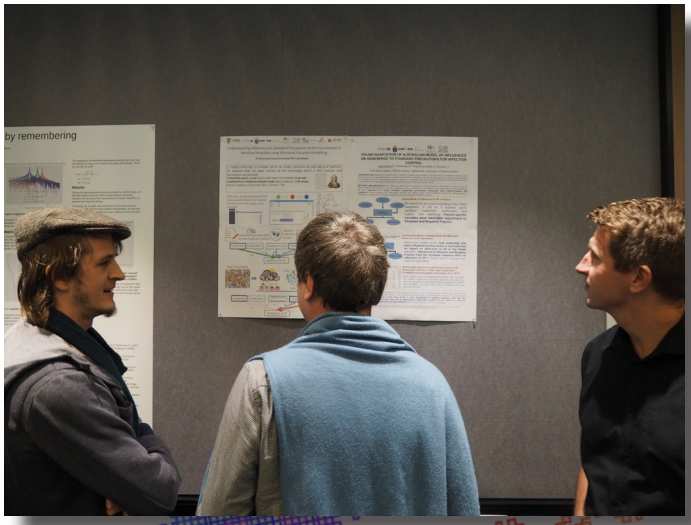
UNSW SYDNEY | Australia's Global University

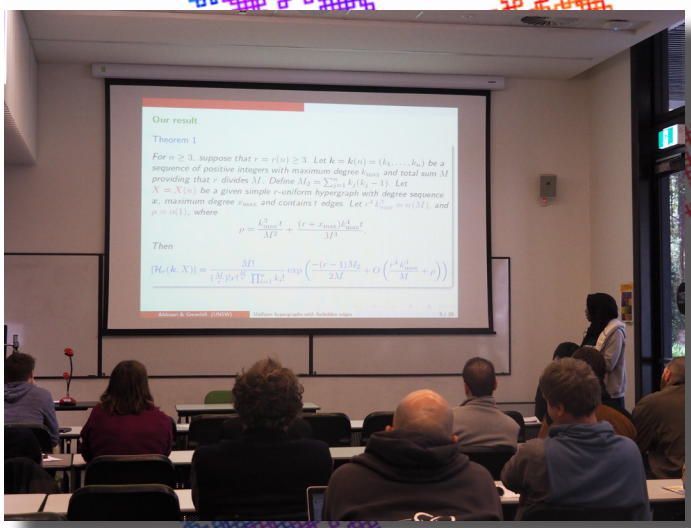
School of Mathematics and Statistics

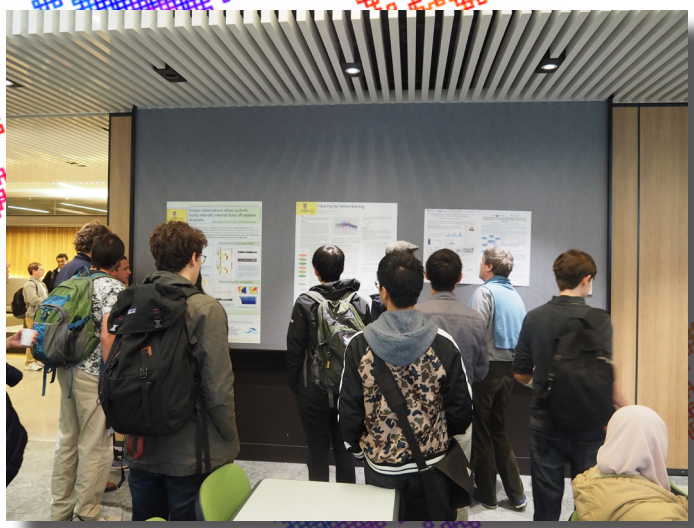
Postgraduate Conference 2019

Abstracts

Tuesday 13 August
Colombo Theatres, UNSW







Postgraduate conference 2019,
School of Mathematics and Statistics, UNSW, Tuesday 13th August, 2019

	Colombo Theatre B	Seminar room LG01	Seminar room LG02
08.50-9.00	Welcome and Opening by Ian Doust ☺		
	Chair: Ian Doust		
09.00-09.25	**Kam Hung Yau** A Relaxation of Goldbach's Conjecture		
09.30-9:55	**Yi-Lung Chen** Exact posterior sampling for the Bayesian Tobit linear model		
	Chair: Haya Aldosari	Chair: Harry Crimmins	Chair: Zhuoshu Wu
10.00-10.15	**Saleh Almuthaybiri** Global Existence Theory for Fractional Differential Equations: New Perspectives via Continuation Methods for Contractive Maps	**Fadi Antown** Linear response for the dynamic Laplacian and finite-time coherent sets	**Max Kulinich** Markov chain application for estimating model weights in climate model ensembles
10.20-10.35	**Meiram Akhymbek** Principal trace function of Carey-Pincus	**Michaela Hall** A dynamic model of human immunodeficiency virus and human papillomavirus interaction	**Raveen de Silva** Maximum Generalised Roundness of Metric Trees
10:40-10:55	**Shaymaa Al-shakarchi** Isomorphisms of AC(σ) spaces	**Eduardo Vitarelli de Queiroz** Ocean observations show cyclonic eddies intensify diurnal and semidiurnal internal tides off eastern Australia	**Elliot Dovers** log-Gaussian Cox process models for combining presence/absence and presence-only data in Ecology
11:00-11:30	**Morning tea**		
	Chair: Kam Hung Yau		
11:30-11:55	**Haya Aldosari** Spanning hypertrees in uniform hypergraphs		
	Chair: Kevin Mandira Limanta	Chair: Christopher Rock	Chair: Max Kulinich
12:00-12.15	**Sean Lynch** Zeta functions in noncommutative arithmetic	**Jeremy Nugent** Classification of superintegrable systems	**Robert Nguyen** Expected Points NRL
12.20-12.35	**Simon Macourt** The sum-product phenomenon and energy bounds	**Harry Crimmins** Rigorous approximation of the statistical properties of Anosov maps	**Jeffrey Kwan** Parametric Inference of the Hawkes process with time-varying background intensity
12.40-12.55	**James Ross** Uniform sampling for regular hypergraphs	**Michael Denes** Identification of Lagrangian Coherent Structures from swarms of virtual drifters using finite element methods	
13:00-14:00	**Lunch and poster session**		

	Colombo Theatre B	Seminar room LG01	Seminar room LG02
	Chair: Fadi Antown		
14:00-14:25	**Christopher Rock** Performance guarantees for detecting finite-time coherent sets with the dynamic Laplacian		
	Chair: Simon Macourt	Chair: Ashwaq Zarban	Chair: Michael Denes
14:30-14:45	**Kevin Mandira Limanta** A curious bijection between Dyck paths	**Chris Bladwell** Diahaline transport in ocean models	**Michael Clarke** Uncertainty Quantification for PDE's with Random Coefficients
14:50-15:00	**Alan Stoneham** Absolutely Continuous Functional Calculus and Variation in the Plane	**Xiongwen Ke** Bayesian variable selection in neural network	**Maeve Mc Gillycuddy** Model-Based Assessment of Covariate Effects in Multivariate Abundance Data
15:05-15:15	**Gavin Robertson** Roundness Of Banach Spaces	**Yandong Lang** Deriving new ways to construct neutral surface	**Michelle Lim** A Generalised Linear Latent Variable Models Approach for Ecological Monitoring
15:20-15:30	**Joshua Ho** Chromogeometry		**Guanting Liu** Positivity-preserving scheme for alpha-CEV process
15:35-15:50	**Afternoon tea**		
	Chair: Manzoor Khan		
15:50-16:15	**Carlos Aya-Moreno** Shape-preserving wavelet-based multivariate density estimation		
16:20-16:45	**Catheryn Gray** The Harmonic Oscillator Model of Akt Translocation		
16:50-17:00	**Awards and Closing**		
17:00-**late**	**After party (the White House)**		

Welcome!

Welcome to the 6th annual School Postgraduate Conference!

Having a Postgraduate Conference was one of the many great ideas that David Warton had during his time as Postgraduate Coordinator. We hope that this year's edition lives up to the high standard that David produced during his tenure.

As in previous years there is a mixture of different types of talks. We have six plenary talks in Colombo B, given by senior students who have published their research in leading journals, or who have given talks at major conferences. Something new this year is a session of shorter talks where beginning students can give us an introduction to their area of research and let us know where their studies are heading. And of course we have the competition for the best talks from each department!

We hope that you will get to meet some new people around the School during the breaks, and that you will join us afterwards to wind down over some food and drink.

Enjoy the conference!

The Organising Committee: left-to-right Susannah Waters, Kam Hung Yau, Fadi Antown, Ian Doust, Manzoor Khan

Our postgraduate research students and their recent achievements

The conference is a chance to celebrate the achievements of our postgraduate students. Please make the most of this opportunity to meet our postgrad students and find out more about them and their research, whether you are a staff member, another postgrad, a student considering a postgraduate research degree, or passing through on your way to outdoor table tennis.

Our research student population has now grown to over 50 students from many different countries, and they form a vital part of our research team in the School of Mathematics and Statistics.

Publishing research while still enrolled in a PhD is the goal of every student but it is difficult to do, given the time it takes to write a paper (many are writing their first) and the potentially long waiting times for review outcomes. Top journals in particular typically have low acceptance rates so are particularly challenging, but despite this, enrolled students manage a swag of publications each year, with several accepted into top journals each year. A big congratulations to the following students for their publications:

Aldosari, H.S. and Greenhill, C., Enumerating sparse uniform hypergraphs with given degree sequence and forbidden edges, journalEuropean Journal of Combinatorics, **77** (2019), 68–77.

Aya-Moreno, C., Geenens, G. and Penev, S, Shape-preserving wavelet-based multivariate density estimation, =Journal of Multivariate Analysis, **168** (2018), 30–47.

Baier, S., Lynch, S.B. and Zhao, L., A lower bound for the large sieve with square moduli, *Bulletin of the Australian Mathematical Society*, (2019).

Botev, Z., Chen, YL., L'Ecuyer, P., MacNamara, S. and P. Kroese, D. Exact posterior simulation from the linear LASSO regression, *Proceedings of the 2018 Winter Simulation Conference, WSC '18, Gothenburg, Sweden*, (2018), 1706–1717.

Crimmins, H. and Froyland, G., Stability and approximation of statistical limit laws for multidimensional piecewise expanding maps, *Annales Henri Poincaré*, (2019).

Doust, I. and Al-shakarchi, S., Isomorphisms of $AC(\sigma)$ spaces for countable sets, In: Böttcher A., Potts D., Stollmann P., Wenzel D. (eds), *The Diversity and Beauty of Applied Operator Theory. Operator Theory: Advances and Applications*, **268** (2018), pp 193–206, Birkhäuser, Cham.

Froyland, G., Rock, C.P. and Sakellariou K., Sparse eigenbasis approximation: Multiple feature extraction across spatiotemporal scales with application to

coherent set identification, *Communications in Nonlinear Science and Numerical Simulation*, **77** (2019), 81–107.

Gray, C.W. and Coster, A., Models of Membrane-Mediated Processes: Cascades and Cycles in Insulin Action *Reference Module in Biomedical Sciences, 2019*, doi: 10.1016/B978-0-12-801238-3.11348-0.

Khan, M. and Olivier, J., Quantifying the regression to the mean effect in Poisson processes, *Statistics in Medicine*, year=2018, **37** (2018), 3832–3848.

Khan, M. and Olivier, J., Regression to the mean for the bivariate binomial distribution, *Statistics in Medicine*, **38** (2019), 2391–2412.

Macourt, S., Shparlinski, I. E. and Shkredov, I. D., Multiplicative energy of shifted subgroups and bounds on exponential sums with trinomials in finite fields. *Canad. J. Math.* **70** (2018), 1319–1338.

Macourt, S., Bounds on exponential sums with quadrinomials, *J. Number Theory*, **193** (2018), 118–127.

Macourt, S. and Shparlinski, I. E., Double sums of Kloosterman sums in finite fields, *Finite Fields Appl.*, (to appear)

Macourt, S., Decomposition of subsets in finite fields, *Funct. Approx. Comment. Math.*, (to appear).

Yau, K.H., Bounds for triple exponential sums with mixed exponential and linear terms, *Bull. Aust. Math. Soc.*, **98** (2018), 64–69.

Yau, K. H., Distribution of $\alpha n + beta$ modulo 1 over integers free from large and small primes, *Acta Arith.* **189** (2019), 95–107.

Yau, K.H., Kerr, B. and Shparlinski, I.E., A refinement of the Burgess bound for character sums, *Michigan Math. J.*, (to appear).

Yau, K.H. Munsch, M. and Shparlinski I. E., Smooth square-free and square-full integers in arithmetic progressions *Mathematika*, (to appear).

Graduate list:
Anna McGann PhD
Kylie-Anne Richards PhD
Ramanan Rajkumar MSc
Firouzeh Noghrehchi PhD
Peter Ayre PhD
Yoshihito Kazashi PhD
Eric Kwok PhD

Thanks

The conference is an opportunity not just for our students to present their research, but also to get some experience at the important professional skills of running such a meeting. Although I provide a guiding hand, most of the work is actually done by the student organising committee, which this year was Manzoor Khan, Fadi Antown and Kam Hung Yau. But many others will contribute in other ways but chairing sessions and so forth.

We also receive great support from the professional staff of the School, particularly Susannah Waters, who is an honorary member of the committee, helping with promotion and much advice, and Kaye Sedgers and Gemayne Magbanua, for their help on the day.

Finally, thanks to my colleagues who serve on the Postgraduate Review Committees, providing guidance and advice to students throughout their studies, and importantly, helping us choose the prize winning talks: Feng Chan, Christ Angstman, Jim Franklin, David Warton, Anna Cai and Denis Potapov.

Ian Doust Director of Postgraduate Studies (Research) School of Mathematics and Statistics, UNSW

Principal trace function of Carey-Pincus

Meiram Akhymbek *(10.20-10.35 am, Colombo Theatre B)*

F. Radulescu obtained a direct proof of the existence of the principal function g_T, introduced by Carey and Pincus, for almost normal operators T, by estimating integrals of type $\int_{-\infty}^{+\infty} e^{itA}\langle\cdot,\xi\rangle\eta e^{itA}dt$ for certain elements ξ and η, and applying Krein's spectral shift formula. I will briefly outline the main facts about principal function, well-known results and prospects for further research.

Supervisor: Dr Fedor Sukochev

About the speaker: I completed my BSc and MSc at Kazakh National University of Almaty, Kazakhstan. Currently I am finishing my first year of PhD at UNSW.

Spanning hypertrees in uniform hypergraphs

Haya Aldosari *(11:30-11:55 am, Colombo Theatre B)*

An r-uniform hypergraph $H = (V, E)$ consists of a set of vertices V and a set of edges E, where each edge is an r-element subset of V. This hypergraph is linear if any two edges of H intersect in at most one vertex. A spanning hypertree $T = (V(T), E(T))$ in H is a connected and acyclic hypergraph with $E(T) \subseteq E$ and $V(T) = V$. In this talk I will present some switching methods that allow us to approximate the probability of random linear hypergraph containing a given hypergraph. This can be used in estimating the expected number of spanning hypertrees in uniform hypergraphs and linear uniform hypergraphs with given degrees.

Supervisor: Catherine Greenhill

About the speaker: I am from Saudi Arabia and I get my Master degree from King Saud University.

Global Existence Theory for Fractional Differential Equations: New Perspectives via Continuation Methods for Contractive Maps

Saleh Almuthaybiri *(10.00-10.15 am, Colombo Theatre B)*

The aim of this talk is to introduce new existence theory for "global" solutions to nonlinear fractional differential equations. Traditional approaches to existence, uniqueness and approximation of global solutions for initial value problems involving fractional differential equations have been unwieldy or intractable due to the limitations of previously used methods. This includes, for example, certain invariance conditions of the underlying fixed point strategies. Herein we draw on an alternative tactics, applying the more modern ideas of continuation methods for contractive maps to fractional differential equations. In doing so, we shed new light on the situation, producing these new perspectives through a range of novel theorems that involve sufficient conditions under which global existence, uniqueness, approximation and location of solutions are assured.

Supervisor: Prof. Chris Tisdell

About the speaker: Saleh completed his Bachelor degree in mathematics in 2012, from the College of Science at Al Jouf University, Saudi Arabia. In 2017, he completed his Master of Science degree in applied mathematics at University of Dayton, U.S.A. He is now in his end of 1st year of his PhD under the supervision of Prof. Chris Tisdell, in which he is studying existence theory of nonlinear fractional differential equations.

Isomorphisms of $AC(\sigma)$ spaces

Shaymaa Al-shakarchi *(10:40-10:55 am, Colombo Theatre B)*

In 1938, Gelfand and Kolmogorov proved that the compact spaces X and Y are homeomorphic iff $C(X)$ and $C(Y)$ are isomorphic as algebras. Analogue to this theorem, Doust and Ashton in 2005 introduced appropriate definition of the algebras of absolutely continuous function $AC(\sigma)$ on a compact subset of the plane and they studied if there was the same link between the domains and these algebras. In 2015, Doust and Leinert proved that if $AC(\sigma 1)$ isomorphic to $AC(\sigma 2)$ then $\sigma 1$ and $\sigma 2$ are homeomorphic and the converse doesnt satisfy by supposing $\sigma 1$ closed disk and $\sigma 2$ closed square. In the positive direction, Doust and Leinert showed that there is isomorphic between $AC(\sigma 1)$ and $AC(\sigma 2)$ where $\sigma 1$ and $\sigma 2$ are two polygonal compact subset of C. Our work now, I will discuss if this result also holds where σ and σ are finite union of convex edges.

Supervisor: Dr Ian Doust

About the speaker: I am from Iraq. I finished my Master degree at the university of Baghdad.

Linear response for the dynamic Laplacian and finite-time coherent sets

Fadi Antown *(10.00-10.15 am, Colombo LG01)*

Finite-time coherent sets represent minimally mixing objects in general nonlinear dynamics, and are spatially mobile features that are the most predictable in the medium term. When the dynamical system is subjected to small parameter change, one can ask about the rate of change of (i) the location and shape of the coherent sets, and (ii) the mixing properties (how much more or less mixing), with respect to the parameter. We answer these questions by developing linear response theory for the eigenfunctions of the dynamic Laplace operator, from which one readily obtains the linear response of the corresponding coherent sets. We construct efficient numerical methods based on a recent finite-element approach and provide numerical examples.

Supervisor: Professor Gary Froyland

About the speaker: I did my undergraduate at UNSW. Hope to end up somewhere good.

Shape-preserving wavelet-based multivariate density estimation

Carlos Aya-Moreno *(15:50-16:15 pm, Colombo Theatre B)*

Wavelet estimators for a probability density f enjoy many good properties, however they are not shape- preserving in the sense that the final estimate may not be non-negative or integrate to unity. A solution to negativity issues may be to estimate first the square-root of f and then square this estimate up. In this work, we propose and investigate such an estimation scheme, generalising to higher dimensions some previous constructions which are valid only in one dimension using nearest-neighbour-balls. The theoretical properties of the proposed estimator are obtained, and it is shown to reach the optimal rate of convergence uniformly over large classes of densities under mild conditions.

For spatially inhomogeneous densities, there is a need to threshold the empirical wavelet coefficients in order to avoid overfitting. This means that a suitable primary resolution level that allows to get the bulk of the square-root of the densitys fluctuations needs to be chosen first. Then, we select additional wavelet coefficients at higher resolution levels in order to provide a better fit by exploiting the locality of wavelet estimates. For both, we apply a cross-validation type approach using an empirical Bhattacharyya coefficient and the associated Hellinger distance, which is suitable when the square-root of the density is estimated and efficient in our setting. The universality of these tools is briefly discussed.

Supervisor: Spiridon Penev

About the speaker: I am mathematician and software engineer, originally from Colombia (South America), living and enjoying Australia now for over 17 years. Software has been my career over 20 years and now I am very happy to be able to bring maths and statistics as integral part of my work. Currently, I am a Product Team Lead, leading the development of a sophisticated stats/ML product from an engineering and data science perspective.

Diahaline transport in ocean models

Chris Bladwell *(14:30-14:45 pm, Colombo LG01)*

The rate of global evaporation and precipitation has been shown to increase under climate change. As the water cycle is difficult to measure by direct observation, recent efforts to quantify this amplification have focused on the relationship between ocean salinity and global rainfall patterns: the high salinity subtropical gyres experience net evaporation while the low salinity tropics and poles have net precipitation. For a quasi-stationary distribution of salinity to be maintained in the ocean, large amounts of salt must be transported away the evaporation dominated regions of the ocean, crossing surfaces of constant salinity. In the present work we develop a Water Mass Transformation based approach to study the processes which transport salt across isohaline surfaces. Using the salt budget of a water mass we are able to isolate the contribution of non-physical numerical mixing in ocean models from parameterised diabatic processes. We introduce a method to quantify the meridional transport of salt, and relate this to the pathway of atmospheric freshwater fluxes entering and leaving the ocean. We apply these methods to 1° global ocean model and describe how they can be used to quantify long-term water cycle change.

Supervisor: Jan Zika, Trevor McDougall, John Church

About the speaker: I am a PhD candidate in physical oceanography researching ocean models. This is an exciting area of research as we try to understand global issues such as climate change, and I am able to use my background in mathematics and life science, as well as experience in industry as a software developer. I hope to continue to use applied mathematics to develop theory and methods that can be used to model physical systems.

Exact posterior sampling for the Bayesian Tobit linear model

Yi-Lung Chen *(12:20-12:40 pm, Colombo LG01)*

The Tobit linear model is an extension to the linear regression model in the sense that censoring is introduced for the response variable. To be precise, the Tobit model introduces a latent random variable, and the value this random variable takes is only observed when it is above a certain threshold, otherwise we only observe the threshold value. This is useful for modelling non-negative response, for example the expected number of apples produced from a tree.

In this talk we consider the Bayesian analogue for this model where we introduce prior probabilities to the model parameters. It turns out that the posterior density for the parameters can be written as a Gaussian density over some linear constraints, and we propose an exact sampling method from this posterior density.

Supervisor: Zdravko Botev, Josef Dick

About the speaker: I am in the 3rd year of my PhD degree. I had the chance to give a talk in Winter Simulation Conference at the end of last year in Gothenburg. The conference provided good food, but I would like to know why they only provided vegetarian food for lunch.

Uncertainty Quantification for PDE's with Random Coefficients

Michael Clarke *(02:30-02:40 pm, Colombo LG02)*

The modelling of complex systems inherently involves statistical uncertainties due to the underlying physics and the constraints in our understanding thereof through empirical measurements or otherwise. The role of uncertainty quantification in the context of PDE's can be summarised as the assignment of random fields to parameters pertaining to the deterministic equations with the goal of yielding information about a functional of the solution, referred to as a quantity of interest. We study the Navier-Lamé equation, which governs linearly elastic behaviour of solids, by considering the elastic moduli (Lamé parameters) as random fields. The applications are motivated by the need to account for variability and correlations in microsopic properties such as structural defects and chemical composition which have flow-on effects in macroscopic observations of elastic behaviour whether in the context of structural engineering or biomimetic and organic materials for example. Furthermore, we analyse the regularity of solutions and functionals thereof in order to obtain rigorous error bounds and estimates in the setting of Sobolev space embeddings within the canonical L^2 Hilbert space. The primary quantity of interest is an expectation value of the numerical solution to the PDE, which is implemented using a combination of Finite Element, Quasi-Monte Carlo and Sparse Grid Methods. Finally we compare the numerical results with theoretical estimates and analyse the computational costs involved.

Supervisors: Josef Dick and Quoc Thong Le Gia

About the speaker: I completed my undergraduate studies at the University of Sydney in 2017, majoring in maths and physics, and subsequently specialised in numerical analysis for my Honours thesis under the supervision of Sheehan Olver. I commenced my PhD at UNSW in mid 2018.

Rigorous approximation of the statistical properties of Anosov maps

Harry Crimmins *(12.20-12.35 pm, Colombo LG01)*

It is well-known that hyperbolic dynamical systems admit strong statistical characterisations in the form of limit laws, such as a central limit theorem and large deviation principle. A natural question in this context is whether such statistical descriptions are computationally accessible: how could one rigorously construct approximations of the SRB measure, variance and rate function of a given hyperbolic map? By relating the statistical properties of the dynamics to the spectral data of a family of analytically 'twisted' transfer operators, this question is converted into one concerning the spectral stability of families of quasi-compact operators. We develop two numerical schemes for approximating these twisted transfer operators for Anosov maps on tori, prove spectral stability of the twisted transfer operators for each scheme, and obtain rigorous approximations of the aforementioned statistical data.

Supervisor: Gary Froyland

About the speaker: I completed my undergraduate and honours degrees at UNSW. Other than writing papers, which consumes most of my time, I keep busy by cooking, taking photos, and (very slowly) learning polish.

Maximum Generalised Roundness of Metric Trees

Raveen de Silva *(10.20-10.35 am, Colombo LG02)*

Given a metric space, we can define its maximum generalised roundness, a non-negative real number which determines geometric properties such as embedding into L^p spaces. We investigate the distribution of the maximum generalised roundness of large random trees, endowed with the path length metric, presenting experimental data and discussing the limiting behaviour.

Supervisor: A/Prof Ian Doust

About the speaker: I have studied at UNSW since 2011, completing an undergraduate degree in Mathematics and Computer Science and Honours in Pure Mathematics. In my spare time, I enjoy running and touch football.

Identification of Lagrangian Coherent Structures from swarms of virtual drifters using finite element methods

Michael Denes *(12.40-12.55 pm, Colombo LG01)*

Ocean flows are dominated by coherent structures, like eddies, with lifetimes longer than typical dynamical timescales. These features are embedded within and transported by the surrounding fluid flow, and are frequently referred to as Lagrangian Coherent Structures (LCSs). Due to their capacity to transport water and material over long distances, LCSs play an important role in climate, biogeochemistry, and small-scale mixing. A range of powerful techniques have been adopted from the dynamical systems theory literature to identify coherent features in fluid flows. The most widely used of these methods require Eulerian observations of ocean currents, that is, on a fixed grid. However, due to the paucity of available observations of oceanic velocity fields with sufficient spatio-temporal resolution, it is often difficult to identify and track LCSs in the real ocean. Typically real ocean data come from Lagrangian observations, such as those from drifters, gliders, and ARGO floats. Therefore, an outstanding challenge in Mathematical Oceanography is the development and validation of new methods for identifying LCSs in real ocean data. One recent method uses the transfer (or dynamic Laplace) operator to identify regions of phase space that form finite-time coherent sets. Finite-time coherent sets are sets or regions of fluid flow that for a finite period of time minimally mix with the remainder of the flow. In this talk I will provide an overview of the dynamic Laplacian approach using finite element methods, discuss results regarding the robustness of the method, provide an example of an application to global-scale ocean flows, and discuss future ideas and directions for research.

Supervisor: Shane Keating, and Gary Froyland

About the speaker: I completed my undergraduate degree at the University of Sydney in 2016 in applied mathematics and computer science, with an honours thesis in mathematical finance. I've spent a couple of years working in a data and predictive analytics team in industry, before beginning my PhD in mid 2018.

log-Gaussian Cox process models for combining presence/absence and presence-only data in Ecology

Elliot Dovers *(10:40-10:55 am, Colombo LG02)*

Modelling species distributions with respect to their environment can be improved by combining data from various sources. Presence/absence samples contain detailed information but are costly. Conversely, historic records of presence are often more readily available but can be biased due to the opportunistic nature of their collection. Researchers have been able to leverage information within the two by assuming the data sets share an underlying spatially inhomogeneous Poisson process. However, this assumes that there is no form of spatial clustering, nor dependence across data sources, beyond that induced by measured covariates. We develop a log-Gaussian Cox process (LGCP) approach, using a shared latent random field to account for both potential unmeasured environmental and bias covariates in the data, and as a mechanism to capture other sources of dependence across the two data sets. Using our recently developed fast approximation methods, we are able to estimate the shared parameters of the joint likelihood of the combined data in a computationally efficient manner. We illustrate this through the example of a Eucalyptus tree species in the Greater Blue Mountains World Heritage Area.

Supervisor: David Warton and Gordana Popovic

About the speaker: Originally from Coffs Harbour, I completed my undergraduate studies at the University of Queensland. After that I spent a few years faffing about in the UK and have now been studying at UNSW since 2017.

The Harmonic Oscillator Model of Akt Translocation

Catheryn Gray *(15:50-16:15 pm, Colombo Theatre B)*

Akt is a key signalling protein of mammalian cells that is involved in many cellular processes, such as glucose metabolism, cell growth and proliferation. Disregulation of Akt is implicated in a variety of disorders, from diabetes to cancer.

Akt derives signalling specificity from both its biochemical state and its cellular location. Akt is initially synthesized inside the cell. Following stimulation by insulin, it travels to the cell membrane, where it is activated (phosphorylated). As the phosphorylation of Akt only occurs at the cell membrane, translocation is a crucial step in the activation process, a step that is currently not well understood.

We have developed a deterministic three-compartment ordinary differential equation model of Akt translocation. It can be shown that this three-by-three system is equivalent to the damped harmonic oscillator equation, a canonical second order differential equation that has been well studied. With this framework, we have been able to elucidate the modes of behavior of the system, and understand the nature of the parameter space.

Supervisor: Adelle Coster

About the speaker: I am from Sydney. I studied at UNSW. I hope to move to Okayama, Japan. I don't have time for hobbies, odd or otherwise.

A dynamic model of human immunodeficiency virus and human papillomavirus interaction

Michaela Hall *(10.20-10.35 am, Colombo LG01)*

The transmission, progression and treatment of human immunodeficiency virus (HIV) can have unexpected effects on the acquisition and progression of human papillomavirus (HPV) in co-infected patients. HPV is the causative agent of cervical cancer, which is a leading cause of cancer death among women in the developing world. We have developed a dynamic model of HIV and HPV co-infection, accounting for a range of demographic and behavioural factors with the aim of assessing the impact of the HIV epidemic on HPV and cervical cancer in Tanzania. The model has been calibrated using epidemic data local to Tanzania and has been subjected to extensive validation and sensitivity analysis prior to being deemed fit-for-purpose. Findings from preliminary analysis suggest that in the short-term, effective HIV treatment and prevention will increase rates of cervical cancer in Tanzanian women, due to the removal of HIV death as a competing risk. However, in the long-run HIV treatment is predicted to reduce rates of cervical cancer, due to reconstitution of the immune system delaying progression from HPV infection to cervical cancer. This type of modelling is incredibly useful for predicting epidemic trends and assessing the unexpected impacts of interventions, which can be used to guide future healthcare policy and investment decisions.

Supervisor: John Murray

About the speaker: Michaela Hall is undertaking her PhD in Applied Mathematics under the supervision of Professor John Murray. Her thesis is grounded in the application of mathematical modelling to the field of epidemiology, with the aim of strengthening the evidence base for investment in disease prevention. Michaela enrolled at the start of 2018 and will be incredibly pleased if she completes her studies on time.

Chromogeometry

Joshua Ho *(15:20-15:30 pm, Colombo Theatre B)*

Chromogeometry is an extension of classical Euclidean geometry through the introduction of three different bilinear forms and the study of their interaction. Such extension brings in two flavours of relativistic geometry (red and green) to augment Euclidean geometry (blue), and introduces three different notions of perpendicularity. Instead of the traditional approach based on concepts of distance and angles, the study will be carried out in the framework of rational trigonometry and universal geometry.

Supervisor: Prof. Norman Wildberger

About the speaker: I did my undergraduate studies in computer science and electrical engineering degrees at UNSW. After many years of working at different roles in the IT industry, I decided to come back to UNSW and completed my master degree in Mathematics and started PhD this year.

Bayesian variable selection in neural network

Xiongwen Ke *(14:50-15:00 pm, Colombo LG01)*

The high dimensional feature space arises in many areas, including biotechnologies document classification, diseases diagnosis and so on. This problem is challenging due to the nonlinear nature of data and irrelevant of some covariates. Motivated by the universal approximation theory, we use a neural network to approximate the unknow nonlinear function. We will also employ the Bayesian variable selection method into the neural network model.The Monte Carlo EM will identify the sparse sub-model with high posterior probability. In E step, the Hamilton Monte Carlo approach will approximate the expected log likelihood. Since the EM algorithm has been vulnerable in multi-modal problem and this is the case for Bayesian variable selection with spike and slab prior, we suggest using a deterministic annealing(DA) EM to overcome this problem. We call the whole algorithm as DAHMCEM.

Supervisor: Yanan Fan and Josef Dick

About the speaker: I am a Chinese stat student. I like playing dota and table tennis.

Markov chain application for estimating model weights in climate model ensembles

Max Kulinich *(10.00-10.15 am, Colombo LG02)*

Climate change is modelled using complex mathematical models of physical processes taking place through longer periods of time. Multi-model ensembles of GCMs (Global Coupled Models) showed a better correlation with the observations than individual models separately. How to combine GCMs into ensembles in a best way is currently an open research question. We present a novel approach based on Markov Chains to estimate model weights in such ensembles. Several methods of constructing transition matrix were studied and applied on climate data. The method was compared to other ways of estimating model weights for both approximating and predicting the climate observations. The Markov chain showed improved performance over some of those methods, when measured by RMSE and other metrics. We use cross-validation to verify the method performance and avoid a common problem of over-fitting. The results of this comparative analysis should be considered as a pilot study to motivate further Markov chain application studies that address the issues of finding optimal model weights.

Supervisor: Yanan Fan, Spiridon Penev, Jason Evans

About the speaker: I am Swedish, though born in Belarus. Studied mathematical computations and complex adaptive systems, and worked 10 years as a Data Scientist in automotive industry. I spend a lot of my free time in meditation centers and yoga retreats.

Parametric Inference of the Hawkes process with time-varying background intensity

Jeffrey Kwan *(12.20-12.35 pm, Colombo LG02)*

The Hawkes process is a class of Self-Exciting Point Processes (SEPP) that is commonly used to describe sequences of events at random times that display a temporal clustering behaviour. By allowing the background intensity of the Hawkes process to vary, it presents a much more flexible class of Hawkes processes. Our focus on this work is to explore asymptotic theory for maximum likelihood estimation based statistical inference through a sequence of parametric SEPP models with time-varying background intensities. Ogata (1978) established consistency and asymptotic normality of Maximum Likelihood Estimators (MLE) under stationarity and ergodicity. Due to the time-varying background intensity component, the models that we consider are generally non-stationary, therefore the typical scenario is not appropriate in this setting. By expressing the score function as a series of martingale difference triangular array, a central limit theorem could be obtained for the score function. Other convergence results will be used to study the asymptotic behaviours of the MLE of the parameters.

Supervisor: Feng Chen

About the speaker: Undergraduate at UNSW, Honours with Feng Chen on the asymptotic behaviour of the Renewal Hawkes process. One year into PhD with Feng, currently looking into parametric inference for a SEPP with time-varying background intensity.

Deriving new ways to construct neutral surface

Yandong Lang *(15:05-15:15 pm, Colombo LG01)*

As Trevor McDougall defined neutral density by using usual neutral relationship in 1997, now, we want to present a new way to define neutral density, which can be called Submesoscale Coherent Vortex (SCV) relationship. The SCV relationship, standing for Submesoscale Coherent Vortex relationship, means that the oceanographic datum has the same pressure as it neutral position on the reference cast. The reason why we use this relationship is that we can calculate this kind of Neutral density independent of the pressure of the ocean observation. The difference between the neutral related neutral density (γ^n) and SCV related neutral density (γ^{SCV}) will be mathematically and numerically compared. We also find out the material derivative of γ^{SCV} to explore the implications of it. The material derivative of γ^{SCV} will be compared with the material derivative of γ^{SCV}. Finally, the γ^{SCV} will be interpolated on the ω surface (Klocker et al, 2009) to find out the relative merits of γ^{SCV} versus γ^n.

Supervisor: Trevor McDougall, Jan Zika, Geoff, Stanley

About the speaker: I was studied in ANU majored in math and physics for my bachelor degree. My honours program is physics in earth science (ocean) in research school of earth science in ANU. I am from China. I want to keep doing research in several countries. I like music and singing.

A Generalised Linear Latent Variable Models Approach for Ecological Monitoring

Michelle Lim *(15:05-15:15 pm, Colombo LG02)*

Ecological monitoring is widely used to detect the impacts of human activities on ecosystems and to assess the effectiveness of restoration efforts. Monitoring generally involves simultaneously recording abundances of different taxa in an assemblage resulting in multivariate abundance data. Methods of statistical process monitoring and control, originally developed for industrial applications, offer some promise in determining whether an environmental impact has occurred or is still occurring. However, traditional control charts were mostly developed to handle normally distributed data, so they cannot be directly applied to multivariate abundance data. Such data are usually discrete with lots of zeros and will typically exhibit a strong mean-variance relationship. To account for these data properties, we propose a new multivariate control chart method based on generalised linear latent variable models (GLLVM). We illustrate how this new approach can be used in monitoring the effects of crayweed restoration on the fish assemblages along the coastline of Sydney, Australia.

Supervisor: Professor David Warton

About the speaker: I am a CPA with a Master in Quantitative Finance from Singapore Management University. In my free time, I enjoy reading, baking and playing PC games.

A curious bijection between Dyck paths

Kevin Mandira Limanta *(14:30-14:45 pm, Colombo Theatre B)*

Given a two-dimensional integer lattice $\mathbb{Z}^2$, one can make a lattice path starting at $(0,0)$ which consists of up-steps $(1,1)$ and down-steps $(1,-1)$. A Dyck path of semilength n (or of length $2n$) is such a lattice path between $(0,0)$ and $(2n,0)$ which never goes below the x-axis. It is well-known that the number of all Dyck paths of semilength n is the nth Catalan number given by the sequence A000108 in OEIS. In this talk, I will describe an interesting bijection between the set of Dyck paths of semilength n which was motivated by a bijection given by Elizalde and Deutsch.

Supervisor: Norman Wildberger

About the speaker: I did my undergraduate studies in Indonesia, my home country. I did my master by research in UNSW and graduated in 2017. Started my PhD the year after. Hoping to end up in academia although I am still open to many possibilities.

Positivity-preserving scheme for alpha-CEV process

Guanting Liu *(15:20-15:30 pm, Colombo LG02)*

We propose a positivity-preserving implicit Euler-Maruyama scheme for a jump-extended CEV (constant elasticity of variance) process, where the jumps are governed by a compensated spectrally positive α-stable process for $\alpha \in (1, 2)$. Li and Taguchi considered a CIR (Cox-Ingersoll-Ross) model with such infinite activity jumps, and derived a strong convergence rate **?**. Following Li and Taguchi's methodology, we calculate, in this specific model, the strong rate of convergence.

Supervisor: Libo Li

About the speaker: I am from China, I completed my undergraduate and honours degrees in our school. Now I am studying mathematical finance with Dr. Libo Li.

Zeta functions in noncommutative arithmetic

Sean Lynch *(12:00-12.15 pm, Colombo Theatre B)*

SeanLynchIn his monumental memoir of 1859, Reimann laid out a plan to extract an asymptotic formula for the number of primes at most x from what is now known as the Riemann zeta function. Hadamard and de la Valle Poussin independently executed Riemann's plan in 1896, yielding the celebrated prime number theorem. Due in part to the success of the aforementioned approach, the Riemann zeta function and its analogues, zeta functions, are now ubiquitous in number theory. After motivating zeta functions, we will look at how they manifest in different arithmetic situations, culminating in noncommutative arithmetic.

Supervisor: Daniel Chan and Lee Zhao

About the speaker: I have studied at UNSW since the beginning of my undergraduate degree in 2014. After completing my PhD, I hope to change my last name to Moreau and claim as my home a secluded island in the southern Pacific Ocean.

The sum-product phenomenon and energy bounds

Simon Macourt *(12.20-12.35 pm, Colombo Theatre B)*

We introduce the notion of a sum set $A+B = \{a+b : a \in A, b \in B\}$ and equivalently that of a product set. The sum-product problem suggests that at least one of the sum and product sets must be large. We will give a short background to this problem, focusing on the case where A and B are subsets of a finite field. We then introduce the related ideas of additive and multiplicative energy. We define the additive energy $E^+(A, B) = |\{(a_1, a_2, b_1, b_2) \in A^2 \times B^2 : a_1 + b_1 = a_2 + b_2\}|$, and similarly for multiplicative energy, and relate this to the sum-product question. Finally, we will present some new energy bounds with an outline of how these are achieved.

Supervisor: Igor Shparlinski

About the speaker: I studied my undergraduate and masters at Macquarie University. I will be submitting my thesis at the beginning of next year and currently working out the options of what to do next year. I enjoy watching and playing most sport, which tends to deprive me of time and sleep.

Model-Based Assessment of Covariate Effects in Multivariate Abundance Data

Maeve Mc Gillycuddy *(14:50-15:00 pm, Colombo LG02)*

Each year, several hundred studies conducted by Governments, consultants, and companies, investigate ecological communities using abundances separately recorded for different species at many sites, referred to here as multivariate abundance data. This data is often used to study environmental impacts on ecological communities, to model current conditions and predict future impacts under different climate and land use scenarios, or to study effects on communities of changing the abundance of key species or environmental variables.

Multivariate abundance data is technically difficult to analyse, because: they are non-Gaussian with many zeros; they are often high dimensional, with the number of species exceeding the number of sites; different species respond differently to environmental variables, so many model parameters are required to quantify both environmental responses and correlation between species. One approach to estimating the covariance matrix is to use latent variables, which can be understood as missing covariates, or a low rank approximation of the covariance matrix.

This project presents a step forward by extending the generalised linear latent variable model to include random effects across species to characterise covariate effects. We will build on existing tools for fitting these models (in particular, the `glmmTMB` package which uses automatic differentiation to speed up computation) by adding latent variables. This is computationally difficult and in this talk, I will discuss the framework I plan to use to fit these models.

Supervisor: Prof. David Warton, Dr. Gordana Popovic

About the speaker: I completed my Undergraduate and Master's Degree in University College Cork, Ireland. Before moving to Sydney, I worked in a Clinical Research Facility as a research associate.

USING EXPECTED POINTS TO EVALUATE DECISION MAKING IN NATIONAL RUGBY LEAGUE

Robert Nguyen *(12:20-12:40 pm, Colombo LG02)*

To develop an expected point value model for rugby league and use it to inform decision-making and to value players decision making in game. This can be used informing playing strategy of teams and assessing individual performance in professional rugby league (Kempton 2016).

Method:. Play-by-play data were taken from all regular-season National Rugby League (NRL) matches during 2016-2018 season. A generalised additive model estimates the expected point outcome at a player level in a possession given a tackle count. We use as covariates the (x,y) coordinates and event level data. The equity of the players team before and after the tackle then informs the contribution of the player and event to the teams expected points. We show by example how this technique can be used to objectively rate players by position and to inform decision-making and strategy.

Results & Discussion:. We estimated our expected points model and used it to evaluate decisions players make such as the type of kick and weather to kick or pass the ball on a given tackle.

Conclusion:. Expected points models are relatively straightforward to construct, given event data, and provide a common currency that can be used at a team or player level for tactical and recruitment purposes.

Supervisor: David warton

About the speaker: Average podcast host

Classification of superintegrable systems

Jeremy Nugent *(12:00-12.15 pm, Colombo LG01)*

Superintegrable systems are physical systems with the maximum amount of symmetry. These can be further categorized by the types of symmetry they admit, in this talk we look at these different categories and the progress that has been made in each case.

Supervisor: A/Prof. Jonathan Kress

About the speaker: I grew up in north west Sydney and have been at UNSW since 2011 (for undergrad and then PhD) and was hoping to be gone before the light rail is completed. I hope to end up with a PhD in Mathematics. I enjoy music a lot, listening to it, playing it etc.

Roundness Of Banach Spaces

Gavin Robertson *(15:05-15:15 pm, Colombo Theatre B)*

Roundness of metric spaces was first introduced by Enflo, where it was used to distinguish between certain infinite-dimensional L^p spaces up to uniform homeomorphism. This is, however, quite misleading about the nature of roundness, since it is really an isometric invariant of metric spaces rather than a uniform one. For roundness of Banach spaces, it turns out that there is a slightly broader theory that one may consider which serves to illuminate many of the known properties of roundness. In this talk we provide the basics of this theory, and in particular, we give a characterisation of those Banach spaces that have non-trivial roundness.

Supervisor: Ian Doust

About the speaker: I completed honours in pure mathematics at UNSW last year. I hope to pursue a career in mathematics.

Performance guarantees for detecting finite-time coherent sets with the dynamic Laplacian

Christopher Rock *(14:00-14:25 pm, Colombo Theatre B)*

Finite-time coherent sets are regions in phase space that interact minimally with the rest of the phase space over a finite time. In geophysical systems, these can be eddies or vortices which often have physical significance. In addition, finite-time coherent sets provide relatively stable high-level descriptions of otherwise turbulent flows.

Finite-time coherent sets can be identified using the *dynamic Cheeger constant*. The dynamic Cheeger constant identifies sets whose boundaries remain small over time compared to their volume (or weighted volume). Identifying coherent sets is a major goal of the dynamical systems community. In this talk, I will present one approach, using the eigenfunctions of an operator known as the *dynamic Laplacian*. This approach has been used for several years, and it is well understood that this method always detects at least one coherent set if it exists (by a dynamic analogue to Cheeger's inequality). I will show that all the coherent sets in a system can be detected by the same method (either by a higher version of Cheeger's inequality for manifolds recently proposed by Miclo, or more practically by ideas from Ben Madafiglio's Honours thesis). I will also show that in many systems, the resulting coherent sets must be within a constant factor of optimal.

Finally, I will present a new technique to find a sub-partition of the phase space according to which eigenfunctions if any take large values in each region. This lets us identify coherent sets automatically from the eigenfunctions.

Supervisor: Gary Froyland

About the speaker: I studied mathematics and actuarial studies for my undergraduate degree at UNSW. I did my Honours with Gary Froyland in optimisation, finishing in 2017. I am currently in the second year of my PhD.

Uniform sampling for regular hypergraphs

James Ross *(12.40-12.55 pm, Colombo Theatre B)*

In this talk, we consider the challenges associated to sampling regular hypergraphs, and outline methods for overcoming these challenges. This includes counting loops produced by a sampling via the configuration model, and counting multiple edges produced by sampling adjacency matrices. We will describe how switchings can be used to sample from the set of multigraphs (avoiding loops entirely), and then again to remove multiple edges from a multigraph. This allows us to define a fast algorithm for approximately uniform sampling of regular hypergraphs, and to quantify the probability that a random multihypergraph is also a simple hypergraph.

Supervisor: Prof. Catherine Greenhill

About the speaker: James completed his BSc (Advanced Mathematics) at UNSW in 2015. He is currently working as a data scientist at Commonwealth Bank, and completing his Masters of Mathematics part-time.

Absolutely Continuous Functional Calculus and Variation in the Plane

Alan Stoneham *(14:50-15:00 pm, Colombo Theatre B)*

For functions defined on compact subsets of the real line $\mathbb{R}$, the notions of absolute continuity and variation are well understood. Operators on a Banach space that possess a functional calculus for the absolutely continuous functions on a compact interval admit a type of spectral resolution of the identity. Moreover, if the functional calculus is weakly compact, the spectral resolution exhibits much more satisfying properties, and the functional calculus can always be extended to functions of bounded variation. However, a more natural setting for spectral theory is within the complex plane $\mathbb{C}$. Attempts to generalise absolute continuity and variation to arbitrary compact subsets of $\mathbb{C}$ have seen mild success with regards to functional calculus. In this talk, we discuss a promising definition of variation on compact subsets of $\mathbb{C}$ and known results, as well as some open questions.

Supervisor: Ian Doust

About the speaker: I completed my honours in pure mathematics mid 2018 at UNSW under Ian Doust. I also completed a physics major before defecting to maths, and I still possess an innate curiosity for mathematical physics.

Ocean observations show cyclonic eddies intensify diurnal and semidiurnal internal tides off eastern Australia

Eduardo Vitarelli de Queiroz *(10:40-10:55 am, Colombo LG01)*

Internal tides can generate ocean mixing, surface convergences and near-bottom currents, so their predictability is of interest. The interaction between internal tides and mesoscale ocean features makes their prediction challenging. Using in situ observations of temperature, salinity and velocities from an array of deep ocean moorings, this study characterises the strength and variability of the internal tides, in both time and space, off eastern Australia (27 S). The internal tide energy in the diurnal frequency band is, generally, greater than in the semidiurnal band. Internal tide variability is compared to local barotropic tidal forcing, stratification, sea surface density and eddy kinetic energy to determine the influence and interaction with mesoscale ocean circulation. The results reveal that the diurnal internal tide is locally generated above the continental slope and the strength is modulated by the passing of mesoscale cyclonic eddies that alter the local stratification and velocity field. Peaks in semidiurnal internal tide energy are sporadic and may result from a combination of remote and local generation. The results provide insight into the origin of the internal tides above the continental slope and the mechanisms of variability. Studying the characteristics of internal tides and their interaction with ocean features helps us quantify their variability and improve their predictability, which is non-trivial in contrast to the deterministic barotropic tides that generate them.

Supervisor: Moninya Roughan

About the speaker: I'm studying at School of Mathematics and Statistics. I'm from Brazil and I hope to find a postdoctoral at the end of my PhD. I like to ride bike.

A Relaxation of Goldbach's Conjecture

Kam Hung Yau*(09.00-09.25 am, Colombo Theatre B)*

The Goldbach conjecture states that all even integer greater than 2 is a sum of two primes. Currently we do not have sufficient tools to prove this conjecture but we can obtain the following relaxation: Uniformly for small q and $(a, q) = 1$, we obtain an estimate for the weighted number of ways a sufficiently large integer can be represented as the sum of a prime congruent to a modulo q and a square-free integer with an even (or odd) number of prime factors. Our method is based on the notion of local model developed by Ramaré and may be viewed as an abstract circle method.

Supervisor: Prof. Igor E. Shparlinski

About the speaker: Like paper folding.