NSW ANZIAM 2025

Contents

Information

Location All talks in room X803 in the NUSpace building, Newcastle NSW. Breaks and lunches are as shown on the timetable.

Talks Plenaries are 50 minutes plus 10 minutes for questions and changeover. All contributed talks are 20 minutes plus 5 minutes for questions and changeover.

Funding The conference is grateful for support from the NSW branch of ANZIAM and the University of Newcastle School of Information and Physical Sciences.

Conference dinner The conference dinner will be held at The Curve Thai Restaurant in Newcastle West. The conference does not have funds to support the dinner. Please register your intention to attend. It is easy to travel from the NUSpace conference venue to the restaurant using the Newcastle Light Rail; alight at Newcastle Interchange, which is the final stop.

Timetable

Thursday 27 November

12:00–13:00 **Registration**

13:00–13:20 **§ Rehab Aljabri** Time Domain Vibrations of a Circular Plate with Mixed Boundary Conditions

13:25–13:45 **§ N. Jothilakshmi** Embedding parameters in interconnection network

13:50–14:10 **§ Agus Soenjaya** Finite element approximations of a nonlinear micromagnetic model at elevated temperatures

14:15–14:35 **§ Josiah Murray** Infinite beams, undetermined coefficients, and the Laplace transform

14:40–15:30 **Plenary: Melanie Roberts** Contributing to Improved Water Quality for the Great Barrier Reef Through Mathematics

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15:40–16:00 **Break** in X802

16:00–16:20 **Mariano Rodrigo** On a stochastic Omori law for earthquake aftershock sequences

16:25–16:45 **§ Dilani P J G Dewage** Integration-based method for reconstructing the deactivation coefficient in aftershock frequency data

16:50–17:10 **Ravi Pethiyagoda** Crestlines for gravity-capillary ship waves

17:15–17:35 **§ Faraj Alshahrani** Ice Shelf Breakup Simulation

17:40–18:00 **§ Lamees Alasmari** Gravity–Capillary Wave Scattering by a Change in Depth

18:05–18:25 **§ Mitchell Bonham** Watching a Rogue Wave Hit an Iceberg: Modelling the Draupner Event

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19:00–20:30 **Conference Dinner** The Curve Thai Restaurant (own cost)

Friday 28 November

08:30–09:20 **Plenary: Michael Watson** When vascular smooth muscle cells go rogue: a mathematical model of smooth muscle cell phenotype switching in atherosclerotic plaques

09:30–09:50 **§ Amanda Munasinghe** Numerical methods for general financial derivative PDEs in 1D and 2D using implicit boundary conditions

09:55–10:15 **John H Knight** Periodic soil heat flow – the phase difference between maximum heat flux and maximum temperature

10:20–10:40 **§ Lucy Dowdell** The Abundance Constraints Method: A New Approach to Ensemble Ecosystem Modelling for Large Networks

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10:45–11:15 **Break** in X504 (past the quiet study space)

11:15–11:35 **§ Hongfei Qiao** Mathematical Modeling of oncolytic Ads in combination with αPD-L1 in immunogenic solid tumor

11:40–12:00 **§ Mst Shanta Khatun** Investigating Cancer Evolution Using a Voronoi Cell-Based Model

12:05–12:25 **§ Neda Khodabakhsh** Modeling How Intercellular Forces Shape Stratification and Drive Wound Healing in the Corneal Epithelium

12:30–12:50 **§ Pantea Pooladvand** Cultural Drivers of Pathogen Emergence: Why New Diseases Appear

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12:55–14:00 **Lunch** in X504 (past the quiet study space)

14:00–14:15 **Prizes for student talks**

14:15–14:45 **NSW ANZIAM AGM**

Full schedule

Student talks indicated by **§**. All talks in room X803.

Thursday 27 November

12:00–13:00 **Registration**

Session chair: Ravi Pethiyagoda

13:00–13:20 **§ Rehab Aljabri** University of Newcastle

Time Domain Vibrations of a Circular Plate with Mixed Boundary Conditions

In this talk, I will present an analysis of the vibrations of a circular plate in the time domain with mixed boundary conditions. The vibration modes are computed efficiently using the separation of variables and expressed in terms of Bessel and modified Bessel functions. Two cases of mixed boundary conditions are examined: clamped–simply supported and simply supported–free circular plates. Lastly, numerical simulations in the time domain are presented.

13:25–13:45 **§ N. Jothilakshmi** Hindustan Institute of Technology and Science

Embedding parameters in interconnection network

Graph embedding is a critical technique for mapping a guest graph into a host graph, applicable across many fields. For example, in architecture simulation, one architecture can be modeled and studied using another by embedding the guest graph into the host graph. Similarly, in parallel computing, large computational processes are often broken down into smaller sub-processes that execute in parallel, where communication among them can be represented as an embedding of the sub-processes into a computing system modeled as a graph. An embedding of a guest graph G into a host graph H refers to a one-to-one mapping of the vertices in G to those in H. The quality of this embedding is evaluated using various criteria, including metrics like dilation, congestion, wirelength, load, and expansion. Dilation measures the efficiency of graph embeddings by evaluating the ratio of the longest path in an embedded graph to the shortest path in the original graph, thereby assessing the impact of routing on signal integrity. Congestion, on the other hand, reflects the degree of overcrowding in routing paths, indicating the maximum number of overlapping connections at any edge, which can lead to delays and increased power usage. Wirelength quantifies the total distance of interconnections required to link components, directly influencing signal delay, power consumption, and manufacturing costs. In this paper, we discuss the wirelength of an embedding into special types of line graphs.

13:50–14:10 **§ Agus Soenjaya** University of NSW

Finite element approximations of a nonlinear micromagnetic model at elevated temperatures

The Landau-Lifshitz-Bloch (LLB) equation is a nonlinear vector-valued (deterministic or stochastic) partial differential equation that arises in micromagnetics to describe the time evolution of the magnetisation field in ferromagnetic materials at elevated temperatures. In this talk, I will present several fully discrete finite element schemes for the numerical solution of the LLB equation. In the deterministic setting, we propose a linear, energy-stable finite element method based on the scalar auxiliary variable (SAV) approach. The scheme satisfies a discrete energy law associated with an SAV-based energy functional that approximates the true micromagnetic energy. Under appropriate regularity assumptions, we establish unconditional energy stability and derive optimal-order error estimates in various norms. In the stochastic setting, we also develop a fully discrete scheme and conduct a rigorous strong convergence analysis. Due to the limited regularity theory currently available for stochastic LLB equations in spatial dimensions $d \geqslant 2$, the analysis is restricted to the one-dimensional case. Numerical experiments are presented to complement the theoretical results.

14:15–14:35 **§ Josiah Murray** University of Newcastle

Infinite beams, undetermined coefficients, and the Laplace transform

Effectively developing and maintaining railway infrastructure is increasingly important as the need for heavier loads and higher-speed trains increases. Of particular importance are sections of track where the foundation properties change significantly along their length - termed ‘transition zones’. Transition zones are known to degrade much more rapidly than other sections of track, motivating a thorough understanding of their mechanics. One model for these systems is an infinite Euler-Bernoulli beam resting on a piecewise-constant viscoelastic foundation. An attractive approach for solving these models is a combination of undetermined coefficients and the Laplace transform, due to its relative simplicity, effectiveness for dealing with discontinuities in the foundation, and avoidance of time-stepping.

14:40–15:30 **Plenary: Melanie Roberts** Griffith University

Contributing to Improved Water Quality for the Great Barrier Reef Through Mathematics

Water quality is one of the most significant risks facing the Great Barrier Reef—second only to climate change—and similarly threatens other marine ecosystems. Sediments, nutrients, and other pollutants delivered from catchments drive declines in marine health, contributing to coral disease and mortality, algal blooms, crown-of-thorns starfish outbreaks, loss of seagrass habitat, and increased vulnerability to bleaching events. Because these impacts are shaped by processes operating across the entire catchment, effective improvement requires a coordinated mix of responses that tackle different sources of pollution and leverage opportunities for rehabilitation and mitigation.

Mathematical modelling plays a critical role in this work. It deepens our scientific understanding of how catchment processes interact and provides the evidence needed to guide investment, prioritise interventions, and design effective on-ground actions. In this talk, I will introduce our team's research aimed at delivering meaningful environmental outcomes through the strategic management and rehabilitation of natural systems, with a focus on improving downstream water quality while supporting local co-benefits

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15:40–16:00 **Break** in X802

Session chair: Mike Meylan

16:00–16:20 **Mariano Rodrigo** Univeristy of Wollongong

On a stochastic Omori law for earthquake aftershock sequences

Omori's law describes the temporal decay of earthquake aftershock rates as an inverse power of time. This talk presents a stochastic generalisation governed by a nonlinear stochastic differential equation. An exact solution is obtained, enabling a probabilistic characterisation of aftershock decay. Parameter estimation is performed via a quasi maximum likelihood approach. The distribution of the inverse aftershock frequency is derived, and approximate analytical confidence intervals are established. Numerical simulations illustrate the theoretical results and estimation performance.

16:25–16:45 **§ Dilani P J G Dewage** University of Wollongong

Integration-based method for reconstructing the deactivation coefficient in aftershock frequency data

This study presents an integration-based method for reconstructing the time-dependent deactivation coefficient in earthquake aftershock frequency data. The contemporary interpretation of Omori law marks a transition from a purely empirical relationship to a dynamical model rooted in physical principles and expressed through an ordinary differential equation (ODE). Our approach employs four distinct integration-based techniques to analyze the temporal behavior of deactivation coefficient using aftershock data. Applying this method to multiple aftershock sequences, we identify intervals where deactivation coefficient remains nearly constant (the "Omori epoch") as well as periods of significant variability. These insights provide a clearer understanding of post-seismic relaxation mechanisms and demonstrate the value of mathematical techniques in seismology.

16:50–17:10 **Ravi Pethiyagoda** University of Newcastle

Crestlines for gravity-capillary ship waves

As a disturbance moves through the water at small length scales the effects of gravity and surface tension influence the wave pattern in interesting ways. I will use the method of steepest descent to isolate all oscillating components of the wave pattern, including those that are exponentially small.

17:15–17:35 **§ Faraj Alshahrani** University of Newcastle

Ice Shelf Breakup Simulation

A time-domain hydroelastic model for a bounded ice shelf, obtained by coupling Kirchhoff-Love plate theory with the linear shallow-water equations, is developed and solved. We first formulate and solve the initial-boundary value problem for a single bounded ice shelf, which leads to a nonlinear eigenvalue problem treated using an iterative scheme. The model is then extended to simulate ice-shelf breakup by introducing additional boundary conditions at crack interfaces and expanding the nonlinear eigenvalue matrix formulation to efficiently handle larger multi-segment systems. Numerical results, including breakup simulations, animation of the fracture process, and energy-conservation, are presented and discussed.

17:40–18:00 **§ Lamees Alasmari** Univeristy of Newcastle

Gravity–Capillary Wave Scattering by a Change in Depth

We consider linear gravity–capillary wave scattering by a depth step, with surface tension included. The single-frequency problem is solved by eigenfunction matching across the step, leading to a block-matrix system from which reflection and transmission coefficients are obtained. A generalised eigenfunction expansion (GEM) is then introduced to build time-domain solutions for free-surface operators with a continuous spectrum. To demonstrate the approach, GEM is applied in constant depth, where the scattering basis reduces to plane waves and the time evolution of arbitrary initial data is recovered by continuous superposition. Numerical results for constant depth are presented by reconstructing a prescribed Gaussian initial packet.

18:05–18:25 **§ Mitchell Bonham** Univeristy of Newcastle
Watching a Rogue Wave Hit an Iceberg: Modelling the Draupner Event
I model the 1995 Draupner wave impacting an idealised iceberg using a coupled fluid–elastic system. The water motion follows linear potential flow theory, and the iceberg is treated as a flexible floating plate that bends and oscillates in response. By reconstructing the Draupner wave as a short, intense pulse, the model captures how energy transfers between the wave and the ice, exciting flexural motion across the iceberg. I'll share animations of the model in action to illustrate how rogue-wave impacts can drive complex iceberg vibrations.

19:00–20:30 **Conference Dinner** The Curve Thai Restaurant (own cost)

Friday 28 November

Session chair: Natalie Thamwattana

08:30–09:20 **Plenary: Michael Watson** University of NSW
When vascular smooth muscle cells go rogue: a mathematical model of smooth muscle cell phenotype switching in atherosclerotic plaques
Atherosclerotic plaques are fatty, cellular lesions that form in artery walls and can lead to heart attack or stroke. Plaques are initiated by blood-borne lipid particles ("bad cholesterol") that become trapped in the artery wall and trigger an immune reaction. Subsequent plaque progression involves a complex interplay between these lipids and the cells that are recruited to the lesion site.
The two main cell types in plaques are macrophages (specialised immune cells) and smooth muscle cells (SMCs), which reside in the artery wall. Macrophages are recruited to the early plaque to ingest and remove retained lipids. SMCs enter the plaque when ineffective lipid removal by macrophages causes localised accumulation of lipid and cellular debris. SMCs form a protective cap over this hazardous material but can undergo a harmful transition towards a defective macrophage-like phenotype.
In this talk, I will present an ODE model of plaque formation in which cap SMCs can change their phenotype to become macrophage-like cells. Using steady state analysis and numerical simulations, we consider how the exposure of SMCs to uncleared lipid can drive this phenotypic transition and accelerate plaque progression. This model represents a small part of a larger body of recent modelling research that aims to provide novel mechanistic insight into the formation of dangerous atherosclerotic plaques.

09:30–09:50 **§ Amanda Munasinghe** University of Wollongong
Numerical methods for general financial derivative PDEs in 1D and 2D using implicit boundary conditions
This study develops and evaluates advanced numerical methods for solving one- and two-dimensional partial differential equations (PDEs) in settings where boundary conditions are not explicitly specified and therefore require careful boundary treatment. To address this challenge, the study focuses on the use of implicit quadratic boundary conditions, which stabilise the numerical solution and enhance accuracy at the domain boundaries—a crucial requirement for models operating without prescribed boundary conditions. The numerical framework incorporates semi-Lagrangian, Crank–Nicolson, alternating direction implicit (ADI) and 1D and 2D hybrid methods, each adapted to handle implicit boundaries effectively. These schemes are systematically tested on benchmark models, including Vasicek, Cox–Ingersoll–Ross (CIR) and the multi-dimensional Heston framework for path-dependent options. The findings demonstrate that combining robust interior schemes with implicit boundary conditions leads to improved numerical stability and significant accuracy gains, particularly for complex, high-dimensional problems. This approach offers broad applicability in computational finance, enabling efficient and reliable pricing of derivatives in scenarios where boundary information is realistic but limited.

09:55–10:15 **John H Knight** Australian National University
Periodic soil heat flow – the phase difference between maximum heat flux and maximum temperature
The problem of soil temperature variation in response to a periodic variation of the temperature at the soil surface has been studied and solved analytically a long time ago. For each frequency a temperature wave travels

down through the soil while its amplitude decays exponentially with depth, with higher frequencies being more strongly damped. The solution works well for both the daily and annual variations in surface temperature, as confirmed by field measurements. The solution gives a phase difference between the temperature wave and the corresponding soil heat flux wave of one eighth of a period, three hours for the daily wave and a month and a half for the annual wave.

Over my long career as an environmental applied mathematician I have often been asked why this is so – why is the daily peak of solar radiation at about noon, whereas the hottest daily temperature is several hours later? I have usually replied that the phase lag is what the mathematics requires.

In this talk I will give a more detailed explanation. I will derive a solution for a soil of finite depth with an insulating boundary at the base, and show how the phase lag between heat flux and temperature varies with the finite depth, reaching a limit as the depth of the soil layer approaches zero.

10:20–10:40 § **Lucy Dowdell** Queensland University of Technology

The Abundance Constraints Method: A New Approach to Ensemble Ecosystem Modelling for Large Networks

Ensemble Ecosystem Modelling (EEM) is a powerful tool for quantitatively analysing ecosystem networks. EEM randomly samples values for the parameters of the Generalised Lotka-Volterra equation and the samples are accepted if they meet two conditions: (1) feasibility and (2) stability. Such analysis is incredibly important to predict the lasting impacts of human activities on ecosystem networks and will help inform ecosystem management decisions. A challenge with utilising EEM is the high computation time required for ecosystems with a large number of species due to the low acceptance rate of samples. In an effort to increase the acceptance rate, the abundance constraints approach is proposed. The abundance constraints approach shifts the sampled parameters such that it meets feasibility automatically and therefore, only needs to satisfy stability. This method resulted in an increased acceptance rate compared to three variants of EEM, each variant sampling the parameters of the Generalised Lotka-Volterra Equation from a different statistical distribution. This could unlock EEM for networks with a large number of species, leading to an ability to practically model ecosystem network structures of far greater complexity than was previously thought possible.

10:45–11:15 **Break** in X504 (past the quiet study space)

Session chair: Mariano Rodrigo

11:15–11:35 § **Hongfei Qiao** University of Sydney

Mathematical Modeling of oncolytic Ads in combination with αPD-L1 in immunogenic solid tumor

Cancer immunotherapy harnesses the patient's immune system, both innate and adaptive, to attack and abolish the tumors. Immune checkpoint inhibitor (ICI) have shown promising results against a variety of solid tumors across clinical tri-als. Most of the clinically approved immune checkpoint inhibitors are designed to obstruct the interaction between co-inhibitory receptors and their ligands. However, ICI monotherapy is often ineffective in patients with non-immunogenic tumors that exhibit high level of immunosuppression and low level of tumor infiltrating lymphocytes. While, several clinical trials and preclinical studies have successfully demonstrated that oncolytic viruses can mount a potent antitumor immune reaction against solid tumors by promoting tumor-specific T helper type 1 (Th1) response. Among the oncolytic viruses, adenovirus (Ad) is a particularly promising vector for immunotherapy. Thus, Hyo Min Ahn proposed a investigated a combination of ICIs with several different immune stimulatory oncolytic adenoviruses (Ads).

Now, we developed a nonlinear ordinary differential equation framework to analysis the above combination therapy. We used ode45 and lsqnonlin to fit the available experimental data. The model provides a powerful tool to explain and predict oncolytic virus–immune combination effects and to compare dosing regimens.

11:40–12:00 § **Mst Shanta Khatun** Univeristy of Sydney

Investigating Cancer Evolution Using a Voronoi Cell-Based Model

Epithelial cancer progresses through a series of mutations that occur during cell division. These successive mutations trigger unregulated cell growth through excessive cell division, migration, and invasion of the underlying extracellular matrix (ECM) of the tissue. In epithelial carcinogenesis, mutations accumulating in a cell play a critical role by giving rise to heterogeneous cell populations that interact and cooperate with each other and with their microenvironment, such as the ECM. In this talk, I will discuss how a heterogeneous malignant tumour forms through either lineal evolution, characterised by minimal clonal interactions, or interclonal cooperativity, in which mutations cause the cells to affect the behaviours of surrounding cells. Also, I will discuss which of those mechanisms can produce a faster-growing tumour.

12:05–12:25 **§ Neda Khodabakhsh** Univeristy of Sydney

Modeling How Intercellular Forces Shape Stratification and Drive Wound Healing in the Corneal Epithelium

The cornea is a self-renewing, multilayered tissue maintained with remarkable precision. Its outermost layer, the corneal epithelium, consists of five to seven stratified cell layers, sustained by two coordinated processes: the centripetal migration of transit amplifying cells (TACs) from peripheral limbal epithelial stem cells (LESCs), and delamination (vertical movement) of cells between layers. Despite this well-organized renewal, the mechanisms governing epithelial stratification remain largely unknown. In this study, we present a two-dimensional Voronoi cell-based model that captures the dynamics of epithelial stratification. Our model incorporates two distinct epithelial layers—the basal and the suprabasal layers—and accounts for key cellular processes. These processes are mediated by mechanical interactions such as cell-substrate adhesion, as well as horizontal and vertical intercellular forces. Our simulations show that cell delamination, which drives stratification, is strongly linked to TAC proliferation. In contrast, LESC division remains largely unchanged, suggesting that TACs buffer LESC activity, consistent with the slow-cycling nature of stem cells. This reveals that processes weakening the cell-to-substrate interaction will enhance the turnover of epithelial cells without the need for external growth factor induction, which is a notable finding. Interestingly, although increased shedding promotes division and delamination, excessive shedding leads to mechanical compensation via cell stretching in the upper layers. This mechanical response explains the presence of enlarged cells in the superficial layers of the corneal epithelium. We further outline the corneal epithelial wound healing process, highlighting the contribution of mechanical forces in guiding tissue recovery.

12:30–12:50 **§ Pantea Pooladvand** University of Sydney

Cultural Drivers of Pathogen Emergence: Why New Diseases Appear

Human cultural practices can rapidly spread and unintentionally create conditions that favour the emergence of new diseases. We develop a mathematical model showing that when a risky practice disseminates, emergence can become unavoidable, with fast social learning, slow abandonment, and high perceived benefits accelerating this process. A complementary cluster analysis of 44 diseases identifies seven recurring patterns of human factors linked to emergence, including domestication, wildlife contact, and changes in human movement. Together, these findings illustrate how cultural change shapes microbial environments and why disease emergence is both patterned and inherently unpredictable.

12:55–14:00 **Lunch** in X504 (past the quiet study space)

14:00–14:15 **Prizes for student talks**

14:15–14:45 **NSW ANZIAM AGM**