2025 SDG Workshop Information Booklet

Kioloa Coastal Campus

10-14 November 2025

Figure 1: Attendees at the 2025 Kioloa SDG Workshop.

Contents

Acknowledgements

The organisers gratefully acknowledge financial support from UNSW's School of Mathematics and Statistics through an Australian Research Council scheme.

Basic Information

- A take-away sandwich lunch will be provided on Monday from 1pm, followed by dinner. Breakfast, morning tea, lunch, and dinner are provided Tuesday to Thursday; breakfast, morning tea, and lunch are provided on Friday. Tea and coffee is available during breaks in the afternoons.
- Rooms for staff and postdocs have two single beds per room. Rooms for students have a variable number of beds per room, ranging from two to four.
- WiFi is available in all cabins and open spaces in and around the London Shed conference space. Eduroam is available, and there is also the option to obtain a guest username and password for ANU Secure. Telstra mobile phone data should work; all other providers are "patchy at best".
- In the conference room (London Shed), there is a projector with an HDMI connector for electronic presentations; please bring your own required connectors. There are also two whiteboards.
- BYO alcohol is permitted and no alcohol is sold on the premises. Please familiarise yourself with the alcohol policy on the following page.
- Due to fire risk, Kioloa Coastal Campus is a fire-free zone in November; in particular, the campfire may not be used.
- You may wish to bring: sun protection i.e. hat, sun glasses, sunscreen, long-sleeve tops, swimwear, beach towel, warm clothes for the evening including long pants and a jacket, wet weather gear, sturdy shoes, small carry bag or daypack, water bottle, snacks, and mosquito repellent (perhaps including electric repellers for overnight as some buildings lack screens).
- The beach is not patrolled. If swimming, be aware of rips, swim with others, while sober, in daylight.

Australian National University

Kioloa Coastal Campus Alcohol Policy Guidelines

- The responsible consumption of alcohol at the KCC is the responsibility of all users on site and will be BYO. There is to be no sale of alcohol unless for approved functions by the Functions on Campus Team.

- The group leader (main contact for the booking) is responsible for all guests knowing their responsibilities in relation to alcohol. The group leader will also be responsible for ensuring all guests are familiar with the KCC site induction and the ANU Liquor Policy.

- Any groups that include undergraduate students are not to bring or consume alcohol at the KCC. It will be the responsibility of the group leader to ensure all members of their group are aware of this policy.

- The group leader is responsible for the following:
  - Ensuring no alcohol is consumed by underage guests.
  - No drinking games that encourage consumption, and
  - No swimming after dusk or if any members of the group have been consuming Alcohol.

- Drunk and disorderly conduct at the KCC will not be tolerated.

- When consuming alcohol guests are to be mindful of other guests staying at the KCC. Noise is to be kept to a minimum, with large group gatherings not allowed after 10pm.

- Guests are responsible for cleaning up any alcohol related rubbish immediately following their gathering, placing all containers in rubbish receptacles.

- Failure to leave an area clean may incur a $150 site cleaning fee.

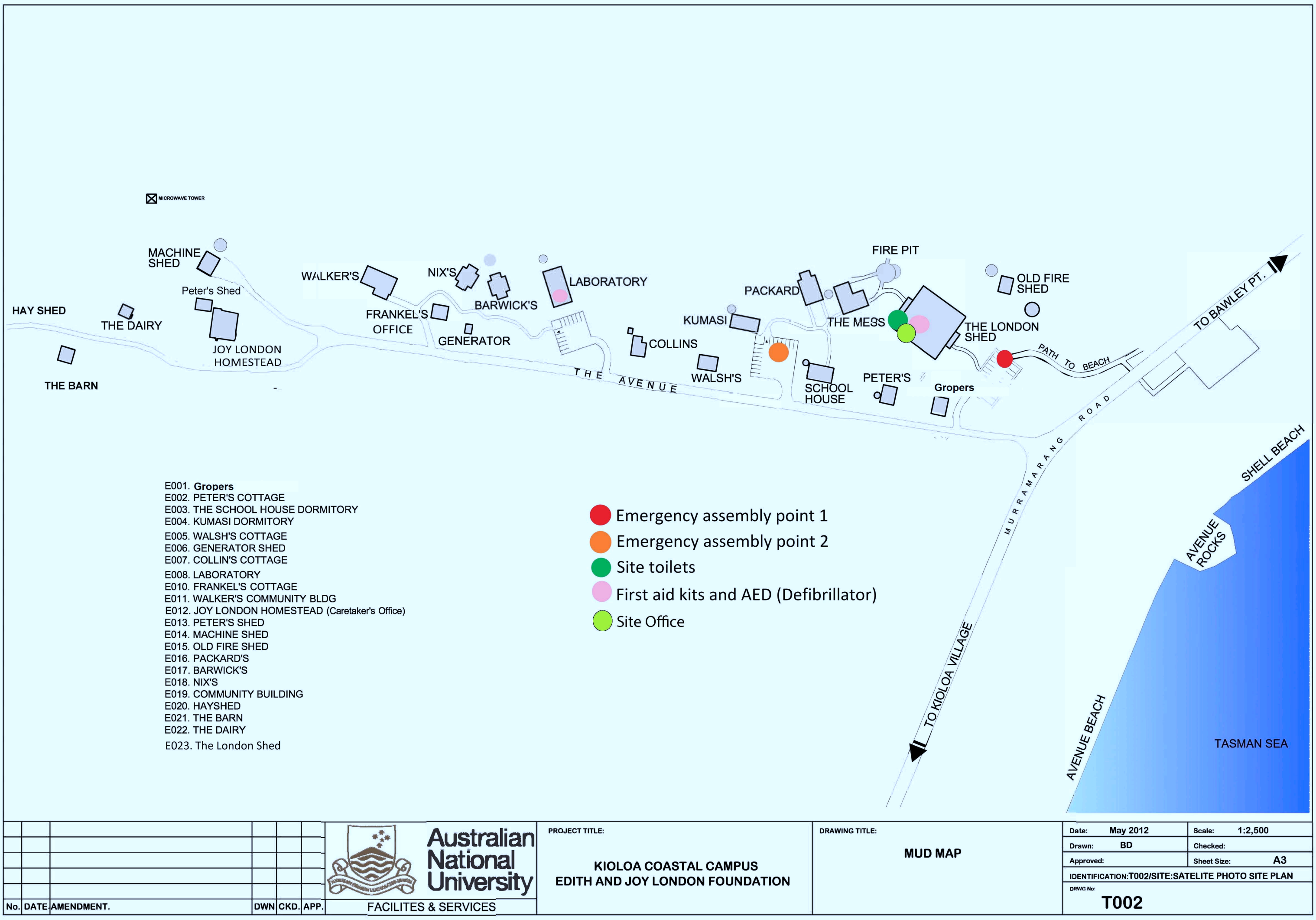
- Noting that some guests at the KCC may be underage, all alcohol must be stored in a safe and secure location.

- Non-compliance with these guidelines may be considered misconduct or serious misconduct and be managed under applicable University policies, legislation of the ANU Enterprise Agreement.

- Affiliate or External groups Non-Compliance of these guidelines could result in their booking being cancelled and future bookings being refused.

Date: 22nd September 2023

Kioloa Coastal Campus Map



Schedule

Time	Monday	Tuesday	Wednesday	Thursday	Friday
07:30 – 09:00		Breakfast	Breakfast	Breakfast	Breakfast
09:00 – 10:30		E-Poster (Session 3)	Nugget (Session 1)	Nugget (Session 2)	Subnugget (Session 10)
10:30 – 11:30		Coffee/Tea break	Coffee/Tea break	Coffee/Tea break	Coffee/Tea break
11:30 – 12:30		E-Poster (S. 4) & Subnugget (S. 1)	Subnugget (Session 4)	Subnugget (Session 7)	Discussion Session
12:30 – 13:00		Lunch	Lunch	Lunch	Lunch & Goodbyes
13:00 – 14:00	Take-away lunch & Welcome				
14:00 – 15:00	E-Poster (Session 1)	Discussion Session	Discussion Session	Discussion Session	
15:00 – 15:30		Subnugget (Session 2)	Subnugget (Session 5)	Subnugget (Session 8)	
15:30 – 16:00	Coffee/Tea break				
16:00 – 16:30	E-Poster (Session 2)	Coffee/Tea break	Coffee/Tea break	Coffee/Tea break	
16:30 – 17:30		Subnugget (Session 3)	Subnugget (Session 6)	Subnugget (Session 9)	
17:30 – 18:30	Pre-dinner break	Pre-dinner break	Pre-dinner break	Pre-dinner break	
18:30 – 20:00	Dinner	Dinner	Dinner	Dinner	

Abstracts

E-poster Session 1

Optimal Linear Response of the ENSO Cycle to Perturbations of the Transfer Operator

Nicholas Peters

University of New South Wales

The El Nino Southern Oscillation (ENSO) is a heating and cooling cycle that occurs mainly in the Pacific ocean. With the current rapidly changing climate, we are interested in what would happen if this cycle became stronger/weaker or faster/slower. We start by using sea surface temperature measurements to construct a Markov matrix which is a data-driven approximation the transfer operator. The eigendecomposition of this matrix is used to separate out the parts of the dynamics associated with the ENSO cycle by identifying the relevant eigenvalue/eigenvector pair. We then perturb the matrix in such a way that optimally increases either the magnitude or frequency of this eigenvalue and investigate the response of the corresponding eigenvector.

First-passage times of superdiffusive processes arising from compounded random walks

Boris Huang

University of New South Wales

Numerous mathematical models have been derived through the concept of random walks. These models give useful insight into physical properties, such as first-passage times and reaction dynamics, within biological and chemical processes. It has recently been demonstrated that models which exhibit superdiffusivity on unbounded domains while also being well defined in the bounded domain may be derived via a compounded random walk. In this talk, we formulate the governing equations, which include a space-fractional spectral Fokker-Planck operator, for these models and examine their first-passage properties. Due to the incorporation of compounding in the stochastic formulation, many of the unusual phenomena which arise cannot be obtained from existing models.

Rectangles and more rectangles

Sean Skinner

University of Sydney

Consider T the full binary tree of height n. (So there is one root at the top, and there are 2^n leaves all the way down the bottom.) If you take any subset S of these 2^n leaves, you can naturally obtain a 'subtree' T_S of T, by including all ancestors of each leaf in S. For a vertex v in the vertex set of T_S, let's say that v *splits* whenever it has 2 distinct children. If we played a game where I pointed a gun to your head and asked you to calculate the size of the biggest subset S of the 2^n leaves such that T_S has exactly x vertices that split, (with the implication being that if you don't answer the question correctly within say an hour then I pull the trigger...) I would bet good money that you will probably live. One can ask very similar questions in the setting of products of trees, but if I only gave you an hour, I'd advise not playing the game at all.

Billiards within conics in a finite projective plane

Harry Hiatt

University of Sydney

Billiard dynamics within conics are usually considered in the Euclidean plane however, billiards can equally be played in conics in projective planes over finite fields. Doing so introduces the projective law of reflection along with some unintuitive behaviours unique to the finite projective setting. Therefore, some background on the system will be provided such as confocal conics in a projective plane and the projective law of reflection, before introducing Cayley conditions over finite fields as well as a mystery sequence derived from the billiard dynamics within a certain class of confocal conics over $\mathbb{F}_3$.

Finite-size induced random switching of chimeras in a deterministic two-population Kuramoto-Sakaguchi model

Henry Irvine

University of Sydney

The two-population Kuramoto-Sakaguchi model for interacting populations of phase oscillators exhibits chimera states, whereby one population is synchronised and the other is desynchronised. Which of the two populations is synchronised depends on the initial conditions. This deterministic model exhibits random switches of their chimera states, alternating between which of the two populations is synchronised and which is not. It is possible to model this behaviour through a reduced stochastic process, based on a central limit theorem. It is also possible to consider this system as a form of the Kramers problem, where we can then estimate how often switching occurs, and why it only occurs for finite sizes.

E-poster Session 2

Modelling and Analysis of Semiconductor Lasers Subject to Fibre Bragg Grating Feedback

Joe Steele

University of Auckland

The Lang-Kobayashi equations are the standard tool for modelling lasers subject to external feedback from a regular mirror. When the feedback comes from a fibre Bragg grating (FBG), present modelling requires a computationally expensive convolution term, which provides limited analytical insight into the system's behaviour. We present a novel modelling approach that approximates FBG feedback using discrete delay terms, avoiding the need for numerical convolution while preserving the essential physics. This enables analysis of mode structure and solution stability, providing a bridge between numerical simulation and analytical understanding.

Blenders and blender-like chaotic attractors in a three-dimensional Hénon-like diffeomorphism

Sanaz Amani

University of Auckland

We investigate a three-dimensional Hénon-like map in the regime with a chaotic attractor interspersed by periodic windows. We show that, throughout this regime, there exists a transitive invariant set (chaotic attractor or hyperbolic set), which exhibits the carpet property: the relevant invariant manifolds behave as geometric objects of higher dimension.

Invariant Manifolds and Wild Chaos

Sam Doak

University of Auckland

We study a three-dimensional diffeomorphism exhibiting a higher-dimensional form of chaos known as *wild chaos*. Wild chaos is associated with robust heterodimensional cycles, which, in three dimensions, counterintuitively include the robust occurrence of non-transverse intersections between one-dimensional stable and unstable manifolds. We show how the one-dimensional stable and unstable manifolds of the system's fixed points behave like surfaces, where robust intersections are heterodimensional cycles.

A computer-assisted proof of the existence of blenders

Natalia McAlister
Monash University

A blender is a hyperbolic set whose stable, or unstable, manifold, when looking at certain intersections, appears to have a greater dimension than it actually does. Blenders are known to generate robust heterodimensional cycles and have been used to construct examples of robustly transitive maps that are not uniformly hyperbolic. However, they have been mainly studied from an abstract perspective and there are not many explicit examples. In this talk, I will present a characterisation of blenders as a family of curves satisfying a finite amount of interval inclusions. This characterisation is amenable to computational verification and can potentially be used to find new explicit examples.

Geometric methods for the study of relaxation oscillations arising from switching in multi-scale dynamical systems

Tyson Rowe
University of Adelaide

Mathematical models of multiple time scale phenomena – such as those in biological and neuronal systems – often feature *switching*: a dramatic change in system behaviour in response to certain variables crossing over a threshold. This typically indicates the transition of one or more variables from slow to fast (or vice versa). In this talk, we explore how switching provides a mechanism to construct two-stroke relaxation oscillations in planar systems. We then conclude by discussing the extension of these ideas to three-dimensions.

Prediction of synchronisation in networks of coupled oscillators using data assimilation and model reduction methods

Meghna Mistri
University of Auckland

Networks of coupled oscillators undergo a phenomenon called spontaneous mutual synchronisation, where the oscillators lock onto a common frequency and display coherence. Predicting the onset of synchronisation (or associated desynchronisation) is useful for real-world systems, like power grids and neuronal networks, where the state of synchronisation affects their performance. We attempt to build a combined methodology using data assimilation and model reduction, that applies to networks of finitely large number of coupled oscillators, that will enable this prediction.

E-poster Session 3

Title

Antony Mizzi
University of Western Australia

Abstract.

Debiasing Estimates of Power Spectral Density

Marcus Dyson
University of Western Australia

Estimators of power spectral density (PSD), such as Welch's estimator, exhibit bias when applied to finite data due to convolution with the spectral window. We address this by representing both the biased and true PSD with families of B-splines. By fitting a convolved model to the biased estimate, coefficients are inferred for the B-splines, allowing for a debiased representation. We incorporate Bayesian variable selection to determine knot locations adaptively, yielding locally adaptive variance on estimates, while maintaining bias reduction. This framework addresses the bias-variance trade-off inherent in nonparametric PSD estimatioin. We demonstrate our approach for Autoregressive and Matérn processes.

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Calibration of Statistical Finite Elements

Daniel Claassen
University of Western Australia

We develop Bayesian data assimilation methods for statistical finite element models of PDEs that jointly estimate states and parameters. By combining low-rank smoothing with dual estimation via Kalman filtering and MCMC, our approach balances accuracy with efficiency while capturing structural and parametric uncertainty. We demonstrate the framework on nonlinear PDEs, including the Kuramoto–Sivashinsky and Korteweg–de Vries equations.

Collective Motion in Flocks: Hunger, Game Theory, and Phase Transitions

Junhe Qiao

University of Western Australia

We extend the Couzin collective motion model with energy–dependent foraging, where agents balance two competing motivations: remaining with the group versus breaking away to refuel. While both behaviors are individually driven, they reflect different priorities–social cohesion versus physiological need. Our results bridge foraging theory with collective motion, revealing how state-dependent behavioral switching produces phase transitions with implications for collective decision-making in natural systems and autonomous swarm design. Local repulsion–orientation–attraction interactions produce group behavior, whereas refueling requires an intentional defection from this emergent cohesion. Our model explores how agents switch between these internally motivated but functionally distinct behaviors and how this switching gives rise to collective phase transitions. Environmental constraints like ground repulsion radius restrict parameter regions supporting coherent motion while preserving energy balance, showing maintained foraging performance despite spatial limitations.

Singular Perturbation Analysis of Three-time-scale Ecological Model

Matthew Lim

University of Sydney

Three-time-scale analysis extends fast-slow system theory to explain complex oscillatory dynamics in science and technology. A key challenge in this framework arises from its multi-parameter singular perturbation structure: singularities in fast-slow (slow-super-slow) subsystems coexist and interact, with trajectories inheriting behaviours from both. With reference to a canonical tritrophic food-chain model we present an overview of the Canard-Delay-Hopf (CDH) singularity, which exists at the coalescence of a Delay-Hopf bifurcation and a Folded Singularity. We emphasize the role of such singularities as organising centres and establish their connection to global separatrices of the flow.

Average measure theoretic entropy for a family of expanding on average random Blaschke products

Renee Oldfield

University of Queensland

We give a computable formula for the average measure theoretic entropy of a family of expanding on average random Blaschke products, generalizing work by Pujals, Roberts and Shub to the random setting. In doing so, we describe the random invariant measure and associated measure theoretic entropy for a class of admissible random Blaschke products, allowing for maps which are not necessarily expanding and may even have an attracting fixed point.

E-poster Session 4

Dynamics induced by a heteroclinic network between five equilibria

Md Azmir Ibne Islam

University of Auckland

We consider a spatially extended system of the non-transitive game 'Rock-Paper-Scissors-Lizard-Spock'. The system has a heteroclinic network comprising several heteroclinic cycles. Diffusion in one dimension in the system leads to travelling wave solutions, which are periodic orbits in a travelling frame of reference. We find a large number of different types of periodic solutions. Some of these solutions are very straightforward, and originate from Hopf bifurcations. However, some are complicated and there are complex transitions between them. In this talk, we will discuss these new periodic orbits and describe their interaction.

Superintegrable Geodesic Flows with a Linear First Integral

Gleb Palshin

University of Sydney

One of the most basic problems in differential geometry is finding the shortest path (a geodesic) between two points on a Riemannian manifold. It is well known that this problem leads to a Hamiltonian flow on the manifold's cotangent bundle, whose Hamiltonian is determined by the metric. A Hamiltonian system with a maximal set of independent first integrals is called maximally superintegrable. In this talk, we will discuss a new algebraic way to find superintegrable metrics on two-dimensional Riemannian manifolds that admit two additional first integrals: one linear and one polynomial in momenta of arbitrary degree.

Subnugget Session 1

Ruelle-Pollicott resonances of Annealed systems

Sakshi Jain
Monash University

I will start with introduction of resonances followed by introduction of Annealed systems. Finally stating some recent results on locating resonances of various annealed systems. It is based on joint work with Maxence Phalempin.

Subnugget Session 2

Stability of Depth-Two Heteroclinic Networks

Claire Postlethwaite
University of Auckland

The simplest heteroclinic cycles are the union of a set of equilibria and connecting heteroclinic orbits. Trajectories with initial conditions on a heteroclinic orbit asymptote in forward or backward time to one of the equilibria in the cycle. Heteroclinic networks are then the union of several heteroclinic cycles which share one or more equilibria.

I will discuss the dynamics near so-called *depth-two heteroclinic networks*. Here, trajectories with initial conditions on the connecting heteroclinic orbits may asymptote (in forward or backward time) not to a single equilibria but to a subset of the network which is itself a heteroclinic cycle. Computing stability conditions for these depth-two networks initially appeared to be very complex, but actually simplifies to be very similar in form to those for standard heteroclinic cycles. However, numerical simulation indicates that when stability is lost, very complicated dynamics can appear immediately.

On the cardinality of measures of maximal relative entropy for smooth skew products

Matheus Manzatto de Castro
University of New South Wales

Let Ω and M be compact smooth manifolds and let $\Theta : \Omega \times M \to \Omega \times M$ be a $\mathcal{C}^{1+\alpha}$ skew-product diffeomorphism over an Anosov base and $\mathbb{P}$ be a boundary-avoiding invariant measure in the base dynamics. We show that Θ has at most countably many hyperbolic measures of maximal relative entropy. If $\dim M = 2$, then Θ has at most countably many measures of maximal relative entropy. This is a joint work with Gary Froyland.

Subnugget Session 3

Statistical tests for data-driven eigenvalues

Caroline Wormell

University of Sydney

Consider a matrix that we estimate by least squares from data. (A motivating example could be the infinite-data but finite-basis limit for any data-driven operator approximation method). How can we locate its true eigenvalues from a finite data sample, or vice versa?

In this nugget I will discuss some statistical methods that appear to do this almost as well as possible, with a reasonable computational load. The key idea is to try and find a best bound on the probability of the resolvent sending a likely vector to zero. This idea may have some interesting applications, and there are some questions around implementation of more (statistically) efficient methods.

Optimal linear response

Maxence Phalempin

University of New South Wales

This talk present the notion of Linear response over an additive perturbation of an Anosov Transformation and the problem of finding the perturbation maximizing an averaged target associated to the new SRB measure with a numerical outlook.

Nugget Session 1

Phase-resetting in higher-dimensional systems

Bernd Krauskopf and Hinke Osinga

University of Auckland

Phase-resetting is a well-known technique in neuroscience to probe responses of cells to external perturbations. Theoretical studies are based on single-oscillator models, even though experiments inherently apply to coupled systems. We are interested in studying differences between single- and coupled-oscillator models, as well as introducing phase resetting to other applications, specifically coupled laser systems and mechanical devices.

Directional expansivity and its applications

Alexander Fish and Shrey Sanadhya

University of Sydney

A $\mathbb{Z}^d$ action is called ergodic if translations of any set of positive measure (under the $\mathbb{Z}^d$ action) cover the entire space up to zero measure. In this talk, we discuss the notion of directional expansivity : In other words, what happens when we restrict the translations to a certain direction in $\mathbb{Z}^d$. It was recently shown by Björklund-Fish that, under certain spectral conditions, there are always directions that significantly expand a given positive measure set. In this nugget, we will discuss various possible extensions of the directional expansivity and their applications.

Subnugget Session 4

Strong Symmetry Breaking in Coupled, Identical Slow/fast Oscillators

Theo Vo

Monash University

We study minimal networks of symmetrically-coupled, identical slow/fast oscillators. We find a plethora of strong symmetry breaking rhythms, in which the two oscillators exhibit qualitatively different oscillations, and their amplitudes and frequencies can differ by as much as an order of magnitude. Such differences in amplitude and frequency can be associated with different functional states, such as unihemispheric slow-wave sleep in certain marine animals and birds during which one hemisphere exhibits large-amplitude, low-frequency oscillations characteristic of sleep while the other exhibits small-amplitude, high-frequency oscillations associated with a wakeful state. This is joint work with Naziru Awal, Irving Epstein, and Tasso Kaper.

Rigorous geometric approaches to model reduction in gene regulatory dynamics

Sam Jelbart

University of Adelaide

Mathematical models for complex dynamical systems like gene regulatory networks (GRNs) are – like the systems they represent – high-dimensional, multi-scale and highly nonlinear. This creates a need for more tractable reduced models, however, the relationship between the original system and its reduced model is often a non-trivial one. We will discuss the pros, cons, rights and wrongs of model reduction in the context of GRN modelling, and culminate with (i) a couple of mathematically rigorous results on the the validity and invalidity of standardised approaches from the literature, and (ii) a whole bunch of questions for discussion. This is joint work with Lukas Baumgartner and Kristian Uldall Kristiansen.

Subnugget Session 5

Ginzburg-Landau type approximation of stochastic harmonic map heat flow

Chunxi Jiao

University of New South Wales

For harmonic map heat flow (HMF) in dimension 2, the construction of global weak solutions via smooth approximations is well-studied. Since the main nonlinearity in the equation arises from the projection of Laplacian on the target manifold (often the unit sphere $\mathbb{S}^2$), Ginzburg-Landau approximation seems natural as its key penalty term relaxes the constraint that the solution remains $\mathbb{S}^2$-valued. In the stochastic case, the convergence of such approximations is unaffected when the noise is linear and multiplicative, but becomes problematic when the noise is additive. We aim to explore different penalty and noise formulations, and the corresponding modified energies. This talk is based on joint work (in progress) with Ben Goldys (USYD).

Coarse-graining of stochastic differential equations

Upanshu Sharma
University of New South Wales

Coarse-graining is the procedure of approximating a large and complex system by a simpler and lower-dimensional one. It is especially relevant in molecular dynamics, which deals with stochastic systems that involve large spatial and temporal scales. A key feature that allows for such an approximation is a choice to consider only part of the information by means of a coarse-graining map ξ that is strongly many-to-one. Assuming that the configuration of the full system is governed by a stochastic differential equation (SDE), for, say, a random variable X (representing for instance, the position of particles in the system), Itô's formula provides an equation for the reduced (coarse grained) variable $\xi(X)$. This reduced SDE is non-closed and therefore cannot be used in practice. In this talk, I will present a Markovian approximations for $\xi(X)$ and discuss several mathematical challenges associated with this approximation.

Subnugget Session 6

Identifying Quasi-Stationary Families of Almost-Invariant Sets in Two and Three-Dimensional Flows Using the Inflated Generator

Aleks Badza
University of New South Wales

The inflated generator is an operator whose eigenvectors are used to detect quasi-stationary families of almost-invariant sets; which are metastable flow structures which remain fixed in space in a non-autonomous velocity system. In this talk, I detail how we use the inflated generator to identify characteristic metastable flow behaviour in two- and three-dimensional real world dynamical systems. In two dimensions, we detect atmospheric blocking events, known for causing extreme weather events such as the intense heatwaves which occurred in Europe during the Summer of 2003. In three dimensions, we identify key patterns of heat transport in a simulated Rayleigh-Bénard convection system. This research has been supervised by Gary Froyland and conducted in collaboration with Jörg Schumacher and Roshan J. Samuel of Technische Universität Ilmenau.

The problem with overshoots

Courtney Quinn

University of Tasmania

There is increasing interest in the response of complex systems to relative rapid change in external forcing. One obvious motivating problem is the rapidly rising CO_2 emissions and subsequent rising global temperatures. In the context of this application, more emphasis has been placed on convergence to a certain level of overall warming as opposed to the transient precursory behaviour. The idea of "overshoot" has thus emerged as an attractive pathway for mitigating global emissions. In this talk I will outline the definition of overshoot in the climate mitigation sense and compare it with overshoot as a mathematical concept in the application to critical transitions. I will discuss some of the risks and complications in evaluating the outcomes of an overshoot emissions scenario and introduce the studies we are currently undertaking to disentangle these similarly-named concepts. The research involves collaboration with Dr Paul Ritchie (University of Exeter), Prof. Michael Charleston (UTAS), and Dr Shane Richards (UTAS).

Nugget Session 2

Fractals in rate-induced tipping

Eduardo G. Altmann and Jason Wang

University of Sydney

When the parameters of a dynamical system change fast enough, critical transitions can take place even in the absence of bifurcations. This phenomenon, known as rate-induced tipping, is observed in a variety of non-autonomous systems, from simple ordinary differential equations and maps to mathematical models in climate sciences and ecological networks. In most examples, the irreversible transition between different stable states happens at a critical rate, the so-called rate-induced tipping point, and is associated to a simple unstable orbit separating them (edge state). In this work, we show how this simple picture changes when non-attracting fractal sets exist in the autonomous system, a generic situation in non-linear dynamics. We show that these fractals in the phase space induce rate-induced fractals in parameter space. We illustrate our general theory in two paradigmatic systems: a piecewise linear one-dimensional map and the two-dimensional Hénon map. Joint work with Yi Zheng.

Hit me with your best shock: entropy in shock selection in reaction-diffusion equations with partially negative diffusivity

[1]Robert Marangell and [2]Bronwyn Hajek

[1]University of Sydney and [2]University of Adelaide

Shocks arising from nonlinear hyperbolic PDEs are well-studied and it's known that entropy can be used to determine the correct solution and it's direction of travel. But what about shocks arising in parabolic PDEs? Much less is known here – prepare to be shocked! Joint work with Tom Miller, Alex Tam, Martin Wechselberger, and Phil Broadbridge.

Subnugget Session 7

Which maps are return maps of a flow in $\mathbb{R}^3$?

Nathan Duignan

University of Sydney

Let's play a game. You hand me a a diffeomorphism $f : \Sigma \to \Sigma$ of some surface Σ. Can I find a smooth vector field in $\mathbb{R}^3$ whose flow admits a global Poincaré section diffeomorphic to Σ and whose return map is f? When is this possible? For which surfaces Σ, and for which maps f? In this talk, I'll explore examples, obstructions, and constructions that mostly resolve these questions.

Calculating exponentially-small eigenvalues for discrete NLS

Christopher Lustri

University of Sydney

It is a classical result that standing wave solutions to the discrete Nonlinear Schrödinger equation (NLS) can appear in two configurations: on-site and inter-site solutions. On-site solutions are stable to translation and inter-site solutions are unstable. Using exponential asymptotics, it is possible to calculate the exponentially-small translational eigenvalues associated with the instability. We need to be a little more careful to extend these results to include long-range interactions, but it is possible to do so. I hope to discuss the connection between Stokes' phenomenon and spectral matters, which has not yet been studied as carefully as it perhaps ought to have been.

Subnugget Session 8

Lyapunov–Oseledets spectrum and statistical properties for random metastable maps

Cecilia González-Tokman

University of Queensland

Abstract. We discuss progress in the analysis of random metastable maps, relying on understanding the Lyapunov-Oseledets spectra of associated transfer operator cocycles and approximating the distribution of jumps between metastable components by the jump process of an associated time-homogeneous Markov chain. This approach provides insights into the random (and stationary) physical measures of these systems and yields asymptotic estimates for the rates of correlation decay and diffusion coefficient. (Based on joint works with Joshua Peters and Anthony Quas.)

Blenders, Cycles, and Tangencies

Andy Hammerlindl

Monash University

Abstract. One formulation of a conjecture of Jacob Palis is that every dynamical system which is not uniformly hyperbolic can be perturbed by an arbitrarily small amount to produce a heterodimensional cycle or a homoclinic tangency. I will talk about these two types of dynamical/geometric objects and the problems involved in detecting and analyzing them numerically.

Subnugget Session 9

Dynamics on (co)adjoint orbits

Holger Dullin

University of Sydney

What is the dimension of the set of matrices with given eigenvalues and Jordan block structure and how does the dimension depend on the eigenvalues and the Jordan block structure? This question leads to the study of (co)adjoint orbits, which appear naturally as the phase space of dynamical systems with symmetry. I will explain a recent example of this: The dynamics of the symmetry reduced Newtonian N-body problem takes place on coadjoint orbits of the symplectic group. This is joint work with Richard Montgomery (UCSC).

Averaging: The GSPT Remix

Martin Wechselberger
University of Sydney

I shall present a constructive link between classical Pontryagin-Rodygin averaging and modern Geometric Singular Perturbation Theory (GSPT). Using the *parametrisation method*, we develop a coordinate-independent and systematic procedure to compute the slow drift on a normally hyperbolic manifold to any order. The core contribution is a constructive proof that an averaged, skew-product system exists, governing the slow dynamics on this manifold.

This is joint work with Bob Rink (VU Amsterdam) and Theodore Vo (Monash).

Subnugget Session 10

Trimmed ergodic sums

Max Auer
University of Queensland

I will reintroduce the well-known technique of trimming the study ergodic sums of non-integrable observables. While well-studied for iids and "very" mixing systems, results in non-mixing systems are basically non-existent. Together with Tanja Schindler it is shown for rotations.

Arithmetic and geometric aspects of the (symbolic) dynamics of piecewise-linear maps

John A G Roberts
University of New South Wales

We study planar area-preserving maps, described by different real unimodular matrices on the right and left half-planes. Such maps, studied previously by Lagarias and Rains, can support periodic and quasiperiodic dynamics with a foliation of the plane by invariant curves. The parameter space is two dimensional (given by the traces of the two matrices) and the set of parameters for which an initial condition on the half-plane boundary returns to it are algebraic "critical" curves, described by the symbolic dynamics of the itinerary between the boundaries.

I will sketch how the arithmetic, algebraic, and geometric aspects of the planar and circle (symbolic) dynamics has connections to various parts of number theory and geometry, including: Farey sequences; continued fraction expansions and continuant polynomials; the character variety of matrix group representations.

This is joint work with Asaki Saito (Hakodate) and Franco Vivaldi (London).

Yet another generative model: not the Koopman operator again!

Georg A. Gottwald

University of Sydney

In generative models one aims to draw new samples from some distribution to which we only have access via some given samples. A (not very useful) example is generating images which have never been actually taken by any photographer. The state-of-the-art method are diffusion models which estimate the so-called score function. Recently, together with Sebastian Reich, we developped a new method based on Schrödinger bridges that estimates transition probabilities to calculate conditional expectation values, with several advantages over score-based methods. In this talk we will propose a different method to calculate conditional expectation values via a Koopman operator acting as a transport map.

This is joint work with Nisha Chandramoorthy (Chicago).
