cardiac Amyloidosis*, Materials, In preparation.

5.18. **L. Miller**, P. Stewart and R. Penta, *Addressing Macular holes via a homogenization approach*, in preparation.

5.19. S.M. Sachhin, U.S. Mahabaleshwar, **L. Miller** and R. Penta *An impact of magnetohydrodynamics and Brinkman ratio on modified tetra hybrid nanofluid flow with threshold non-Fourier heat flux model: An analytical approach, In preparation.*

5.20. U.S. Mahabaleshwar, K.N. Sneha, T. Maranna, Nihaal K.M, **L. Miller** & R. Penta, *An effect of inclined MHD and mass transpiration on Boussinesq couple stress CNTs-water-based nano liquid flow past a stretching/shrinking sheet with heat transfer, In preparation*

6. Research Dissemination

Invited Talks

6.1. University of Glasgow Applied Maths Seminar, 9th March 2023 - Presentation titled "Micromechanical analysis of the effective stiffness of poroelastic composites and a first approximation to modelling structural changes induced by myocardial infarction".

Invited Mini-Symposium Presentations

6.2. Invited mini-symposium talk titled "Homogenized modelling of a coupled electrical and mechanical bidomain model for the myocardium" at the International Conference on Non-linear Mechanics. To be held in Cagliari June 11th-14th 2024.

6.3. Presentation (online) titled "Micromechanical analysis of the effective stiffness of poroelastic composites" at SIAM Conference on Mathematical & Computational Issues in the Geosciences (GS23) 19th-22nd June 2023.

6.4. Presentation at XXIV Computational Methods in Water Resources 2022 titled Double poroelasticity derived from the microstructure" as part of a mini symposium. Held in Gdansk, Poland from 19th -23rd June 2022.

6.5. Presentation at the International Conference on Nonlinear Solid mechanics 2022, as part of a mini symposium titled "Homogenized balance equations for nonlinear poroelastic composites". Held in Alghero, Sardinia from June 13th -June 16th, 2022.

6.6. BAMC 2022 – Presentation titled "Double poroelasticity derived from the microstructure" as part of a mini symposium. 11th – 13th April 2022.

6.7. BAMC 2021 - Was due to present as part of a mini symposium at BAMC Glasgow April 2020 https://sites.google.com/view/bmcbamc2021/home (rescheduled online April 2021). Presentation titled "Effective Balance Equations for Poroelastic Composites".

Contributed Talks

6.8. Presentation titled "Investigating the effects of microstructural changes induced by myocardial infarction on the elastic parameters of the heart" at the 6th SoftMech Soft Tissue Modelling Workshop 7th – 9th June 2023.

6.9. Presentation titled "Homogenized balance equations for nonlinear poroelastic composites" at the International Workshop on The Evolving Nonlinear Continuum Panorama. Held in Castro Urdiales, Spain from July 11th, 2022 – July 15th, 2022.

6.10. Presentation titled "Effective Balance Equations for Poroelastic Composites" at the London Mathematical Sciences Women in Mathematics Day hosted online by the University of Strathclyde June 16th, 2021.

6.11. Presentation titled "Double poroelasticity derived from the microstructure" at the SoftMech 5th Soft Tissue Modelling Workshop. Hosted online by the University of St Andrews from June 1st, 2021- June 3rd, 2021.

6.12. Presentation titled "Effective Balance Equations for Poroelastic Composites" at the International Conference on the multiscale spectrum of constitutive modelling in solid mechanics. Held in Castro Urdiales, Spain from July 1st, 2019 – July 5th, 2019.

Poster Presentations

6.13. Poster Presentation titled "Effective Balance Equations for Poroelastic Composites" at the CMALS (Centre for mathematics applied to life sciences) poster day. Held at the University of Glasgow on May 31st, 2022.

6.14. Poster Presentation titled "Effective Balance Equations for Poroelastic Composites" at the SoftMech 4th Soft Tissue Modelling Workshop. Held at the University of Glasgow from June 5th, 2019 – June 9th, 2019.

7. Reviewer for Academic Journals

7.1. Reviewed papers for publication in Scientific Reports, Applied Bionics and Biomechanics, Composite Structures, and Mathematics and Mechanics of solids.

8. Teaching, Scholarship and Supervision

8.1. **Lecturer - Scottish Mathematical Sciences Training Centre (SMSTC)** - Delivered a 2-hour lecture on "An introduction to asymptotic homogenisation and its application to real-world biological problems" to year 1 PhD students across Scotland - 1st February 2024.

8.2. **MSc Project Supervision** – Aishwarya Raman- "The Influence of the Magnetic Lorentz Force on Fluid and Drug Transport in Cancerous Tissues", University of Glasgow, October 2023-December 2023 (co-supervised with Dr Raimondo Penta)

8.3. **Graduate Teaching Assistant (Lecturer)** University of Glasgow School of Mathematics & Statistics, Course Maths 1C - September 2022 – December 2022. (2 Lectures a week, fortnightly tutorials and associated administrative tasks).

8.4. **Lecturer Widening Participation Summer School** University of Glasgow Marketing and Recruitment International Office – June 2022 – July 2022 (Course Lead, Online Teaching, flipped learning, student led pedagogy, lecture recordings, administrative tasks).

8.5. **Graduate Teaching Assistant Level 1 and Level 2** University of Glasgow School of Mathematics & Statistics - September 2021 – March 2022 (approx. 10 hours/week).

8.6. **Lecturer Widening Participation Summer School** University of Glasgow Marketing and Recruitment International Office – June 2021 – July 2021 (Course Lead, Online Teaching, lecture recordings, flipped learning, student led pedagogy administrative tasks)

8.7. **4H Honours Partial Differential Equations Tutor** University of Glasgow School of Mathematics & Statistics - September 2020 – December 2020.

8.8. **Graduate Teaching Assistant Level 1 and Level 2** University of Glasgow School of Mathematics & Statistics - September 2020 – March 2021 (approx. 10 hours/week).

8.9. **Widening Participation Summer School Mathematics Lecturer** University of Glasgow Marketing and Recruitment International Office – June 2020 – July 2020 (Approx. 10 hours of lectures per week as well as preparation and administrative tasks, flipped learning, student led pedagogy).

8.10. **Graduate Teaching Assistant Levels 1/2** University of Glasgow School of Mathematics & Statistics - September 2019 – March 2020 (approx. 15hrs/week).

8.11. **Levels 1/2 Tutor and Level 3 Lab demonstrator** University of Glasgow School of Mathematics & Statistics - September 2018 – March 2019 (approx. 8hrs/week).

8.12. **LMS Summer School Tutor** University of Glasgow School of Mathematics & Statistics – July 2018.

8.13. **Level 3 Maths Help Room Tutor** University of Glasgow School of Mathematics & Statistics - October 2017- March 2018 (approx. 4hrs/week).

8.14. **Level 2 Maths Tutor** University of Glasgow School of Mathematics & Statistics - September 2017- March 2018 (approx. 8hrs/week).

8.15. **Widening Participation Summer School Mathematics Tutor** University of Glasgow Marketing and Recruitment International office - July 2017 and June/July 2018 (approx. 10hrs/week).

9. Computational Software and Skills

9.1. Finite element software for 3D numerical simulations: COMSOL Multiphysics https:/www.comsol.com/comsol-multiphysics.

9.2. Other Programming software: Basic level Python and Matlab.

10. Attendance at Academic Events

10.1. Attended Mathpeat Workshop on Peatlands Modelling Thurso, Scotland, 22nd -24th May 2024.

10.2. Attended Maths in Eyes Special Interest Group Meeting at University of Glasgow 10th - 12th January 2024.

10.3. Attended the SoftMech 6th Soft Tissue Modelling Workshop. Hosted by the University of Glasgow from June 7th -9th 2023.

10.4. Attended ICMS Retreat for Women in Applied Mathematics, Edinburgh 9th-13th January 2023.

10.5. Attended the International Workshop on The Evolving Nonlinear Continuum Panorama. Held in Castro Urdiales, Spain from July 11th, 2022 – July 15th, 2022.

10.6. Attended Computational Methods in Water Resources conference. Held in Gdansk, Poland from 19th - 23rd June 2022.

10.7. Attended the International Conference on Nonlinear Solid mechanics 2022. Held in Alghero, Sardinia from June 13th – June 16th, 2022.

10.8. Attended the International workshop: "A symposium on continuum questions". Held in Glasgow, Scotland on May 12th and 13th 2022.

10.9. Attended BAMC 2022 Loughborough April 11th - April 13th, 2022

10.10. Attended the London Mathematical Sciences Women in Mathematics Day hosted online by the University of Strathclyde June 16th, 2021.

10.11. Attended the SoftMech 5th Soft Tissue Modelling Workshop. Hosted online by the University of St Andrews from June 1st, 2021- June 3rd, 2021.

10.12. Attended the joint BMC/BAMC 2021 April 6th - April 9th, 2021, https://sites.google.com/view/bmcbamc2021/home

10.13. Attended the ECMI Webinar "Math for industry 4.0- Models, Methods and big data" http://www.wias-berlin.de/workshops/MA4DIFA/program.jsp (December 2nd- 3rd 2020 online).

10.14. Attended the International Conference on the multiscale spectrum of constitutive modelling in solid mechanics. Held in Castro Urdiales, Spain from July 1st, 2019 – July 5th, 2019.

10.15. Attended the SoftMech 4th Soft Tissue Modelling Workshop. Held at the University of Glasgow from June 5th, 2019 – June 9th, 2019.

10.16. Attended the International CMALS Workshop on Mathematical modelling in Biomechanics at The University of Glasgow 19th March 2019.