KOZWaves 2026

The 7th Australasian conference on wave science

28–30 January, Sydney, Australia

Conference booklet

Local Organising Committee

Stuart Hawkins, Nicole Kessissoglou, Erik García Neefjes

Scientific Committee

K. W. Chow, Marie Graff, Christopher Poulton, Ann Roberts, Alex Skvortsov, Colin Whittaker, Hugh Wolgamot

KOZWaves Executive Committee

Luke Bennetts, Ross McPhedran, Mike Meylan

Sponsors

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Code of conduct

KOZWaves is dedicated to providing a safe, inclusive and respectful enviroment for all participants at its conference series, regardless of gender, gender identity and expression, sexual orientation, disability, physical appearance, body size, race, age, religion, nationality, or other personal characteristics.

We expect all participants of KOZWaves 2026 to adhere to our code of conduct.

If you experience or witness a code of conduct violation or have any concerns, please contact one of the members of the local organising committee. All reports will be treated confidentially.

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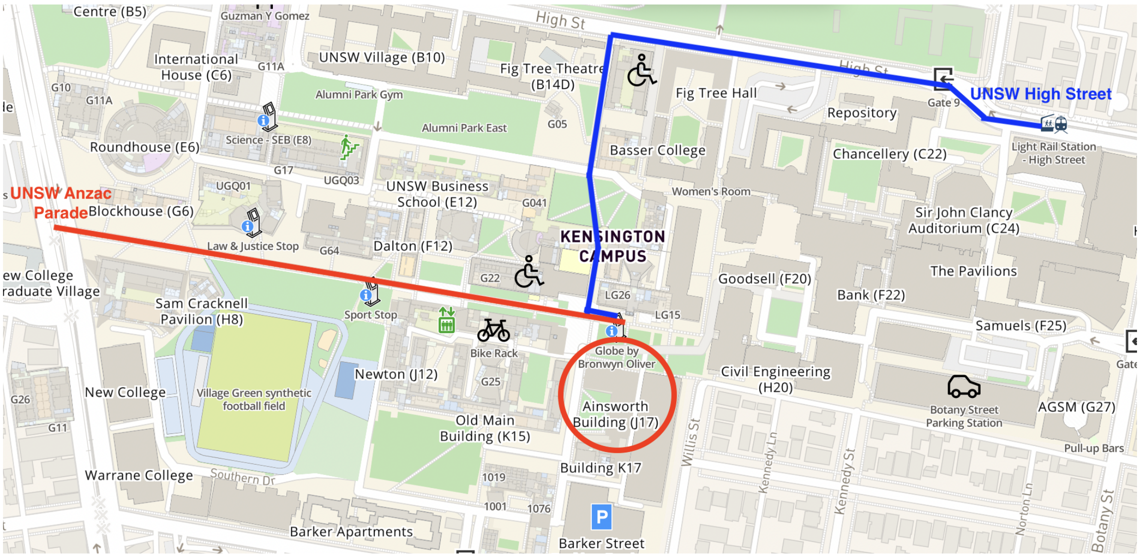
General Information

Conference Venue

The conference will be held in the School of Mechanical and Manufacturing Engineering, Ainsworth Building, UNSW Sydney.

Talks will be in Room 504 and Room 201. Morning and afternoon tea, and lunch will be served in Room 504.



Travel Information

Sydney Kingsford Smith International Airport is about 12km from UNSW and 15km from Sydney's CBD.

Taxis to UNSW from the airport should cost about AUD45 and take less than 20 minutes.

Trains run regularly from the airport to the CBD and cost around AUD25 one-way and take less than 30 minutes.

UNSW is about 6km from Sydney's CBD. Public transport options from the city include

- Light rail route L2 from Circular Quay via Central to Randwick. Alight at UNSW High Street.
- Light rail route L3 from Circular Quay via Central to Randwick. Alight at UNSW Anzac Parade.
- Various Anzac Parade Buses from Elizabeth Street, including 392 and 396. Alight at UNSW Anzac Parade.

See https://www.unsw.edu.au/estate/getting-here for more information on how to get to UNSW.

Welcome Reception

The reception will be held from 4pm to 8pm on Tuesday 27th January at the Coogee Surf Life Saving Club.

Coogee Surf Life Saving Club is at the south end of Coogee Beach.

Coogee Beach is about 30 minutes walk from UNSW Sydney. The 370 bus runs from UNSW High Street to Coogee Beach and takes about 20 minutes.

Conference Dinner

The conference dinner will be from 6pm–10pm on Thursday 29th January at The Lounge UNSW.

The Lounge is on Level 11 of the UNSW Library Building.

Registration

Registration desks will be open at the welcome reception at Coogee Surf Life Saving Club, and in Room 504 at the conference venue from 8am on Wednesday 28th.

Information for Speakers

Plenary talks are allocated a total of 40 minutes and other talks are allocated a total of 20 minutes.

The time allocated includes time for questions and for changeovers. For a 20-minute talk we recommend talking for 15 minutes, allowing 4 minutes for questions, and 1 minute for changeover.

Speakers please check your allocated room and upload your talk to the podium computer before your session starts. Speakers may also use their own computers but please check in advance whether you are able to connect your computer's video output. Please also make contact with your session chair before your session.

Refreshments and food

Morning and afternoon tea and lunch will be provided in Room 504.

We thank Wave Motion for sponsoring morning and afternoon tea.

Internet access

Eduroam is available at UNSW Sydney to members of Eduroam institutions.

If you do not have Eduroam access, please use the UNSW Guest wi-fi network.

Conference Proceedings

Proceedings from the conference will be published in a special issue of the journal Wave Motion.

Manuscript submission will be available to all conference participants and their collaborators. The submission deadline will be advertised after the conference.

Conference Program

Tuesday

16.00–20.00 Welcome reception at Coogee Surf Life Saving Club

Wednesday 28th January

8.00–8.45 **Registration**

8.45–9.00 **Welcome (Room 504)**

9.00–9.40 **Plenary talk (Room 504)**
Chair: Michael R. Haberman

Martin Wegener
Waves in nonlocal metamaterials

9.40–10.20 **Morning tea sponsored by Wave Motion**

10.20–11.40 **Photonic waveguides and electromagnetics (Room 504)**
Chair: Christopher G. Poulton

10.20–10.40 **Michael J. Steel**
Stimulated Brillouin Scattering in integrated photonic waveguides

10.40–11.00 **Graeme W. Milton**
Bounds on the complex permittivity and Q-factors in two-phase composites

11.00–11.20 **Younes Ra'di**
Passive Non-Foster microwave systems approaching fundamental limits

11.20–11.40 **Willie J. Padilla**
An agentic framework for automated inverse design of electromagnetic metamaterials

11.40–12.00 **Break**

12.00–13.00 **Nearest neighbour (Room 504)**
Chair: Rajesh Chaunsali

12.00–12.20 **Gregor Tanner**
Closed form expressions for the Green's function of waves on graphs - a scattering approach

12.20–12.40 **Timothy A. Starkey**
Engineering complex dispersion relations with beyond nearest neighbour couplings

12.40–13.00 **Fernando Guevara Vasquez**
A discrete potential theory on weighted graphs

13.00–14.00 **Lunch**

14.00–14.40 **Plenary talk (Room 504)**
Chair: Hugh Wolgamot

Malin Göteman
Water waves modelling in offshore renewable energy farms–status and challenges, and what can AI bring to the table?

14.40–15.00 **Break**

15.00–16.40 **Water waves (Room 504)**
Chair: Ben Wilks

15.00–15.20 **Fabien Montiel**
Spectral wave modelling in the marginal ice zone: symptoms and remedies

15.20–15.40 **Ravindra Pethiyagoda**
Tsunami waves in a weakly compressible ocean near a step-type topography

15.40–16.00 **Wenhua Zhao**
Resonant heave response of floating wind turbine in long waves

16.00–16.20 **Hugh Wolgamot**
Ocean wave energy: reports from the field

15.00–16.40 **Optics/Acoustics (Room 201)**
Chair: Michael J. Steel

15.00–15.20 **Ann Roberts**
Nonlocal metasurfaces for phase contrast imaging and quantitative phase microscopy

15.20–15.40 **Christopher G. Poulton**
Opto-acoustic quasi-solitons

15.40–16.00 **Rocio Camacho Morales**
Metasurfaces for dynamic and nonlinear imaging

16.00–16.20 **Laura Cobus**
Aberration correction for photoacoustic imaging - a matrix approach

16.20–16.40 **Afternoon tea sponsored by Wave Motion**

16.40–18.00

Wave energy conversion (Room 504)
Chair: Fabien Montiel

16.40–17.00 **Nataliia Sergiienko**
Experimental investigation of broadband power absorption in graded wave energy converter arrays

17.00–17.20 **Matthaus Zering**
Isolating nonlinear hydrodynamic forces on a cylinder using multi-input phase decomposition

17.20–17.40 **Renjie Tian**
Wave energy extraction from an array of semi-circular oscillating water columns situated along a straight coastal structure

17.40–18.00 **Lei Guo**
New gap modes and mode avoidance: from hydrodynamic resonance to mechanical vibration

Inverse problems (Room 201)
Chair: Fernando Guevara Vasquez

16.40–17.00 **Marie Graff**
Bayesian Adaptive Eigenspace Inversion

17.00–17.20 **Darko Volkov**
Passive inverse problems: stability and neural network solutions

17.20–17.40 **Yan Kei Chiang**
Compact acoustic direction estimation via metagrating-enabled sensing

17.40–18.00 **Nasrin Nikbakht**
A novel methodological framework for inverse problems using Adaptive Spectral Inversion

Thursday 29th January

9.00–9.40 **Plenary talk (Room 504)**
Chair: Yan Pennec

Daria Smirnova
Topological metasurfaces and photonic lattices

9.40–10.20 **Morning tea sponsored by Wave Motion**

10.20–11.40 **Periodic arrays (Room 504)**
Chair: William J. Parnell

10.20–10.40 **Federico Bosia**
Metareef: a metamaterial to attenuate surface gravity waves

10.40–11.00 **Luke Bennetts**
Broadband absorption of water wave energy using graded arrays of heaving buoys in 3D

11.00–11.20 **Malte A. Peter**
Acoustic lattice resonances and generalised Rayleigh–Bloch waves

11.20–11.40 **Charles Dorn**
Ray theory for modeling and design of spatially graded metamaterials

11.40–12.00 **Break**

12.00–13.00 **Topological photonics (Room 504)**
Chair: Younes Ra'di

12.00–12.20 **Rajesh Chaunsali**
New tools to shape topological boundary states: hidden symmetry and nonlinearity

12.20–12.40 **Yan Pennec**
Topological modes in PhoXonic crystals for Optomechanical applications

12.40–13.00 **Hai Zhang**
Mathematical theory of interface/edge spectra in topological photonics

13.00–14.00 **Lunch**

14.00–14.40 **Plenary talk (Room 504)**
Chair: Ann Roberts

Andrea Alù
Floquet metasurfaces

14.40–15.00 **Break**

15.00–16.40 **Disordered media (Room 504)**
Chair: Federico Bosia

15.00–15.20 **Tomasz J. Antosiewicz**
Effective optical properties of disordered arrays of nanoparticles with arbitrary material dispersion

15.20–15.40 **Boris T. Kuhlmey**
Gradient aware multipole method for optimizing passive radiative cooling fibres

15.40–16.00 **Thomas Brunet**
Experimental search for 3D Anderson localisation of scalar classical waves

16.00–16.20 **Michael R. Haberman**
Tunable flow-induced excitation of guided acoustic waves using spatiotemporally modulated boundary impedances

Fluid-structure interaction (Room 201)
Chair: Amin Chabchoub

15.00–15.20 **Faraj Alshahrani**
Ice shelf breakup simulation

15.20–15.40 **Mitchel Bonham**
Modelling the interaction of a Draupner wave with an iceberg

15.40–16.00 **Ben Wilks**
Water wave scattering by a surface-mounted rectangular anisotropic elastic plate

16.00–16.20 **Mike Meylan**
The abstract linear wave equation and application to Marine Hydrodynamics

16.20–16.40 **Afternoon tea sponsored by Wave Motion**

16.40–17.20 **Exceptional points and cloaking (Room 504)**
Chair: Darko Volkov

16.40–17.00 **Kei Matsushima**
Numerical study of exceptional points in two- and three-dimensional elastic solids

17.00–17.20 **Aaron Welters**
Bounds and limitations to broadband quasi-static passive cloaking

Optics (Room 201)
Chair: Rocio Camacho Morales

16.40–17.00 **Qiang Sun**
Optical torque enhancement in eccentric Core-Shell nanoparticles

17.00–17.20 **Lincoln Clark**
Free-form diffractive metasurface for analogue optical computation

17.20–18.00 **Distinguished Speaker**
Chair: Luke Bennetts

Ross McPhedran
Digging deep

18.00–22.00 **Conference dinner at The Lounge, UNSW**

Friday 30th January

9.00–9.40 **Plenary talk (Room 504)**
Chair: Vladislav S. Sorokin

Stefanie Gutschmidt
Mathematics, coupled oscillators and information: hearing for the deaf

9.40–10.20 **Morning tea sponsored by Wave Motion**

10.20–11.40 **Homogenisation (Room 504)**
Chair: Graeme W. Milton

10.20–10.40 **Alexei T. Skvortsov**
Two models of acoustic Faraday cage

10.40–11.00 **William J. Parnell**
Elastodynamic resonance and its influence on elastodynamic metamaterials

11.00–11.20 **Kenneth M. Golden**
Homogenization for waves in multiscale materials

11.20–11.40 **Christian Kern**
Limits to the Faraday effect and other nonreciprocal effects in 3D composites

11.40–12.00 **Break**

12.00–13.00 **Vibrations (Room 504)**
Chair: Steffen Marburg

12.00–12.20 **Vladislav S. Sorokin**
Theoretical and experimental analysis of axial wave transmission in a rod with attached nonlinear absorbers

12.20–12.40 **Ramathasan Thevamaran**
Exploiting nanoscale friction-governed mechanical memory in carbon nanotube foams for novel wave control devices

12.40–13.00 **Alper Erturk**
Good vibrations and waves: from metamaterials and reservoir computing to transcranial ultrasound and bioinspired underwater robotics

13.00–14.00 **Lunch**

14.00–14.40 **Plenary talk (Room 504)**
Chair: Mike Meylan

Anastasia Kisil
An overview of the use of the Wiener-Hopf method in wave scattering

14.40–15.00 **Break**

15.00–16.40 **Wiener-Hopf (Room 504)**
Chair: Malte A. Peter

15.00–15.20 **Alistair D. G. Hales**
Applications of the Unified Transform Method to poroelastic plates in uniform flow

15.20–15.40 **Matthew Nethercote**
Aeroacoustics of dynamic stall

15.40–16.00 **Andrey I. Korolkov**
On an analogy between the Wiener–Hopf formulations of discrete and continuous diffraction problems

16.00–16.20 **Rehab Aljabri**
Time domain vibrations of a circular plate with mixed boundary conditions

Special topics (Room 201)
Chair: Laura Cobus

15.00–15.20 **Andrew Hall**
Step change: using granular materials to silence floor play

15.20–15.40 **Gabriel Núñez**
Effective mass density for wave propagation in layered media: a study of the elastic/acoustic transition

15.40–16.00 **Mehdi Akbarzadeh**
Towards noncontact weighing scales: electrical input-mass correlations in acoustic levitation

16.00–16.20 **Steve J. Kongni**
A Swarmalator approach to how vibratory signals shape foraging-site selection in termites.

16.20–16.40 **Afternoon tea sponsored by Wave Motion**

16.40–17.20 **Special topics (Room 504)**
Chair: Andrew Hall

16.40–17.00 **Steffen Marburg**
From acoustic bound states to exceptional energy harvesting

17.00–17.20 **Amin Chabchoub**
Observation of Manakov-type solitons and breathers

17.20–17.30 **Closing remarks**

Plenary abstracts

Floquet metasurfaces

Thursday 14:00–14:40 Room 504

<u>Andrea Alù</u> (City College of New York)

Metasurfaces have emerged as a powerful platform to manipulate light, from the nanoscale to the far-field. They rely on careful spatial structuring at the nanoscale, which can control to a large extent the optical wavefront in space and momentum. Here, I discuss our recent efforts in the context of adding time as an additional degree of freedom to manipulate light with metasurfaces. By combining the strong light-matter interactions enabled by spatial structuring, and their large control over the spatial information, with temporal variations and non-equilibrium dynamics, we unveil exciting opportunities for nanophotonics and electromagnetics. We rely on processed mediated by polaritonic responses, leveraging excitonic, phononic, electronic and magnonic material responses coupled to engineered metasurfaces. In my talk, I will discuss our recent theoretical and experimental results in the context of time variations and parametric processes enabled by Floquet metasurfaces, the role of symmetries in their control, and their opportunities for technological advances. The combination of parametric processes, time reflections and spatial photonic engineering enables totally new opportunities in the quest to manipulate light in extreme ways within an ultrathin platform.

Water waves modelling in offshore renewable energy farms–status and challenges, and what can AI bring to the table?

Wednesday 14:00–14:40 Room 504

<u>Malin Göteman</u> (Uppsala University)

Ensuring a reliable future electricity supply while minimizing climate impact is among the most pressing global challenges. Offshore renewable energy systems hold substantial promise in meeting growing electricity demand. As of 2025, global installed offshore wind power capacity reached 83 GW—a remarkable 400the past five years. The majority of these installations are located in shallow waters and rely on fixed, bottom-mounted monopile foundations. However, over 80deep waters, necessitating the deployment of wind turbines on floating platforms. Although floating offshore wind turbines (FOWTs) are still in an early stage of development compared to fixed offshore wind, several pilot farms have been successfully commissioned in recent years. Wave energy converters (WECs), designed to convert the energy of ocean waves into electricity, is another class of renewable technologies with great potential. To achieve economic viability, FOWTs or WECs are deployed in arrays or farms, allowing shared electrical infrastructure and reduced costs. The configuration of individual devices and the overall farm layout influence the wave field within the farm, which in turn affects device stability, dynamics, and performance. This is particularly critical for wave farms, where devices are highly dynamic and often operate in resonance with incoming waves. Interactions between WECs—through scattered and radiated waves—impact their motion and energy absorption. Extensive research has been devoted to modelling arrays of WECs and optimizing their layout and operational parameters using analytical, numerical, and experimental approaches. However, the complexity of these models increases rapidly with the number of interacting devices, and current methods are insufficient for simulating commercial-scale wave farms. In this talk, I will present an overview of the challenges associated with modelling water wave fields in offshore renewable energy farms, with a focus on WEC arrays. Current state-of-the art will be discussed, highlighting recent methodological advancements across different levels of fidelity. Particular emphasis will be placed on analytical techniques, including multiple clustering scattering methods and nearest-neighbour approaches. Data-driven techniques and machine learning are increasingly being applied to the modelling and prediction of offshore renewable energy systems. We will explore the capabilities these emerging methods offer and discuss promising directions for future research aimed at overcoming existing limitations.

Mathematics, coupled oscillators and information: hearing for the deaf

Friday 09:00–09:40 Room 504

Stefanie Gutschmidt (University of Canterbury)

Conventional microphone technology has long relied on linear, passive oscillator principles, even though nature repeatedly demonstrates that nonlinear, active processes enable organisms to perceive and process remarkably subtle sound patterns. In this presentation, we show how active and nonlinear dynamics can inspire novel approaches to artificial sensing, with hearing as a central example. We connect research frontiers in coupled oscillators, fluid dynamics, soundscape augmentation, and reservoir computing to outline pathways toward advanced sensing performance. Particular emphasis is placed on the dynamics of coupled MEMS resonators - both passive and actively driven - in fluidic environments, and on how these insights inform novel electro-mechanical transduction strategies that, in the case of cochlear implants, move beyond traditional LCR circuits. Alongside theoretical advances, we highlight new experimental methods, including continuation techniques recently developed for MEMS, and discuss emerging applications in biosensing. Although hearing provides the central example, the underlying principles and approaches extend far beyond the perception of acoustic signals and soundscapes, with potential impact across a wide spectrum of sensing and information-processing technologies. Rather than incrementally improving devices for those who can already hear, our aim is to open the door to provide Hearing for the Deaf - demonstrating that technology can both restore silence to sound and reveal entirely new dimensions of perception.

An overview of the use of the Wiener-Hopf method in wave scattering

Friday 14:00–14:40 Room 504

Anastasia Kisil (University of Manchester)

In this talk an analytical tool called the Wiener-Hopf method will be introduced assuming no prior knowledge. The method stems from an elegant use of complex analysis and have been extensively used across different subject in mathematics including wave scattering. The aim is to introduce the types of problems that have been tackled using this method predominantly in acoustics. The starting point will be the Helmholtz equation and its discretization. Additionally, some uses in simple metamaterials with corners will be discussed. The advantages and difficulties encountered by the method will be addressed. Finally different extensions will be discussed. If there is time I will explain some new links to machine learning.

Digging deep

Thursday 17:20–18:00 Room 504

Ross McPhedran (University of Sydney)

I will discuss how being made aware of an 1892 paper by Lord Rayleigh added a new focus for my research. Rayleigh's paper described an elegant method for solving the Laplace equation in 2D and 3D lattices. With David McKenzie and other colleagues I applied Rayleigh's method to transport properties of composite materials. The method was naturally extended to photonic crystals in the context of the Helmholtz equation, and then to metamaterials. It then provided a powerful insight into the properties of microstructured optical fibres. With colleagues in Liverpool, we extended the Rayleigh multipole method to elastodynamics and then to the biharmonic equation and the study of platonic crystals. A part of these extensions of the technique was the study of methods for accurately calculating lattice sums. Taking the 1892 paper as a starting point and digging deeper provided a powerful stimulus towards enhancing my research and increasing its impact.

Topological metasurfaces and photonic lattices

Thursday 09:00–09:40 Room 504

Daria Smirnova (Australian National University)

The miniaturisation of photonic technologies calls for the wise integration of photonic and material components to enable novel functionalities in chip-scale devices based on enhanced light-matter interactions. Topological metasurfaces have recently been proposed as a promising platform for coupling structured modes of light on-chip with solid-state matter excitations, establishing resilient forms of polaritonic transport. This talk will present heterogeneous topological interfaces and chiral-defect cavities created in planar metasurfaces through inhomogeneous patterning at subwavelength scales. These topological traps and guides offer impactful opportunities for controlling light-matter waves in their dimensional hierarchy, paving the way for topological polariton shaping, ultrathin structured light sources, and thermal management at the nanoscale.

Waves in nonlocal metamaterials

Wednesday 09:00–09:40 Room 504

Martin Wegener (Karlsruhe Institute of Technology)

We review our work on using the concept of beyond-nearest-neighbor interactions (nonlocality) as a design tool for achieving rationally designed periodic composites (metamaterials) with effective properties that go beyond those of their ingredients. The designs are then manufactured, many by means of 3D laser nanoprinting, and characterized experimentally. Historically, we started by tailoring (e.g., roton-like) dispersion relations of Bloch waves in elasticity, acoustics, and electromagnetism. We then moved to the static regime in the same systems, where anomalous frozen evanescent Bloch waves lead to highly unusual behavior. Examples are generalized versions of Hooke's law, Hagen-Poiseuille's law, Ohm's law, and Fourier's law. The latter two correspond to the static limit of diffusion-type problems. However, using the idea of Bloch-wave dispersion relations with purely imaginary frequencies, we show that any (spatially) nonlocal time-dependent anomalous diffusion behavior can be achieved by designed beyond-nearest-neighbor interactions in periodic composites.

Invited abstracts

Metareef: a metamaterial to attenuate surface gravity waves

Thursday 10:20–10:40 Room 504

Federico Bosia (Politecnico di Torino), **Miguel Onorato** (Università di Torino), **Filippo De Lillo** (Università di Torino), **Paolo Pezzutto** (IRBIM – CNR), **Francesco De Vita** (Politecnico di Bari)

This work presents an experimental study of a device called Metareef, composed of a periodic array of submerged, inverted cylindrical pendula (resonators) designed to attenuate surface gravity waves. The concept draws inspiration from metamaterials, engineered structures that manipulate wave propagation through local resonance and Bragg scattering. The experiments are carried out in a wave flume, where waves spanning a broad frequency range are generated. Multiple configurations of the device are tested, and the transmitted, reflected, and dissipated wave energies are systematically measured. When the frequency of the incoming waves approaches the natural frequency of the pendula, substantial wave attenuation occurs, with the effect becoming more pronounced as the number of resonators increases. Furthermore, the device is shown to reflect wave energy at specific frequencies through a generalized Bragg scattering mechanism, which is determined by the spacing between the resonators. These results demonstrate the potential of the Metareef as an environmentally friendly solution for reducing wave impact in coastal zones.

Observation of Manakov-type solitons and breathers

Friday 17:00–17:20 Room 504

Amin Chabchoub (Okinawa Institute of Science and Technology, The University of Melbourne)

The hydrodynamic and integrable Manakov equation can emerge from the coupled nonlinear Schrödinger framework when the crossing angle between two wave systems takes specific values. We report the first experimental observations of exact Manakov-type envelope solitons and breathers in a water wave basin equipped with directional and multi-paddle wave makers. Despite the inherent challenges of designing an experimental configuration capable of producing clean, controlled interactions of crossing wave envelopes, the measurements exhibit excellent agreement with weakly nonlinear wave theory. These results provide new insight into rogue wave formation mechanisms in nonlinear dispersive media, particularly under multidirectional wave interactions.

New tools to shape topological boundary states: hidden symmetry and nonlinearity

Thursday 12:00–12:20 Room 504

Rajesh Chaunsali (Indian Institute of Science, Bangalore)

Topological insulators have generated significant interest in robust wave propagation across diverse physical systems. This talk introduces two powerful tools—hidden symmetry and nonlinearity—for engineering novel topological boundary states in mechanical lattices. First, we explore spinner dimer lattices [1], where hidden chiral symmetry protects distinct topological states at opposite ends. Second, we demonstrate the profound impact of nonlinearity in Kagome lattices. We show how nonlinearity in a topologically nontrivial lattice [2] enables the tuning of higher-order topological states' frequency and stability, revealing new families of states absent in the linear regime. Furthermore, we demonstrate that even in a topologically trivial Kagome lattice [3], which lacks linear corner states, nonlinearity can induce a family of stable corner states. Together, these findings offer fresh insights into controlling the localization and stability of topological boundary states.

[1] U. Vishwakarma, M. Irfan, G. Theocharis, R. Chaunsali, "Edge States with Hidden Topology in Spinner Lattices," Communications Physics, 8, 83, 2025
[2] K. Prabith, G. Theocharis, R. Chaunsali, "Nonlinear corner states in a topologically nontrivial Kagome lattice," Physical Review B 110, 104307, 2024
[3] K. Prabith, G. Theocharis, R. Chaunsali, "Nonlinearity-induced corner states in a kagome lattice," New Journal of Physics 27, 083501, 2025

Experimental search for 3D Anderson localisation of scalar classical waves

Thursday 15:40–16:00 Room 504

Fanambinana Delmotte (University of Bordeaux, University of Manitoba), **Thomas Brunet** (University of Bordeaux), **Jacques Leng** (University of Bordeaux), **John Page** (University of Manitoba)

Anderson Localization is probably one of the most fascinating and remarkable wave phenomena, which is still challenging to demonstrate for scalar classical waves in 3D disordered systems. Inspired by recent advances in the field of soft acoustic metamaterials [1], we have used locally resonant ultrasonic metafluids to observe 3D Anderson localization of acoustic waves. We first studied ultrasonic wave transport in concentrated disordered resonant emulsions without being able to find any evidence of localized states [2]. To transcend this limitation, we have recently fabricated suspensions composed of soft metallic beads exhibiting strong scattering resonances, randomly dispersed in a yield-stress fluid. In this talk, I will report a set of two independent time- and position-resolved experiments performed at ultrasonic frequencies to present direct evidence of unambiguous transitions between diffusion and Anderson localization, and accurately determine the mobility edges. As it is easy to vary the concentration in our model system of disordered resonant scatterers, we will finally show that localization is observed only for an intermediate concentration of beads [3].

[1] T. Brunet, J. Leng, O. Mondain, "Soft acoustic metamaterials", Science 342, 323 (2013)
[2] B. Tallon, T. Brunet, J.H. Page, "Ultrasonic wave transport in concentrated disordered resonant emulsions", Phys. Rev. B 108, L060202 (2023)
[3] F. Delmotte, T. Brunet, J. Leng, J.H. Page, under review

Ray theory for modeling and design of spatially graded metamaterials

Thursday 11:20–11:40 Room 504

Charles Dorn (University of Washington), **Vignesh Kannan** (École Polytechnique), **Dennis M. Kochmann** (ETH Zurich)

While the design of periodic metamaterials for wave manipulation has been the subject of extensive research, spatial grading allows unit cells to smoothly vary in space, offering a significantly larger design space. This expansion of the design space leads to an expansion of functionalities; spatial grading allows fascinating and useful functionality such as wave guiding along curved trajectories, wave focusing, and ultra-wide effective bandgaps from the combination of local bandgaps. However, the lack of periodicity creates a computational bottleneck since multiple length scales must be resolved. This bottleneck has limited the study of gradings to simple spatial profiles or to the long wavelength setting. In this work, we develop ray theory as a semi-analytical multi-scale modeling tool for efficiently capturing elastic wave motion in graded metamaterials beyond the low-frequency homogenization limit. Well-developed ray theories in optics and seismology (among others) apply to smooth heterogeneous media, which we generalize to spatially graded elastic lattices. The efficiency of ray tracing provides a foundation for inverse design of extremely complex, multi-scale spatial gradings to push the limits of wave manipulation. We experimentally demonstrate a spatially graded waveguide design spanning tens of thousands of unit cells. A prototype waveguide is microfabricated from a silicon wafer and characterized using pump laser for excitation and heterodyne interferometer for measurement.

Good vibrations and waves: from metamaterials and reservoir computing to transcranial ultrasound and bioinspired underwater robotics

Friday 12:40–13:00 Room 504

Alper Erturk (Georgia Institute of Technology), **George W. Woodruff** (Georgia Institute of Technology)

This talk will review our efforts on understanding and leveraging vibration and wave phenomena across disciplines, geometric scales, and applications. First, we will discuss mechanical and electromechanical metamaterials and metastructures for vibration attenuation and wave manipulation, including piezoelectric metamaterials with digital programming enabled by synthetic impedance circuits (as voltage-controlled current source shunts of the unit cells). Through the capability of circuit impedance modulation in space and/or time, we will show resonant concepts from tunable rainbow effect and reciprocity breaking to exceptional points and topological interface modes, and from mode conversion to nonlocal concepts. Nonlinear metastructures exploiting chaotic vibrations and envelope soliton generation from a nonlinear piezoelectric metamaterial for reservoir computing will be presented as two scenarios of utilizing nonlinear dynamics. Next, we will discuss gradient-index phononic lens concepts for elastic and acoustic wave manipulation with case studies on the focusing and enhanced harvesting of structure-borne elastic waves as well as in-air and underwater bulk acoustic waves in the audio and ultrasonic frequency ranges, respectively. Further examples of leveraging ultrasonic waves will be given for wireless power and data transfer, including through-metal and underwater communication. After that, we will discuss the use of guided waves for transcranial ultrasound delivery to overcome the state-of-the-art limitations, followed by a discussion on the potential of using mode conversion concepts in this context. Finally, we will conclude with an example of our ongoing efforts on piezoelectric actuator array design of bioinspired underwater robotic fish to enhance our capabilities in the deep ocean.

Tunable flow-induced excitation of guided acoustic waves using spatiotemporally modulated boundary impedances

Thursday 16:00–16:20 Room 504

Blaine T. Gilbert (The University of Texas at Austin), **Benjamin M. Goldsberry** (The University of Texas at Austin), **Michael R. Haberman** (The University of Texas at Austin)

Recent research on wave propagation and scattering in materials with spatiotemporal modulation (STM) of bulk properties or boundary conditions has gained interest as a means to improve the control of wave energy in both time and space. This work employs coupled mode theory (CMT) that was derived to study acoustic waves incident from a half-space and reflected from a fluid waveguide that has a STM boundary impedance. CMT for this system shows that coupling between propagating and evanescent modes exists at frequency-wavenumber combinations related to the modulation frequency and wavenumber that cannot be achieved without boundary modulation. We investigate the case of waveguide excitation by evanescent fields on the non-modulated boundary between a fluid waveguide and a fluid half-space while the opposite boundary is assumed to be an elastic plate with STM stiffness. The "incident" evanescent wave mimics the case of acoustic forcing from turbulent flow, which can generate waves that propagate within the waveguide and plate. We show that STM of the plate stiffness can be used to couple evanescent energy in flow to guided-wave modes at different frequencies and wavenumbers. This approach is then discussed as a unique method to control guided waves excited by turbulent boundary layers through nonreciprocal redirection and absorption of the acoustic energy.

Homogenization for waves in multiscale materials

Friday 11:00–11:20 Room 504

Kenneth M. Golden (University of Utah)

We consider the propagation characteristics of waves in naturally occurring and architected media. For wavelengths much longer than the microstructural scale, the effective parameter characterizing the interaction of a wave with a composite, such as complex permittivity, can be represented with a Stieltjes integral involving a spectral measure that encodes the mixture geometry. We will discuss critical behavior of quasistatic waves in multiscale media, including twisted bilayer composites and the sea ice pack. Computations of spectral statistics show homogenized behavior which mirrors that for Anderson transitions in quantum, optical and acoustic problems. We observe the appearance of localized states, mobility edges, band structures, and universal eigenvalue statistics from random matrix theory - even though there are no scattering or interference effects in our systems.

Bayesian Adaptive Eigenspace Inversion

Wednesday 16:40–17:00 Room 201

Marie Graff (The University of Auckland), **Bamdad Hosseini** (University of Washington), **Alfred Kim** (The University of Auckland)

We develop a probabilistic analogue of the Adaptive Eigenspace Inversion (AEI) method, an algorithm for the adapting regularisation terms towards the recovery of sharp interfaces, from the perspective of Bayesian inverse problems to enable the quantification of uncertainties in the reconstructions. We show that the adaptations of the regularisation terms in AEI is analogous to adapting the prior distributions in a sequence of Bayesian inverse problems. We present a theoretical result, showing that appropriate convergence of the AEI loop will lead to convergence of the resulting Bayesian posteriors in a Wasserstein distance. Furthermore, we propose some numerical experiments to demonstrate the performance and wide applicability of the Bayesian extension of AEI in both linear and nonlinear inverse problems. In particular, we observe in our experiments that the posterior means recover sharp edges in the unknown fields, and the posterior variances are largely concentrated around sharp interfaces, a feature that is also observed in other models for recovery of piecewise constant fields.

Exploiting nanoscale friction-governed mechanical memory in carbon nanotube foams for novel wave control devices

Friday 12:20–12:40 Room 504

Abhishek Gupta (University of Wisconsin-Madison), **Bhanugoban Maheswaran** (University of Wisconsin-Madison), **Nicholas Jaegersberg** (University of Wisconsin-Madison), **Komal Chawla** (University of Wisconsin-Madison), **Ramathasan Thevamaran** (University of Wisconsin-Madison)

Mechanical memory can be classified into two types: constitutive memory such as return-point memory (RPM) observed in hysteretic response of materials and mechanical bits (m-bit) found in bistable or multi-stable metamaterials. Despite its long history, RPM has not been studied in detail, and their potential applications remain untapped because of the lack of experimentally realized RPM in elastically recoverable materials. For example, most viscoelastic polymeric materials exhibit fading memory while rate-independent hysteretic materials such as metals and granular materials exhibit plasticity. Here we show that monolithic vertically aligned carbon-nanotube (VACNT) foams exhibit robust non-volatile RPM, retaining their stress states indefinitely—closely resembling the magnetic hysteretic memory used in hard disks. We attribute this enduring memory to multiscale frictional interactions among nanotubes, which allow VACNTs to both retrace and erase stress histories on demand. RPM enables VACNT foams with tunable dynamic modulus and loss factor that can independently be tuned by strain amplitude and static pre-compression. Exploiting this dual tunability, we experimentally realize a periodic waveguide of VACNTs with aluminum interlayers that slows stress pulses as amplitude increases yet accelerates them under greater pre-compression—enabling amplitude-programmable wave control. This capability points to a new platform for innovative wave control devices useful for applications from impact protection to analog signal processing.

Applications of the Unified Transform Method to poroelastic plates in uniform flow

Friday 15:00–15:20 Room 504

Alistair D. G. Hales (Virginia Tech), **Justin Jaworski** (Virginia Tech)

The Unified Transform Method (UTM) is a powerful semi-analytical framework that combines complex analysis with spectral collocation to solve elliptic partial differential equations. Central to the approach is the derivation of a global relation—a divergence form of the governing PDE integrated over the problem domain—that links boundary and spectral representations of the field. When applied to classical acoustic scattering by flat plates, the UTM provides an alternative to the traditional Wiener–Hopf technique. Instead of relying on complex kernel factorization, the unknown boundary quantities are expanded in suitable basis functions and resolved through spectral collocation, yielding a numerically stable and conceptually transparent formulation. Recent studies have demonstrated the effectiveness of UTM for modeling scattering by collinear elastic plates, establishing a unified framework capable of handling multi-plate configurations and finite geometries. However, most practical aeroacoustic problems involve mean flow, which substantially alters wave propagation and scattering behavior. In this work, we extend the UTM framework to incorporate uniform mean flows and to capture the additional flow-structure interactions that arise in poroelastic plates. The resulting formulation enables the analysis of flow-induced effects on sound transmission, reflection, and edge scattering without the need for classical kernel manipulations. By bridging rigorous analytical methods with high-order numerical approximation, this approach offers new insight into flow–structure–acoustic coupling and provides a versatile foundation for studying more realistic configurations in the future.

Step change: using granular materials to silence floor play

Friday 15:00–15:20 Room 201

<u>Andrew Hall</u> (University of Auckland), **Yousif Badri** (University of Auckland), **Gian Schmid** (University of Auckland), **John Cater** (Auckland University of Technology), **George Dodd** (University of Auckland)

This paper presents the development and evaluation of lightweight flooring systems that incorporate granular materials to mitigate impact noise transmission in buildings. Unlike traditional solutions that depend on increasing mass, granular media exploit interparticle friction and viscous losses to dissipate vibro-acoustic energy, providing an effective and sustainable pathway for improving acoustic performance in lightweight constructions. To identify and quantify the key dissipative mechanisms relevant to practical implementation, including sound absorption and structural damping, a multiscale approach was taken. Impedance tube tests using unconsolidated granular layers revealed a strong dependence of absorption behaviour on particle size. Coarse particles (greater than or equal 2 mm) exhibited resonance-driven peaks near 1 kHz, intermediate sizes produced resistivity-controlled plateaus, and fine powders (less that or equal 100 µm) showed enhanced low-frequency losses due to coupled solid–fluid motion. An equivalent-fluid absorption model was developed to predict the performance of a granular media A discrete element framework simulating energy dissipation through contact interactions under low-amplitude excitation was developed and small-scale panel experiments confirmed frequency-dependent attenuation of both airborne and structure-borne waves through granular-filled cavities, validating the model predictions. Building on these results, a full-scale prototype floor was constructed and tested. The measured Impact Insulation Class (IIC) showed an improvement of 3–6 dB in the 80–250 Hz range, with additional gains at higher frequencies compared to both a conventional lightweight floor and a mass-equivalent design. A hybrid sandwich design was tested showing further increases in performance. This study demonstrates that granular media can provide tuneable, size-dependent acoustic behaviour and meaningful broadband impact noise reduction highlighting their potential as a sustainable strategy for improving sound insulation in lightweight flooring systems.

Limits to the Faraday effect and other nonreciprocal effects in 3D composites

Friday 11:20–11:40 Room 504

<u>Christian Kern</u> (University of Utah), **Aaron Welters** (Florida Institute of Technology), **Graeme W. Milton** (University of Utah)

In the presence of a magnetic field, magneto-optic materials acquire an antisymmetric contribution to the effective permittivity tensor. This antisymmetric contribution can be seen as the fingerprint of nonreciprocal effects, i.e., effects that break the symmetry with respect to the interchange of sources and receivers in a physical system. In order to tailor such effects, one can follow the paradigm of the theory of composites by structuring the materials on a microscopic length scale. If the microstructure is chosen judiciously, composite materials can generally exhibit unusual effective properties that go beyond those of their constituents. However, the extent to which this applies to nonreciprocal composites is presently not well understood. In this talk, I will report on our recent progress on this problem in the quasistatic regime: First, I will present new bounds on the effective material properties of composites that are made from at least one constituent material exhibiting a nonreciprocal effect. Emphasis will be given to the Faraday effect, which describes the nonreciprocal rotation of the polarization of an electromagnetic wave propagating through a magneto-optic material subject to a magnetic field. However, as many other non-reciprocal effects take the same mathematical form, our results are more generally applicable. Second, I will discuss the attainability of our new bounds. In particular, I will show that in the important high-contrast regime many of our new bounds are attained by hierarchical laminate microstructures. Third, I will infer fundamental limitations for key figures-of-merit. In particular, I will show that, in the absence of losses and resonances, the effective Verdet constant of three-dimensional two-phase composites cannot improve on their constituents.

From acoustic bound states to exceptional energy harvesting

Friday 16:40–17:00 Room 504

Felix Kronowetter (Technical University of Munich), **Marcus Maeder** (Technical University of Munich), **Anton Melnikov** (Bosch Sensortec), **Tao Yang** (Technical University of Munich), **Johannes D. Schmid** (Technical University of Munich), **Yan Kei Chiang** (University of New South Wales, Canberra), **Lujun Huang** (University of New South Wales, Canberra), **Sebastian Oberst** (University of Technology), **David A. Powell** (University of New South Wales, Canberra), **Holger Niemeier** (Lindauer DORNIER), **Steffen Marburg** (Technical University of Munich)

Sustainable energy harvesting from ubiquitous low-density acoustic waves represents a critical challenge for powering future low-power devices. This work presents a comprehensive approach combining wave manipulation using bound states in the continuum (BICs) with advanced characterization techniques and practical energy harvesting applications. We demonstrate high-Q acoustic modes based on Friedrich-Wintgen BICs in open resonant cavities, achieving significant local pressure enhancement through destructive interference of degenerate modes. Symmetry reduction techniques further amplify pressure by a factor of three compared to conventional geometries, suppressing unwanted modes while preserving the BIC mode. Laser Doppler Vibrometry (LDV) measurements provide the missing field enhancement data, enabling the first direct visualization of an acoustic BIC and revealing where and when maximum pressure occurs under realistic conditions including thermo-viscous losses. Applying this optimized geometry to acoustic energy harvesting, we develop a BIC-based harvester that outperforms conventional Helmholtz resonator harvesters by factors of 2.2 in voltage amplitude spectral density and 10 in output power under white noise excitation. Coupling two BICs creates a "super-BIC" with exceptional pressure enhancement—achieving a 50-fold voltage increase compared to single BIC harvesters in pseudo-free field conditions. These findings advance sustainable energy harvesting for sensors, medical implants, and self-powered devices. The presented approach combines theoretical prediction, numerical optimization, experimental verification, and practical implementation, demonstrating that high-Q BIC resonances overcome the fundamental limitation of acoustic energy's low density. This work contributes to affordable, low-maintenance sustainable power generation, particularly benefiting communities disproportionately affected by climate change, while supporting global climate action goals toward the 1.5 ℃ target.

Closed form expressions for the Green's function of waves on graphs - a scattering approach

Wednesday 12:00–12:20 Room 504

Tristan Lawrie (University of Nottingham), **Sven Gnutzmann** (University of Nottingham), **Gregor Tanner** (University of Nottingham)

In this work we present a procedure for generating a closed form expression of the Green's function for wave equations on both closed and open finite graphs with general self-adjoint matching conditions. The derivation of the Green's function is based on the scattering approach, in which stationary solutions are constructed by treating each vertex or subgraph as a scattering site described by a scattering matrix. The latter can then be given in a simple closed form from which the Green's function is derived. The relevant scattering matrices contain inverse operators which are not well defined for wave numbers at which bound states in the continuum exist. It is shown that the singularities in the scattering matrix related to these bound states or perfect scars can be regularised. Green's functions or scattering matrices can then be expressed as a sum of a regular and a singular part where the singular part contains the projection kernel onto the perfect scar.

An agentic framework for automated inverse design of electromagnetic metamaterials

Wednesday 11:20–11:40 Room 504

Darui Lu (Duke University), **Jordan M. Malof** (University of Missouri), **Willie J. Padilla** (Duke University)

The evolution from large language models (LLMs) to agentic systems has created a new frontier of scientific discovery, enabling the automation of complex research tasks that have traditionally required human expertise. We develop and demonstrate such a framework specifically for the inverse design of photonic metamaterials. When queried with a desired optical spectrum, the Agent autonomously proposes and develops a forward deep learning model, accesses external tools via APIs for tasks like optimization, utilizes memory, and generates a final design via a deep inverse method. We demonstrate the framework's effectiveness, highlighting its ability to reason, plan, and adapt its strategy autonomously and in real-time, mirroring the processes of a human researcher. Notably, the Agentic Framework possesses internal reflection and decision flexibility, allowing exploration of a large design space and production of highly varied output. In this work we proposed, developed, and demonstrated an Agentic Framework for the automated inverse design of metamaterial systems. The framework consists of a Planner agent to orchestrate the process, an Input Verifier to check the integrity of the input, a Forward Modeler to develop deep learning surrogate models, and an Inverse Designer to propose geometries that achieve the goal. Through experiments on all-dielectric metasurfaces, we demonstrated that the framework is able to dynamically adapt its strategy at each stage and autonomously control the entire design process. Our Agentic Framework consistently achieves performance comparable to human expert-designed solutions. Our results suggest that autonomous agents have the potential to accelerate research in photonics and broader domains of scientific computing while reducing the expertise requirements.

Compact acoustic direction estimation via metagrating-enabled sensing

Wednesday 17:20–17:40 Room 201

Thomas Macleod (University of New South Wales, Canberra), **Sebastian Oberst** (University of Technology Sydney), **David Powell** (University of New South Wales, Canberra), **Yan Kei Chiang** (University of New South Wales, Canberra)

Accurate direction-of-arrival (DOA) estimation plays a vital role in acoustic imaging, surveillance and environmental monitoring. Conventional microphone arrays require multiple synchronised sensors and large apertures to achieve high angular resolution, which increases hardware complexity and limits system compactness. This study presents a metagrating-based sensing framework for 180° acoustic source direction estimation using only one sensor. The proposed metagrating is designed to generate distinct diffraction patterns that spatially encode incident sound fields. The encoded signals are processed to reconstruct the incident source direction. Numerical simulations demonstrate accurate localisation of single source within 0° - 180° sector with high angular precision. The results establish the as an efficient and compact physical platform for wide-angle acoustic direction finding and pave the way for scalable, low-cost sensing architectures.

The abstract linear wave equation and application to Marine Hydrodynamics

Thursday 16:00–16:20 Room 201

Mike Meylan (The University of Newcastle)

The abstract linear wave equation provides a unifying framework for the study of wave phenomena in diverse physical contexts. In this talk, I will present the formulation of the abstract linear wave equation, emphasizing its operator-theoretic structure and spectral properties. This perspective allows for a rigorous treatment of well-posedness, energy conservation, and modal decompositions, while also offering a natural pathway to numerical and asymptotic methods. I will then focus on applications to marine hydrodynamics, where wave–structure interactions are central to problems in coastal engineering, naval architecture, and ocean energy. Particular attention will be given to how abstract theory informs the analysis of scattering, radiation, and resonance for floating and fixed structures in ocean waves. Through this connection, I will highlight both the power of abstract analysis in providing general insights and its practical implications for modelling and simulation in marine environments.

Bounds on the complex permittivity and Q-factors in two-phase composites

Wednesday 10:40–11:00 Room 504

Graeme W. Milton (The University of Utah), **Kshiteej Deshmukh** (The University of Houston), **Christian Kern** (The University of Utah), **Owen Miller** (Yale University)

Back in 1979 when I (Graeme Milton) was at Sydney University doing an honors thesis under the mentorship of Ross McPhedran, I derived bounds on the effective complex dielectric constants of composites of two isotropic phases. The effective complex dielectric constant controls the macroscopic response of composites to fixed frequency electromagnetic fields when the wavelength is much larger than the microstructure - this is the so-called quasistatic limit. These are now known as the Bergman-Milton bounds as Bergman independently derived some of these bounds. By considering composites of well separated inclusions, one gets, for free, bounds on the complex polarizability, and hence on the power absorption of these inclusions. In the case of macroscopically isotropic composites the bounds were a lens shaped region in the complex plane, and I identified 5 points on one of the arcs that are realized by specific microgeometries. Then in 2020, and much to my surprise, Christian Kern discovered many more points of the arc were attained and with Owen Miller we improved upon the other arc deriving an improved bound which was in fact optimal, being attained by assemblages of doubly coated spheres. More recently, Kshiteej Deshmukh and I have studied in more detail composites with a macroscopic uniaxial symmetry and have derived some new bounds and conjectured others. Also, we bounded an appropriately defined Q-factor associated with resonances in two-phase composites or resonances of inclusions (including nanoparticles). This lecture will review these developments,

Spectral wave modelling in the marginal ice zone: symptoms and remedies

Wednesday 15:00–15:20 Room 504

Fabien Montiel (University of Otago), **Martin Forbes** (Otago Polytechnic), **Emilio Echevarria** (CSIRO), **Henrique Rapizo** (MetOcean Solutions), **Mike Meylan** (University of Newcastle), **Stuart Hawkins** (Macquarie University), **Carlo Gamble** (University of Otago)

Ocean wave activity in polar seas is intensifying, so that modelling waves in ice- covered seas accurately is critical for navigational safety and forecasting the response of the declining sea ice. WAVEWATCH III (WW3) has emerged as the leading spectral wave model for high-latitude regions in recent years, having incorporated an extensive suite of 14 ice-induced wave damping parameterizations. A set of WW3 hindcast simulations of the wave event observed during the 2017 PIPERS wave buoy deployment in the Ross Sea is conducted to assess the performance of all ice damping parameterizations and identify consistent biases. It is found that WW3 consistently overestimates significant wave height and underestimates mean wave period at high ice concentrations. Our findings suggest WW3 does not sufficiently damp the mid-to-high frequency tail of the wave spectrum. Looking ahead, two new ice-induced wave attenuation source terms are proposed to remedy these observed shortcomings: (i) a multivariate power-law decay model, and (ii) a non-isotropic scattering-based decay model. Preliminary results will be discussed.

Metasurfaces for dynamic and nonlinear imaging

Wednesday 15:40–16:00 Room 201

Rocio Camacho Morales (The Australian National University)

Metasurfaces have emerged as a transformative platform for manipulating light at the nanoscale, enabling compact and versatile optical components for next-generation photonic devices. This unparalleled control is achieved by engineering subwavelength resonant structures, which serve as the building blocks of metasurfaces. In the linear optical regime, these structures provide precise control over the amplitude, phase, and polarisation of light. Extending their functionality into the nonlinear optical regime, metasurfaces also enable the manipulation of light frequency, unlocking new modalities for imaging and light conversion. This talk will present our recent studies in functional imaging enabled by metasurfaces. By combining the optical response of materials with resonant nanostructure design we achieve enhanced and multifunctional imaging capabilities. In the linear regime, we harness the tuneable optical properties of materials integrated within resonant metasurfaces to develop switchable imaging platforms. Our specific design incorporates the transition phase-change material vanadium dioxide (VO2). By exploiting the VO2's insulator-to-metal transition, which dynamically modulates the metasurface's transmission profile, we demonstrate a single platform capable of switching between phase imaging and bright-field imaging in response to external stimuli. In the nonlinear regime, we leverage high-Q-factor resonant metasurfaces composed of a strong nonlinear material, lithium niobate, to achieve infrared up-conversion imaging. This is accomplished through efficient nonlinear frequency conversion, directly translating infrared images into the visible domain with high resolution and conversion efficiency. Building on this work, we will also discuss the potential for edge-detection image processing in tandem with up-conversion infrared imaging. These results highlight the strategic integration of materials and resonant metasurface design to develop compact and advanced imaging platforms.

Aeroacoustics of dynamic stall

Friday 15:20–15:40 Room 504

Matthew Nethercote (University of Cambridge), **Nigel Peake** (University of Cambridge)

Aerodynamic noise from aircraft and wind turbines is known to be one of the most intrusive types of noise pollution and has been a major source of controversy for populations living or working nearby airports and wind farms. While aerofoils are designed to achieve maximum aerodynamic performance by operating at high angles of attack (AoA), they are also more susceptible to flow separation and stall due to changes in the flow conditions (e.g. gusts, wind shear, wake interaction) which can lead to a drastic reduction in performance and a significant increase in noise. Dynamic stall is also a complex phenomenon triggered by rapid changes in the aerofoil's AoA which turbine blades are highly prone to, and the produced noise is an important issue for the development of next-generation electric propulsion and energy production. We will be considering the attached flow/weak stall situation which occurs at low AoA. We are building upon some very recent work where Goldstein's formulation of Rapid Distortion Theory has been used in symmetric shear flow problems with a small Mach number. For our purposes, we consider the case where this shear flow is slightly asymmetric and is disturbed by a vortex sheet within a boundary layer of the aerofoil. These problems were solved using the scalar Wiener-Hopf technique and after deforming to steepest descent contours, the far-field is composed of three parts: steepest descent, critical boundary layer and wake modal contributions. The effects of the boundary layer profile on acoustic directivity will be provided.

Elastodynamic resonance and its influence on elastodynamic metamaterials

Friday 10:40–11:00 Room 504

William J. Parnell (University of Manchester), **Charlotte Charlton** (University of Manchester), **Philip A. Cotterill** (University of Manchester), **Raphael C. Assier** (University of Manchester), **David Nigro** (Thales UK), **Marie Touboul** (ENSTA Paris), **Nicole Kessissoglou** (UNSW Sydney), **Alex Skvortsov** (Defence Science and Technology Group), **Gyani Shankar Sharma** (Defence Science and Technology Group), **Ian MacGillivray** (Defence Science and Technology Group)

It has been known for many decades that low frequency resonance in acoustic and elastic materials renders unusual macroscopic material properties in the elastodynamic regime. In modern terminology these media are known as "metamaterials" of course. Whilst the acoustic scenario has been studied extensively and thus there has been great progress in the area of acoustic metamaterials, the elastodynamic regime is not as established. This is almost certainly associated with the complex coupling between compressional and shear waves, which is completely absent in acoustics. Here we provide an overview of progress in elastodynamic metamaterials through the lens of elastodynamic resonance, given that this is the key tool to tune metamaterial behaviour. We start with the fundamentals of what resonance in elastic systems can achieve with effective material properties. As noted above this goes back many decades and certainly well before the modern metamaterial terminology. However, it is now known that elastic metamaterials can be elegantly described by the Willis equations, which induce more generalised behaviour than the equations associated with a traditional Hookean elastic medium. This generality includes material asymmetry and resonance allows us to enhance the material response. We show that incorporating loss in such media gives rise to asymmetric absorption, a property which can be highly useful and is encompassed very neatly via Willis coupling. Focussing further on local resonance, we discuss coupled resonators, termed "metaclusters", including the case of voids in soft media, and "rigid-in-soft" resonators as originally introduced in the pioneering paper of Liu et al. (2000, Science). We study local asymmetry for further generality and include thermo-visco-elastic loss to encompass loss. Predominantly, we illustrate how all of this can be exploited to tune the resonant response of elastodynamic metamaterials to further broaden our palette of macroscopic metamaterial behaviour.

Topological modes in PhoXonic crystals for Optomechanical applications

Thursday 12:20–12:40 Room 504

Yan Pennec (Université de Lille)

Nano-Opto-Electro-Mechanical Systems (NOEMS) are devices in which electrons, photons, and phonons can coexist and interact in the nanoscale. With proper engineering, NOEMS can achieve essential functionalities in information and communication technology (ICT) systems. Our interest is focused on a class of periodic structures, called phoXonic crystals, which aim to simultaneously localize photons and phonons in the same submicronic periodic structures. Such confinement can lead to a strong enhancement of the phonon-photon interaction, allowing, for example, the modulation of light propagating in waveguides or cavities by acoustic vibrations. Recently, topological insulating properties systems have emerged as one of the important mechanisms for the control of electromagnetic/elastic waves due to their unique properties like unidirectionality, robustness, backscattering-free propagation in the presence of structural defects/disorders. Here we explore topological properties, using the Su-Schrieffer-Heeger (SSH) to open the way to simultaneous localized acoustic and optical modes at the interface between two trivial and non-trivial phoXonic crystals, resulting in both photonic and phononic topological interface modes. Different cavities will be explored, from conventional to SSH, together with random distribution. These concepts open the way to new information technology based on the manipulation of phonons and their coupling with photons and RF electronics. This work is supported by the European Union's Horizon Europe research and innovation program under MAGNIFIC, MUSICIAN and the European Research Council (ERC) LEIT projects.

Acoustic lattice resonances and generalised Rayleigh–Bloch waves

Thursday 11:00–11:20 Room 504

Malte A. Peter (University of Augsburg), **Luke G. Bennetts** (University of Melbourne), **Gregory J. Chaplain** (University of Exeter), **Stuart C. Hawkins** (Macquarie University), **Kei Matsushima** (Hiroshima University), **Timothy A. Starkey** (University of Exeter)

Rayleigh–Bloch waves are modes localised to periodic arrays of scatterers with unbounded unit cells. They are known to have a large influence on the response of the corresponding semi-infinite or finite structures with equally spaced bodies. Here, Rayleigh–Bloch waves are studied for line arrays of sound-hard circular scatterers embedded in a two-dimensional acoustic medium, for which it has recently been shown that they exist for higher frequencies than previously thought and that they can cut off (disappear) and cut on (reappear), and additional ones can cut on and interact with the existing ones. These complicated behaviours are reconsidered using a family of quasi-periodic Green's functions which allow particular plane-wave components to become unbounded away from the array so as to trace the trajectories of the Rayleigh–Bloch wavenumbers as they swap between Riemann sheets that are categorised according to the unbounded plane wave(s) and provide new understanding of Rayleigh–Bloch waves around the critical frequency intervals where they cut on/cut off/interact. These theoretical investigations are complemented by experimental results in airborne acoustics, in which we experimentally observe the first generalised Rayleigh–Bloch waves above the first cut-off, i.e. in the radiative regime. On short arrays, we observe finite-lattice resonances under continuous wave excitation, and on long arrays, we observe propagating generalised Rayleigh–Bloch waves under pulsed excitation.

Tsunami waves in a weakly compressible ocean near a step-type topography

Wednesday 15:20–15:40 Room 504

Ravindra Pethiyagoda (University of Newcastle), **Santu Das** (Institute of Advanced Study in Science and Technology (India)), **Ben Wilks** (The University of South Australia), **Mike Meylan** (University of Newcastle)

We consider the propagation of tsunami waves both generated by ground motion and by an initial pressure distribution underneath the surface. These disturbances produce waves that subsequently scatter due to sudden changes in bathymetry following linearised water wave theory and a weakly compressible ocean. This talk presents a process of using eigenfunction matching to find solutions for an arbitrary piecewise-constant bathymetry profile and presents solutions showing the propagation of free-surface waves and internal pressure waves. I will touch on some of the numerical difficulties encountered when generating a solution.

Opto-acoustic quasi-solitons

Wednesday 15:20–15:40 Room 201

Christopher G. Poulton (University of Technology Sydney), **Mikolaj K. Schmidt** (Macquarie University), **Alexander S. Solntsev** (Macquarie University), **Michael J. Steel** (Macquarie University), **Antoine F.J. Runge** (University of Sydney)

The nonlinear interaction of optical and acoustic pulses in stimulated Brillouin scattering (SBS) governs many modern photonic applications, from Brillouin lasers to acoustic storage [1]. Here, we analyse both numerically and analytically a family of stable pulse solutions that maintain their form during propagation through a medium. These quasi-solitons [2] differ from conventional solitons: rather than balancing dispersion against nonlinearity, they arise from an exact equilibrium between pump energy transfer and losses in the Stokes and acoustic modes. We show that both forward and backward SBS configurations can support resonant quasi-solitons whose velocity and stability depend on the ratio of optical to acoustic dissipation. Closed-form analytical expressions are derived for these symmetric solitary waves, and their tunable propagation velocities are demonstrated. A second class of non-resonant, asymmetric solitary waves can also be identified [3]. These localized structures exhibit superluminal group velocities that vary with pump amplitude and Stokes rise-time, yet remain stable over a broad range of input conditions. Unlike the resonant case, their formation does not require fine-tuned parameters, emerging instead as a robust feature of the dynamic SBS interaction. These results highlight two distinct regimes of opto-acoustic pulse stability: resonant quasi-solitons driven by energy balance, and non- resonant superluminal solitary waves arising from nonlinear coupling. We discuss the implications for experimental realization in modern SBS platforms and potential applications to Brillouin lasers, optical buffering, and hybrid opto-acoustic information storage.

[1] Merklein et al., Appl. Phys. Rev. 9 (2022).
[2] Picholle et al., Phys. Rev. Lett. 66, 1454 (1991).
[3] Runge et al., APL Photonics 10 (2025).

Passive Non-Foster microwave systems approaching fundamental limits

Wednesday 11:00–11:20 Room 504

Younes Ra'di (Syracuse University)

Electrically thin structures capable of broadband electromagnetic absorption are essential for applications ranging from stealth technology to energy harvesting. However, existing designs perform well below what is predicted by the fundamental limit on the bandwidth-to-thickness ratio imposed by passivity, linearity, and time-invariance. We introduce a new concept that enables designs to approach arbitrarily close to this theoretical bound, allowing the realization of ultra-thin absorbers with unprecedented broadband response. At the core of this advancement lies a novel approach to effectively emulate non-Foster behavior—such as negative reactance—within a fully passive and stable framework. Experimental results confirm the feasibility of this concept, paving the way for compact, wideband electromagnetic devices with performance previously thought unattainable.

Nonlocal metasurfaces for phase contrast imaging and quantitative phase microscopy

Wednesday 15:00–15:20 Room 201

Ann Roberts (The University of Melbourne)

Metasurfaces represent a new paradigm in optical science where functionality derives from the geometry and orientation of subwavelength structures arranged in a surface. Until recently most focus has been on devices generating a spatially varying phase and/or amplitude to produce, for example, a flat 'metalens'. On the other hand, metasurfaces can be produced that have a sensitivity to the spatial frequency content of an incident image or wavefield. This is equivalent to the device having a plane wave transmission with a specific sensitivity to angle of incidence and opens up the prospect of all-optical image processing and analogue computing applications using a single device with subwavelength thickness. This 'object' or 'image' plane approach is in contrast to traditional optical methods where lenses are used to access the Fourier transform of an optical field that is then modified using spatial filters. Such systems, however, require lenses and associated propagation distances and are relatively bulky.

We have been investigating the application of nonlocal metasurfaces to performing phase contrast imaging and quantitative phase microscopy. Specifically, we have demonstrated devices with an asymmetric transmission for angles of illumination about normal incidence. These metasurfaces generate pseudo-relief phase contrast images of transparent samples such as unstained biological cells. Furthermore, by generating images visualising phase gradients along different directions using the polarisation and wavelength sensitivity of the metasurface, we can recover quantitative information about the phase of the field. Background concepts in nonlocal metaoptics and recent experimental results will be presented.

Two models of acoustic Faraday cage

Friday 10:20–10:40 Room 504

Alexei T. Skvortsov (Defence Science and Technology Group), **Stephen Moore** (Defence Science and Technology Group), **Ian R. MacGillivray** (Defence Science and Technology Group), **Martin Kocan** (Defence Science and Technology Group)

A theoretical framework for modelling the acoustic isolation performance of a bubbly curtain consisting of a circular array of bubbly plumes is proposed. The plumes are considered as cylindrical columns with effective acoustic properties deduced from the conventional formulas for a bubbly medium. The rationale for this design is the ability to engage the collective modes of the plumes leading to favorable low frequency performance, defined by a low insertion ratio. Two analytical models have been evaluated. First, the multiple scattering model expressing the results in terms of the scattering amplitude of individual plumes known from the previous studies and, second, the model of an effective boundary condition imposed on the centreline of the array. It is found that the former model performs better over a broad range of parameters. It is shown that the main parameter controlling the system performance is the reflection coefficient of the array which can be deduced analytically and used to maximize the suppression of a given frequency of an acoustic noise source. As a demonstration of the predictive capability of the framework, the optimal system parameters are derived and then validated with the results of finite element modelling, showing good agreement.

Theoretical and experimental analysis of axial wave transmission in a rod with attached nonlinear absorbers

Friday 12:00–12:20 Room 504

Vladislav S. Sorokin (The University of Auckland), **Frances Fulton** (The University of Auckland), **Junqi Pan** (The University of Auckland), **Jon Juel Thomsen** (Technical University of Denmark), **Andrew Hall** (The University of Auckland), **Lihua Tang** (The University of Auckland)

Nonlinear vibration absorbers can feature benefits for vibration suppression as compared to their linear counterparts such as wider frequency bandwidth and higher level of tunability. This talk will present results of analytical, numerical and experimental analysis of axial wave transmission in an elastic rod with two types of damped nonlinear absorbers attached. The first type features conventional Duffing-type nonlinearity, while the second one is an autoparametric pendulum absorber. General equations for wave transmission through the rod with a single nonlinear absorber attached are derived via the wave approach and solved using the Method of Varying Amplitudes. The system parameters affecting the transmitted wave are studied for both types of absorbers, and a comparison is made between the effectiveness of the nonlinear absorbers and the conventional linear mass-spring-damper absorber. It was found that the absorbers can exhibit a wider bandwidth and superior vibration transmission reduction performance compared to the linear absorber. An experimental study has been completed to support the theoretical work.

Stimulated Brillouin Scattering in integrated photonic waveguides

Wednesday 10:20–10:40 Room 504

Michael J. Steel (Macquarie University)

The possibility of coherent light scattering between light and GHz-frequency elastic waves was suggested just over a century ago in separate works by Leon Brillouin and Leonid Mandelstam. With the advent of the laser, stimulated Brillouin scattering (SBS) quickly emerged as one of the strongest and most useful nonlinearities in optical fibres, with applications in sensing and ultra-narrow linewidth lasers. However, the demonstration of *on-chip* SBS in photonic waveguides proved elusive, primarily due to the difficulty of mutually confining optical and elastic waves in the same waveguide core. In almost all common waveguide systems, the conditions for total internal reflection of light and sound are mutually incompatible. This was finally overcome in 2012 by the University of Sydney group, taking advantage of the unique material properties of soft chalcogenide glasses. In the 13 years since, on-chip SBS has evolved into a highly active research area in integrated photonics in many waveguide platforms. On-chip SBS is finding applications in sensing, microwave and RF data processing, lasers, and novel quantum phenomena. In this talk, I will highlight some of the key contributions to the field from a long-running collaboration between three Sydney universities, focusing on theoretical developments. These include new formulations of the nonlinear opto-elastic equations of motion in both classical and quantum regimes, nonlinear pulse dynamics including noise and soliton effects, novel guidance strategies including surface-acoustic wave and anti-resonant acoustic guidance, acoustic data storage, and properties of scale-invariant elastic waveguides.

Optical torque enhancement in eccentric Core-Shell nanoparticles

Thursday 16:40–17:00 Room 201

Qiang Sun (RMIT University)

Light-matter interactions at the nanoscale reveal new regimes of opto-mechanical motion once centre symmetry is broken. We report a class of eccentric core-shell nanoparticles where an offset between the core and shell centres induces morphological asymmetry, producing enhanced optical torques under Gaussian-beam illumination. These torques arise not from material birefringence, but from symmetry-breaking interference of the near-field of the eccentric core and shell, which can convert linear polarisation into angular momentum exchange. Full-field electrodynamic simulations using the non-singular field only surface integral equation method show that eccentric nanoparticles can achieve high torque efficiencies. For Au@SiO2 particles (180 nm diameter), rotation frequencies exceed 800 Hz under 20 mW excitation, nearly an order of magnitude smaller and faster than any previously rotated birefringent probe. The torque direction reverses with refractive-index ordering, providing controllable, morphology-dependent rotational behaviour. Coupling between optical stress and viscous drag introduces hydrodynamic feedback, leading to oscillatory and stable rotation regimes that depend on both eccentricity and medium viscosity. Distinct scattering signatures correlate with the core's orientation, providing an optical readout of nanoscale rotation. These results uncover a material-specific symmetry-breaking channel for coupling light's momentum to mechanical motion, establishing a path toward sub 100 nm rheology probes and nanoscale torque sensors.

Passive inverse problems: stability and neural network solutions

Wednesday 17:00–17:20 Room 201

Darko Volkov (Worcester Polytechnic Institute)

Linear inverse problems have been successfully handled since at least Tikhonov's seminal work. However, PDE based nonlinear inverse problems such as coef- ficient or inner geometry recovery are mathematically more involved. In such problems, the PDE usually includes a known forcing term and a feature to be recovered using overdetermined boundary data. However, this does not apply to passive inverse problems which may occur in radar imaging or seismology. In related mathematical models, the forcing term in the PDE is unknown while the geometry of a feature has to be recovered. In this sense, there are both linear and nonlinear unknowns in passive inverse problems. In this presentation, we will focus on examples illustrating the recov- ery of cracks in unbounded domains with propagating waves. We will discuss recent results regarding the stability of the Hausdorff distance between cracks in terms of overdetermined boundary data [1]. Next, we will turn to the case where cracks are defined through a parameter m in Rp while the forcing term for the PDE is still in an infinite dimensional space [2]. In a recent study, we proved Lipschitz continuity of a related inverse operator if the forward operator is restricted to m -dependent finite dimensional spaces. These finite dimensional spaces are spanned by m -dependent singular functions which can be computed in practice. This led us to build neural networks that can numerically solve the crack inverse problem. The solution is computed in an efficient non-iterative way and is robust to noise. This is joint work with S. C. Hawkins, M. Ganesh, and F. Triki.

[1] Triki, F. and Volkov, D. (2025). Stability of the distance between cracks for small differences in Cauchy data under an escape condition. In preparation.

[2] Ganesh, M., Hawkins, S. C., and Volkov, D. (2025). Machine learning on manifolds for inverse scattering: Lipschitz stability analysis. arXiv preprint arXiv:2502.07093.

Bounds and limitations to broadband quasi-static passive cloaking

Thursday 17:00–17:20 Room 504

Aaron Welters (Florida Institute of Technology), **Maxence Cassier** (Aix Marseille University), **Graeme Milton** (University of Utah)

IIn this talk, we discuss our recent results [1] on the following challenging question: is it possible to use a passive cloak to make invisible a dielectric inclusion on a finite frequency interval in the quasistatic regime of Maxwell's equations for an observer close to the object? By considering the Dirichlet-to-Neumann (DtN) map, we show that not only is the answer no to this question, but are able to go much further by giving some quantitative bounds on this map which provide fundamental limits to both cloaking as well as approximate cloaking. As we will further elaborate on, it is the passivity assumption that allows us to derive sum rules for the DtN map in the near-field cloaking problem using its properties related to two important classes of analytic functions, namely, Herglotz and Stieltjes functions. These results extend those of [2] for the far-field problem by combining two techniques for producing bounds: i) variational bounds (using the Dirichlet and Thomson variational principles) from abstract theory of composite framework [3, 4, 5]; ii) the analytic approach to bounds using sum rules for passive systems [2, 6].

[1] M. Cassier, G. W. Milton, and A. Welters, Broadband quasistatic passive cloaking: bounds and limitations in the near-field regime, preprint.
[2] M. Cassier and G. W. Milton, Bounds on Herglotz functions and fundamental limits of broadband passive quasi-static cloaking, J. Math. Phys. 58, 071504 (2017).
[3] G. W. Milton, Universal bounds on the electrical and elastic response of two-phase bodies and their application to bound- ing the volume fraction from boundary measurements, Journal of the Mechanics and Physics of Solids, 60, pp. 139–155 (2012).
[4] G. W. Milton (Ed.), Extending the Theory of Composites to Other Areas of Science, Milton-Patton Publishing, Salt Lake City, UT, 2016.
[5] G. W. Milton, The Theory of Composites, SIAM, Philadelphia, PA, 2022. Reprint of book originally published by Cambridge Univ. Press, 2002.
[6] A. Bernland, A. Luger, and M. Gustafsson, Sum rules and constraints on passive systems, J. Phys. A: Math. Theor. 44, 145205 (2011).

Broadband absorption of water wave energy using graded arrays of heaving buoys in 3D

Thursday 10:40–11:00 Room 504

Amy-Rose Westcott (University of Adelaide), **Natalia Sergienko** (University of Adelaide), **Ben Cazzolato** (University of Adelaide), **Luke Bennetts** (University of Melbourne)

Wave energy converters are devices that are designed to generate power from ocean waves. They need to be deployed in arrays for commercial viability, which creates opportunities for more effective energy capture than would be offered by the same number of devices acting independently. We generate a strategy to obtain broadband power capture over a target band covering two thirds of useable ocean wave frequencies, by arranging a 3D array of heaving buoys with spring–damper power-take-off systems into rows and gradually changing the resonant properties of successive rows. The mathematical model of the array is developed based on linear wave theory, and semi-analytical methods are used to solve for the hydrodynamic interactions. We show that over 90% of incident wave energy is captured over the target frequency range by an array with six rows (approximately half the length of the longest wavelength). The high absorption is sustained for a broad range of incident wave angles. We also incorporate a non-linear drag correction to decrease the large, resonant motions that occur in the linear wave theory. We show that, although decreased motions reduce power capture, the array continues to demonstrate efficient, broadband absorption, with the average absorption exceeding 70% over the target frequency interval.

Water wave scattering by a surface-mounted rectangular anisotropic elastic plate

Thursday 15:40–16:00 Room 201

Ben Wilks (University of South Australia), **Mike Meylan** (University of Newcastle), **Zachary Wegert** (Queensland University of Technology), **Vivien Challis** (Queensland University of Technology), **Ngamta Thamwattana** (University of Newcastle)

Piezoelectric plates, which become electrically polarised in response to bending, have recently been proposed for the conversion of water wave energy into electrical energy. However, many piezoelectric materials (e.g. Polyvinylidene Fluoride) are anisotropic, which makes them challenging to model in three dimensions. This talk considers the simpler problem of water wave scattering by an anisotropic elastic plate, i.e., the piezoelectric effect is ignored but the anisotropy is retained. The problem is solved using a dry modes expansion. In turn, the necessary diffraction and radiation problems are solved by formulating a boundary integral equation and solving numerically using a constant panel method. Results are presented to highlight the resonant responses of the plate under different forcing scenarios.

Ocean wave energy: reports from the field

Wednesday 16:00–16:20 Room 504

Hugh Wolgamot (The University of Western Australia)

This talk will describe aspects of wave science related to deployment of the M4 wave energy converter prototype in King George Sound, Albany, during summer 2024-25. The 42-tonne, 24-m long M4 is an articulated WEC with three rows of floats. The concept was designed by Prof Peter Stansby to have a relatively broad bandwidth of power absorption, to point into the waves most of the time, and to have good survivability in large waves. These aspects were tested in the field trial, along with efficiency in the power conversion chain, structural vibrations and motions, noise production, etc. Data is in the public domain and fully open. Findings related to improvements for future deployments will be discussed.

Mathematical theory of interface/edge spectra in topological photonics

Thursday 12:40–13:00 Room 504

Hai Zhang (HKUST)

The discovery of topological insulators in condensed matter physics has opened new avenues for generating interface and edge modes in photonic and phononic media. These modes, confined near the interface between two distinct structures or along the boundary of a single structure, offer robust ways to guide and control waves. Their origin lies in the symmetries and/or nontrivial topology of the underlying wave operators. In this talk, we report on recent advances toward rigorously establishing the existence of interface and edge spectra in a variety of topological photonic and phononic structures.

Resonant heave response of floating wind turbine in long waves

Wednesday 15:40–16:00 Room 504

Wenhua Zhao (The University of Queensland, The University of Western Australia), **Lulu Liu** (The University of Western Australia), **Ian Milne** (The University of Western Australia), **Hugh A.Wolgamot** (The University of Western Australia)

Floating offshore wind energy offers a promising pathway to harness wind resources in deep waters, where semi-submersible platforms have become the most viable solution. However, the hydrodynamic response of such platforms under long-period swells remains insufficiently understood, particularly regarding resonant heave motions. At resonance, the response amplitude is very sensitive to the damping level adopted to the system. This study investigates the viscous contributions that are governing the resonant heave response of a 10 MW semi- submersible floating wind platform through a series of large-scale wave basin experiments complemented by linear potential-flow simulations. Results demonstrate that viscous effects, though often small in large offshore structures and thus have been neglected in design-stage analyses, could significantly modulate both the amplitude and frequency of resonant responses [1]. The analysis reveals that viscous damping contributes to a significant increase in added mass, leading to measurable shifts in the natural heave frequency across different sea states. These findings bridge the gap between fundamental hydrodynamic understanding and practical offshore wind design, emphasizing that accurate prediction of viscous effects is essential to avoid overly conservative or unsafe platform designs. Further, these findings can also reduce the uncertainty in assessing weather windows or operability for undertaking, e.g., scheduled maintenance. The work highlights the importance of incorporating viscosity-dependent added mass and damping formulations into engineering models for next-generation floating wind energy systems.

[1] Liu, L., Milne, I. Wolgamot, H.A, Zhao, W., Guanche, R., 2025. Viscosity and nonlinear resonant heave response of a semi- submersible floating wind energy platform. Applied Ocean Research, in press.

Contributed abstracts

Towards noncontact weighing scales: electrical input-mass correlations in acoustic levitation

Friday 15:40–16:00 Room 201

Mehdi Akbarzadeh (University of Technology Sydney), **Michael G. Ruppert** (University of Technology Sydney), **Benjamin Halkon** (University of Technology Sydney), **Joseph C.S. Lai** (University of New South Wales, Canberra), **Jan M. Hemmi** (University of Western Australia), **Theo Evans** (University of Western Australia), **Sebastian Oberst** (University of Technology Sydney)

The acoustic radiation force is a nonlinear acoustic phenomenon, which enables solid objects or fluid droplets to acoustically levitate in air. This phenomenon is usually used for acoustic manipulation tasks, such as particle sorting and separation in air. We investigate whether the same principle can also be harnessed to develop a non-contact weighing scale capable of measuring the weight of levitated objects. Conventional weighing techniques require physical contact, which can contaminate or disturb delicate samples, and make accurately measuring objects in the milligram to microgram range challenging. To investigate the potential of developing this kind of novel non-contact scale, we designed and conducted experiments using a Tiny-Lev acoustic levitator to study the relationship between the weight of levitated objects and the corresponding voltages and currents drawn by the acoustic transducer arrays. When an object is inserted into the acoustic trap or its position shifts within the levitation field, the resulting change in acoustic load alters the current drawn by the transducers, providing a measurable signature of the object's weight. Heavier objects consistently drew higher currents, confirming an input–weight relationship. Our findings indicate that the Tiny-Lev electrical response encodes information about the weight of trapped samples, with the accuracy of this correlation influenced by object weight. Taking this assumption of a potential signature, we discuss a concept and next steps on how these relationships can be extended to infer object properties such as mass and density, to establish a basis for acoustic weighing methods, and applications in laboratory metrology and precision manipulation of small objects.

Time domain vibrations of a circular plate with mixed boundary conditions

Friday 16:00–16:20 Room 504

Rehab Aljabri (University of Newcastle), **Mike Meylan** (University of Newcastle)

In this talk, an analysis will be presented to examine the vibrations of a circular plate in the time domain with mixed boundary conditions. The vibration modes are calculated highly efficiently using separation of variables, expanding the solution in terms of Bessel functions. Numerical calculations are carried out for two cases: clamped-simply supported and simply supported-free circular plates. The solution in the time-domain was found from these modes, and the one-parameter group of operators that determines the time-domain solution were approximated as matrix multiplication. Finally, numerical simulations in the time domain will be shown.

Ice shelf breakup simulation

Thursday 15:00–15:20 Room 201

Faraj Alshahrani (The University of Newcastle, Prince Sattam bin Abdulaziz University), **Michael H. Meylan** (The University of Newcastle), **Ben Wilks** (The University of Newcastle, University of South Australia)

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

Effective optical properties of disordered arrays of nanoparticles with arbitrary material dispersion

Thursday 15:00–15:20 Room 504

Tomasz J. Antosiewicz (University of Warsaw), **Olga Kochanowska** (University of Warsaw), **Krzysztof M. Czajkowski** (University of Warsaw), **Maria Bancerek** (University of Warsaw), **Arumona E. Arumona** (University of Warsaw)

Optical properties of nanoparticles can be well described by Mie theory which uses multipolar decomposition into electric and magnetic contributions. Their existence and characteristics are determined by the nanoparticle size, shape, and material permittivity. Furthermore, they are subsequently modified by the particles' environment, such as through coupling to the substrate as well as multiple scattering off particles. The exact contribution from scattered fields depends on the spatial distribution of particles and is typically difficult to calculate for arrays with nonperiodic arrangement. Here, we describe an analytical framework in which we calculate the effective material properties of an amorphous array of optical nanoantennas by utilizing the single particle T-matrix to account for multipoles of arbitrary order and for the self-consistent interaction between particles. Amorphous arrays are characterized by a random distribution with an enforced minimum center-to-center separation which results in a pair correlation function with characteristic modulation at short distances. The framework is built on the assumption that, on average, a given nanoparticle is excited by the incident field and the average scattered field from all the other particles. We utilize this method to predict the how the interplay between the single particle properties and the collective randomized interaction between particles in the amorphous array determines the optical response of the whole ensemble. The key observations include an appearance of a distance-dependent decaying modulation of the key spectral features such as position, amplitude, and width; relative spectral shift of multipoles of various orders; changes of the absorption-to-scattering ratio.

Modelling the interaction of a Draupner wave with an iceberg

Thursday 15:20–15:40 Room 201

Mitchel Bonham (University of Newcastle)

In this study, we model the dynamic interaction between an iceberg and a Draupner-type rogue wave using a coupled fluid–structure approach. The iceberg is represented as a floating elastic plate governed by the linear equations of motion, while the surrounding water is described by linear potential flow theory. The two systems are coupled at the interface through kinematic and dynamic boundary conditions that account for both hydrodynamic pressure and iceberg flexure. By expressing the iceberg displacement as a modal expansion and combining this with a spectral representation of the incident wave field, we simulate the transient response to an impulsive wave event similar to the 1995 Draupner observation. The model captures the resonance between the iceberg's natural flexural modes and the dominant frequencies of the wave pulse, revealing how extreme wave impacts can amplify surface strain and contribute to iceberg failure. These results provide a theoretical framework for linking rogue-wave forcing to iceberg mechanics in realistic ocean conditions.

Free-form diffractive metasurface for analogue optical computation

Thursday 17:00–17:20 Room 201

Lincoln Clark (University of Melbourne), **Lukas Wesemann** (University of Melbourne), **Ann Roberts** (University of Melbourne)

Conventional microscopes and imaging systems utilising digital cameras or the eye capture images showing the intensity of the optical field. Samples with low absorbance or transparent features, such as unstained cells, are invisible and lack contrast when an image is taken with these systems. Although the amplitude of the field is changed only slightly upon transmission through these samples, spatial variations in the refractive index and thickness of the sample will lead to changes in phase. Converting this phase variation into a measurable intensity provides a means to visualize the structure of these samples and can be performed either optically interferometers or phase contrast microscopes, or computationally. More recently, it has been demonstrated that using ultrathin, non-local metasurfaces, we can perform mathematical operations on the optical field directly in the object or image plane [1], which provides a mechanism to convert phase information into an intensity that can be captured with a conventional imaging system [2]. Here we employ topology optimisation (TO), to design a dielectric metasurface that can compute a first order derivative when illuminated with y-polarised light and performs an identity operation for x-polarised light. The fabricated metasurface, when placed into the optical path with a transparent sample, converts the phase gradients into an intensity variation allowing for visualisation of the transparent features when illuminated with y-polarised light. When illuminated with x-polarised light, the resulting image is simply the conventional "bright field" image, where the transparent features are invisible. Such a metasurface requires an asymmetry about normal incidence in the angular response which is generated through asymmetric diffraction.

[1] Wesemann, L., Rickett, J., Song, J. et al. "Nanophotonics enhanced coverslip for phase imaging in biology", Light Sci Appl 10 (1), 98 (2021).
[2] Priscilla N., Sulejman S. B., Roberts A., and Wesemann L. "New Avenues for Phase Imaging: Optical Metasurfaces", ACS Photonics 11 (8), 2843-2859 (2024)

Aberration correction for photoacoustic imaging - a matrix approach

Wednesday 16:00–16:20 Room 201

Laura Cobus (University of Canterbury, Dodd-Walls centre for Photonic and Quantum Technologies), **Megumi Hirose** (University of Canterbury, Dodd-Walls centre for Photonic and Quantum Technologies), **Jami Shepherd** (University of Auckland, Dodd-Walls centre for Photonic and Quantum Technologies, MacDiarmid Institute for Advanced Materials and Nanotechnologies)

Photoacoustic (PA) imaging for the human body combines the depth and resolution capabilities of acoustics with the contrast and specificity of optics. Unfocused light illuminates an area of interest, resulting in thermoelastic expansion which creates acoustic waves. These waves are then detected by an array of acoustic sensors placed on the skin, and used to create an image. The specificity of PA imaging is complementary to ultrasound, and could improve screening for cancer, microvasculature, inflammatory and cardiac disease, and blood flow analysis [1,2]. However, layers of muscle, fat, bone, and skin can distort the travelling acoustic waves, degrading and aberrating the resulting image. While algorithmic image processing can provide some degree of improvement [3], accurate compensation for this distortion effect is an ongoing research area [4]. A major challenge is quantifying the 'one-way' (travel from the inside to the outside of the human tissue) acoustic wave distortion when the medium is unknown. We aim to solve this problem by leveraging recent work in ultrasound imaging; we have shown how to quantify the one-way distortion that an acoustic wave undergoes when travelling between any two points in human tissue [5,6]. This approach, integrated into PA imaging, will allow correction for aberration with no prior knowledge of the medium. Here, we demonstrate a first proof-of-concept for this approach via simulations and experiments, and discuss the broader perspectives for a matrix approach applied to PA imaging.

[1] Attia, Balasundaram, Moothanchery et al. Photoacoustics 16, 100144 (2019).
[2] Smith, Shepherd, Renaud, van Wijk. Photoacoustics 38, 100602 (2024).
[3] Manwar, Zafar, Xu. Optics 2, 1 (2020).
[4] Shepherd, Renaud, Clouset, van Wijk. Applied Physics Letters 116 (24) (2020).
[5] Lambert, Cobus, Frappart et al., Proc. Natl. Acad. Sci. U.S.A. 117, 14645 (2020).
[6] Lambert, Cobus, Robin et al., IEEE Trans. Med. Imaging 41, 3921 (2022).

A discrete potential theory on weighted graphs

Wednesday 12:40–13:00 Room 504

Trent DeGiovanni (University of Utah, Dartmouth College), **Fernando Guevara Vasquez** (University of Utah)

Starting from the graph Laplacian and a partition of vertices into interior, exterior and boundary, we define discrete single and double boundary layer operators on weighted graphs. As in the continuum, the operators we introduce obey jump relations at the boundary and can naturally translate boundary value problems into linear systems involving only the boundary nodes. The same basic operators allow to express the Dirichlet to Neumann map in a similar manner as in the continuum. A Calderón projector can be formed using the discrete boundary layer operators, proving that other well known continuum relations also hold on weighted graphs. We also show that the discrete Neumann-Poincaré operator obeys similar spectral bounds as in the continuum. We explain how this formalism on graphs can be used to readily formulate and solve boundary value problems (including scattering) on lattices, for discrete versions of both the Laplace and Helmholtz equations.

Numerical study of exceptional points in two- and three-dimensional elastic solids

Thursday 16:40–17:00 Room 504

Hiroaki Deguchi (University of Tokyo), **Kei Matsushima** (Hiroshima University), **Takayuki Yamada** (University of Tokyo)

In this talk, we present some numerical results on exceptional points in two- and three-dimensional elastic solids. In non-Hermitian systems, eigenvalues of the governing matrix/operator may coalesce with defective multiplicity, i.e., the geometric multiplicity is strictly less than the algebraic multiplicity. This gives rise to some intriguing phenomena, e.g., high sensitivity of eigenvalue splitting and non-Hermitian skin effect. Our goal is to provide numerical evidence for the existence of such exceptional points in elastodynamics with radiation loss. To this end, we formulate elastic-wave scattering in cylindrical/spherical coordinate systems and track resonance poles (quasinormal-mode frequencies) as system parameters vary. In addition, we propose a numerical method to locate exceptional points in a two-dimensional parameter space, validated by numerical examples.

Gradient aware multipole method for optimizing passive radiative cooling fibres

Thursday 15:20–15:40 Room 504

Daniel Glass (The University of Sydney), **Stuart Hawkins** (Macquarie University), **Alex Y. Song** (The University of Sydney), **Boris T. Kuhlmey** (The University of Sydney)

We address the optimisation of radiative cooling fibres as desirable for clothing with passive cooling capability, where microscopic pores are introduced into polymer fibres to simultaneously scatter solar radiation and emit thermal radiation in the mid-infrared atmospheric window. The high refractive index contrast between polymer and air leads to strong Mie resonances for pore sizes comparable to solar wavelengths, enabling efficient solar scattering while preserving mid-infrared emissivity of common polymers such as polyester and nylon. The design problem spans an enormous parameter space of pore positions and radii, for which no first-principles optimisation tools currently exist. To make the problem tractable, fibres are modelled as ensembles of non-overlapping, parallel cylinders. Electromagnetic fields are expanded into Bessel and Hankel function bases using a multipole method. The model is implemented within the automatic differentiation framework PyTorch, providing analytic gradients of performance metrics such as backscattering efficiency and absorption with respect to pore parameters. These gradients enable efficient, gradient-based searches of the design space, helping identify promising structures for passive radiative cooling.

New gap modes and mode avoidance: from hydrodynamic resonance to mechanical vibration

Wednesday 17:40–18:00 Room 504

Lei Guo (The University of Western Australia), **Paul H. Taylor** (The University of Western Australia), **Hugh A. Wolgamot** (The University of Western Australia), **Wenhua Zhao** (The University of Western Australia, The University of Queensland)

For two large vessels in a side-by-side configuration (as used for offloading operations of LNG, liquid hydrogen and transfers of bulk minerals), the expected resonant water free-surface motions within the narrow gap become more complex when coupled with vessel motions, both driven by incident waves. This study investigates gap resonances between one floating vessel and one fixed vessel with various gap widths under beam-on plane wave excitation using linear potential flow theory. In addition to the ‘normal’ gap modes with an odd integer number of half sine waves along the gap, which are typical of the both-fixed configuration, new gap modes arise due to coupled body motion, as first observed by Zhao et al. (2022). These modes, there termed camel modes (and here body motion-related modes), exhibit ‘in-phase’ in time surface displacement but with strong spatial variation along the gap. These dominate the response under random excitation. As the gap width is varied, an apparently new phenomenon in hydrodynamics, known in mechanical vibration theory as modal avoidance (or mode veering), is observed: two modal frequency branches approach each other and then veer apart, forming a locally hyperbolic pattern in a frequency-gap width plot. Because these behaviours are difficult to interpret directly in the full hydrodynamic problem that involves fluid-structure coupling, radiation damping, and added-mass effects, two simplified mechanical problems, coupled oscillators and a two-span beam with a centrally mounted oscillator, are introduced to provide an analytical comparison for the observed gap mode behaviors. This study links the hydrodynamic problem to the much simpler mechanical analogues which show both an extra ‘body motion’ and modal veering, and provides new insight into the coupled hydrodynamic gap resonance with body motion problem.

A Swarmalator approach to how vibratory signals shape foraging-site selection in termites.

Friday 16:00–16:20 Room 201

Steve J. Kongni (University of Technology Sydney), **Michael G. Ruppert** (University of Technology Sydney), **Joseph CS Lai** (University of New South Wales, Canberra), **Sebastian Oberst** (University of Technology Sydney)

The study of living systems has provided valuable insights into how organisms interact with one another. In termites, eusocial insects, research over the past couple of decades has revealed the key role of vibratory communication - vibrations propagating as elastic waves in solid media in conveying information. However, its role in guiding decision-making during foraging site selection remains insufficiently understood. In this work, we investigate how vibratory cues shape termite foraging- site choice using the swarmalator framework, which captures both internal and spatial dynamics. We propose a model of termite–foraging site–termite interactions that emphasizes the preferential attachment of termites to foraging sites based on the amplitude and frequency of vibrations emitted. A combined numerical and experimental study on Coptotermes acinaciformis, demonstrates a strong correlation between vibratory communication and preferential attachment in collective foraging behaviour.

On an analogy between the Wiener–Hopf formulations of discrete and continuous diffraction problems

Friday 15:40–16:00 Room 504

Andrey I. Korolkov (University of Manchester), **Raphael C. Assier** (University of Manchester), **Anastasia V. Kisil** (University of Manchester)

The talk is dedicated to unifying the framework used to derive the Wiener–Hopf equations arising in both discrete and continuous wave diffraction problems. The main tools are the discrete Green's identity and the appropriate notion of a discrete normal derivative. The resulting formal analogy between the Wiener–Hopf equations enables a seamless transition between the discrete and continuous formulations. The validity of this novel analogy is illustrated through several well-known two-dimensional canonical diffraction problems and extended to three-dimensional problems. Using the analogy, embedding formulae for diffraction problems on square lattices are introduced and verified numerically with the method of boundary algebraic equations. Finally, we briefly discuss the continuum limit of discrete diffraction problems and indicate a procedure for recovering the continuous solution from the lattice one.

A novel methodological framework for inverse problems using Adaptive Spectral Inversion

Wednesday 17:40–18:00 Room 201

Nasrin Nikbakht (University of Auckland), **Marie Graff** (University of Auckland), **Melissa Tacy** (University of Auckland)

Inverse problems are concerned with the recovery of spatially varying properties of a source or scatterer, denoted by p, within a bounded domain. Such problems have important applications in radar, medical imaging, and geophysical exploration. However, inverse problems are typically ill-posed, often lacking stability, uniqueness, or even the existence of a solution. Furthermore, in practical scenarios, observational data are frequently noisy, incomplete, or inconsistent, which makes direct inversion highly unstable. To address these challenges, we employ the Adaptive Spectral Inversion (ASI) method, a spectral regularisation technique designed to stabilise the solution by projecting the problem onto a truncated eigenfunction basis. In this study, we introduce a novel methodological framework for applying ASI to the recovery of the parameter p. To the best of our knowledge, this approach has not previously been investigated in this context. Our results demonstrate the robustness of ASI in accurately and stably recovering p, even in the presence of noise and incomplete data.

Effective mass density for wave propagation in layered media: a study of the elastic/acoustic transition

Friday 15:20–15:40 Room 201

Gabriel Núñez (The University of Manchester), **William J. Parnell** (The University of Manchester), **Raphael C. Assier** (The University of Manchester)

This work investigates the propagation of acoustic and elastic waves in layered materials, focusing on the effective mass density of the media in each regime and the transition between them. It is well-known that for elastic waves, the density of the effective media is isotropic, while for acoustics it is anisotropic. Usually, one can recover the equations of acoustics by taking the shear modulus to zero in those for elasticity. However, as the effective density does not explicitly depend on shear, the transition between the two regimes remains unclear. To determine such effective density, an inverse problem is solved. Specifically, the reflection and transmission coefficients of a system comprising two layers with different densities, placed between two half-spaces of identical, but unknown, anisotropic mass densities, are calculated. Since the objective is finding the effective properties of the layers, this unknown density is determined by imposing zero reflection and unit transmission coefficients, which is analogous to the dynamic self-consistent method. As expected, it is found that acoustic wave propagation is better modelled using an anisotropic effective density, while for elastodynamics, the effective medium remains isotropic. Most importantly, since the calculations are performed for any shear modulus, it is possible to explicitly understand and visualise the transition from isotropic elasticity to anisotropic acoustics by taking the no-shear limit. Therefore, this work provides a theoretical foundation for developing effective descriptions that incorporate anisotropic density and enable a smooth transition from elasticity to acoustics.

Experimental investigation of broadband power absorption in graded wave energy converter arrays

Wednesday 16:40–17:00 Room 504

Nataliia Sergiienko (Adelaide University), **Amy-Rose Westcott** (Adelaide University), **Benjamin Cazzolato** (Adelaide University)

Wave energy converters (WECs) typically achieve high efficiency only within a narrow frequency band. One promising strategy to broaden their power absorption bandwidth is to deploy them in graded arrays, where device and power take-off properties vary spatially so that each row targets different wave frequency components as waves propagate through the array. Graded structures have been extensively studied in acoustics and photonics, and this concept has recently been adapted to water waves. While numerous theoretical studies predict enhanced energy capture for various WEC types, experimental validation remains limited. This talk presents a series of wave-flume experiments investigating graded arrays of: (i) two-dimensional heaving buoys, (ii) vertical barrier-type oscillating water columns, and (iii) cylindrical oscillating water columns. The results highlight key differences in wave-structure interactions across these WEC types and evaluate how well theoretical predictions translate to physical systems. Practical challenges, design trade-offs, and limitations of existing models will also be discussed, providing insights for future implementation of graded WEC arrays in real ocean environments.

Engineering complex dispersion relations with beyond nearest neighbour couplings

Wednesday 12:20–12:40 Room 504

Timothy A. Starkey (University of Exeter), **Robyn G. Edge** (University of Exeter), **Simon A. R. Horsley** (University of Exeter), **Gregory J. Chaplain** (University of Exeter)

A dominant theme in wave metamaterial physics is engineering material dispersion relations for the purpose of slowing down, and potentially trapping, different classical waves. Recently, in elastic metamaterials, beyond-nearest-neighbour (BNN) couplings have been proposed as a new route to tailor the dispersion relation of waves; with their dispersive characteristics being likened to that of Rotons [Nat. Comms. 12.1 (2021)]. These materials have mixed local and non-local couplings. Borrowing the canonical mass-spring lattice as a conceptual tool; usually springs connect masses directly to their neighbours, providing a 'local' interaction, then by connecting masses with springs that reach-around their neighbouring masses, a beyond-nearest-neighbour (BNN) interaction is introduced. This enables the control of waves of long wavelength with compact unit cells. Motivated by this, Kazemi et al. [Phys. Rev. Lett. 131, 176101 (2023)] proposed an inverse design method to design arbitrary wave dispersions based upon these non-local BNN couplings. Indeed, Kazemi et al., show that any arbitrary dispersion curve on the real frequency-wavenumber (omega-k) plane can be 'drawn' in a lattice of masses and springs by leveraging the Fourier Series representation of the periodic band structure. These systems are formulated using conventional, conservative mass-spring models i.e. dissipation is neglected; here we examine the incorporation of material loss, or gain, in such systems. In this talk, we reimagine this framework via the inclusion of non-conservative couplings, and show that by using non-local couplings that include gain or loss, not only can band structures be drawn, but that arbitrary attenuation of the supported modes can be achieved by tuning their trajectory in the complex frequency plane [Phys. Rev. B, 112, 014304 (2025)]. We demonstrate this general theoretical result using a canonical mass-spring lattice with higher-order spatial connections. Theoretical results demonstrate systems with apparent wavenumber gaps can be readily designed, and that careful choice of loss-profiles can yield compact Fourier representations for designer passive materials. Implications for active materials, unconstrained by energy conservation, may also be discussed.

Wave energy extraction from an array of semi-circular oscillating water columns situated along a straight coastal structure

Wednesday 17:20–17:40 Room 504

Renjie Tian (Zhejiang University), **Siming Zheng** (Zhejiang University, University of Plymouth), **Wenhua Zhao** (The University of Queensland, The University of Western Australia), **Gregorio Iglesias** (Centre for Marine Renewable Energy Ireland (MaREI), University College Cork, University of Plymouth)

Grouping wave energy converters together captures more power. A cost-effective strategy is to build them along breakwaters and other sea walls. This not only saves on construction costs but also improves power harnessing performance, as the structure reflects waves toward the converters. In this paper, a theoretical investigation is conducted into the hydrodynamic performance of an array of semi-circular Oscillating Water Columns (OWCs) situated along a straight coastal structure. By applying linear potential flow theory and eigenfunction expansion, an analytical solution is derived to evaluate wave excitation, wave radiation coefficients, wave power absorption, and hydrodynamic forces acting on the OWC chambers. The model's reliability is confirmed through convergence tests and comparison with prior research. Parametric analyses reveal that the overall hydrodynamic performance and wave forces are highly sensitive to the array configuration and wave incidence, with significant interference effects between chambers that can be either constructive or destructive to power output. These findings provide critical insights for the design and optimization of such multi-chamber OWC systems.

Isolating nonlinear hydrodynamic forces on a cylinder using multi-input phase decomposition

Wednesday 17:00–17:20 Room 504

Matthaus Zering (The University of Western Australia), **Hugh Wolgamot** (The University of Western Australia), **Jana Orszaghova** (The University of Western Australia), **Adi Kurniawan** (The University of Western Australia), **Paul Taylor** (The University of Western Australia)

Wave energy converters (WECs) and floating offshore wind turbines (FOWTs) are energy systems which will substantially contribute to the global energy transition. These devices may be controlled with respect to incident waves, improving power capture and decreasing damaging loads. Control effectiveness can be severely limited as devices are typically deployed in energetic seas where nonlinear hydrodynamic effects can be substantial. Recent work has aimed to improve the understanding of the dominant hydrodynamic forces on these structures through combining multiple phase shifted wave input signals, allowing for individual Stokes-like harmonics of the incident wave and resulting forces to be isolated. This has yielded promising results but has so far focused on manipulating the phase of the incident wave to decompose the forces. This approach is limited as higher order effects, for instance 3rd-order first harmonic forces or drag forces which are relevant to WECs and FOWTs respectively, are not directly separated within each harmonic. By including inputs of phase shifted body motions as well as wave, the forces may be further decomposed into purely wave, motion or wave-motion dependent contributions at higher order. This work elucidates this method by modelling the forces on a semi-immersed horizontal circular cylinder simulated in 2D with OpenFOAM. Simulations were run with 4 phase combinations each of focused wave groups, cylinder heave motion and all combinations of wave and motion. Nonlinear forces for wave, motion and wave-motion dependencies were isolated to higher order and compared to approximations calculated from powers of the linear signal. Applications of this method to multiple modes of motion are discussed, along with its potential to ultimately lead to new models for control algorithms which capture the dominant nonlinear forces.