KOZWaves 2015:
The 2nd Australasian Conference On Wave Science

6 - 9 December, 2015

University of Adelaide, South Australia

Welcome to the 2nd Australasian Conference on Wave Science

…and welcome to the University of Adelaide, which has a proud history in wave science. Thank you travelling from all corners of Australasia and all corners of the globe to be here and participate in the conference.

The inaugural KOZWaves, which was held in Newcastle, February 2014, was a great success. We are very pleased to have many new participants for KOZWaves 2015 alongside many of those that participated in the first conference.

We have a busy conference schedule ahead. We hope that you enjoy the conference, and that it provides plenty of opportunities for you to connect with our wave science community.

Organising Committee

Luke Bennetts, Hyuck Chung, Ross McPhedran, Mike Meylan, Fabien Montiel.

Local Organisers

Luke Bennetts, Ben Binder, Sebastian Rupprecht, David Skene, Lucas Yiew.

Thanks to our sponsors

The School of Mathematical Science at the University of Adelaide (particularly Gary Glonek)

Auckland University of Technology

The Australian Mathematical Sciences Institute

Australian and New Zealand Industrial and Applied Mathematics (particularly Larry Forbes)

The National Computational Infrastructure (particularly Lindsay Botten)

Thanks to others

Louise O'Reilly (for organising the welcome BBQ, the conference dinner and many other aspects of the conference)

Christine Williams (for organising travel and accommodation for the invited speakers and other financial issues)

Monday, 7th December

0820-0830 Welcome

0830-1020 Session 1, Chair: Ross McPhedran

- **0830** Invited speaker: Richard Blaikie
  Super-resolution optical imaging using evanescent waves
- **0920** Michael Meylan
  Extraordinary transmission, symmetry, Helmholtz resonators, and the Blaschke product
- **0940** Marshall Hall
  Results obtained for resonance frequencies of finite in-vacuo cylindrical shells for three scenarios: Donnell-Mushtari model with and without bending, and Flugge model with bending
- **1000** Malte Peter

1020-1050 Coffee

1050-1230 Session 2, Chair: Alessandro Toffoli

- **1050** David Skene
- **1110** Alex Skvortsov
- **1130** Matthieu Sellier
- **1150** Alberto Alberello
  Velocity field underneath a rogue wave: Numerical simulation and physical experiment
- **1210** Fabien Montiel

1230-1330 Lunch

1330-1540 Session 3, Chair: Simon Clarke

- **1330** Invited speaker: Nicole Kessissoglou
  Acoustic performance of locally resonant sonic crystals
- **1420** Mahmoud Karimi
  Flow-induced noise prediction of a cylinder using a CFD-BEM technique
- **1440** Hyuck Chung
  Acoustic scattering by an array of soft scatterers
- **1500** Weikang Jiang
  Acoustic topology optimization of sound power using mapped acoustic radiation modes
- **1520** Elena Vinogradova

1540-1610 Coffee

1610-1800 Session 4, Chair: Hugh Wolgamot

- **1610** Invited speaker: Richard Manasseh
  Issues of wave energy converter operation in arrays
- **1700** Nataliia Sergiienko
- **1720** Peter Hardy
  A maximum capture width tracking controller for a wave energy converter in stochastic waves
- **1740** Boyin Ding
  Sea-state based maximum power point tracking control of a fully submerged oscillating buoy

1800-1900 General meeting

Tuesday, 8th December

0830-1020 Session 5, Chair: Tony Roberts

- **0830** Invited speaker: William Parnell
- **0920** Jane O'Neill
- **0940** Özgür Selsil
- **1000** Sebastian Rupprecht

1020-1050 Coffee

1050-1230 Session 6, Chair: Fabien Montiel

- **1050** Ben Binder
  Predicting channel bed topography in hydraulic falls
- **1110** Jack Keeler
  Stability of free surface flow over topography
- **1130** Ravindra Pethiyagoda
- **1150** Fantai Meng
  The resonant motion of 3 DOF mass-offset submerged buoy in regular waves
- **1210** Hugh Wolgamot

1230-1330 Lunch

1330-1520 Session 7, Chair: Ben Binder

- **1330** Alessandro Toffoli
- **1350** Alex Babanin
  Wave breaking, from statistics to dynamics
- **1410** Stefan Zieger
- **1430** Invited speaker: William Perrie

1520-1550 Coffee

1550-1750 Session 8, Chair: Alison Kohout

- **1550** Roger Hosking
  Modelling long wave forcing on the Ross ice shelf
- **1610** Lucas Yiew
- **1630** Dharma Sree
- **1650** Filippo Nelli
- **1710** Johannes Mosig
- **1730** Kenneth Golden
  Waves and sea ice

1900 Conference dinner

Wednesday, 9th December

0830-1020 Session 9, Chair: Malte Peter

- **0830** Invited speaker: Yuri Kivshar
  Recent progress in optical metamaterials
- **0920** Michael Smith
- **0940** Dimitrios Mitsotakis
- **1000** Tony Roberts

1020-1050 Coffee

1050-1240 Session 10, Chair: William Parnell

- **1050** Invited speaker: Mathias Fink
  Wave control with space or time manipulations
- **1140** Stuart Hawkins
  A numerically stable computational framework for the T-matrix
- **1200** Andrew Gibbs
  Hybrid numerical asymptotic boundary element method for multiple scattering
- **1220** Akhilesh Mimani
  An overview of aeroacoustic time-reversal

1240-1340 Lunch

1340-1520 Session 11, Chair: Hyuck Chung

- **1340** Brian Kennett
  Probing 3-D seismic structure beneath Australia
- **1400** Stuart Anderson
  Observing geophysical wave processes with HF radar
- **1420** Simon Clarke
  The forced coupled KdV equations as a model for internal waves in the atmosphere
- **1440** Paul Smith
- **1500** Ross McPhedran
  Generalised Eisenstein series and displaced lattice sums

1520-1550 Coffee

1550-1720 Session 12, Chair: Michael Meylan

- **1550** Graeme Milton
  Transforming the wave equations of physics
- **1610** Paul Croaker
  Hybrid CFD-BEM and time-reversal techniques applied to flow-induced noise source localisation of a flat plate
- **1630** Invited speaker: Ying Wu

1720 Close

Abstracts

Alberto Alberello, Swinburne University of Technology

Velocity field underneath a rogue wave: Numerical simulation and physical experiment

Abstract During the past decades, a large number of waves of extreme height and abnormal shape, also known as freak or rogue waves, have been recorded in the ocean. Although there are many mechanisms for the formation of a rogue wave, the most plausible explanation relies in the instability of a uniform wave train to side band perturbations (i.e. modulational instability). In response to this instability, one individual wave starts growing into a rogue wave at the expense of the surrounding waves. Eventually, when the rogue wave becomes too steep, breaking would occur.

Forces associates to breaking and non-breaking rogue waves are enormous and can jeopardise the safety of any marine structure. Here we present a numerical and experimental study devoted to investigate the velocity field underneath modulationally unstable rogue waves, as primary input for the estimation of wave loads. The numerical approach is based on a coupled nonlinear potential flow (HOSM) for the development of instability and full two fluids Navier-Stokes equations for the evaluation of the wave-induced velocities in the final development of a non-breaking and breaking rogue wave. Laboratory experiments were carried out in the Extreme Wind-Wave Flume of the University of Melbourne to validate the numerics. The velocity field underneath the rogue waves was extracted using a Particle Image Velocimetry (PIV) system.

Results indicate that the horizontal velocities strongly exceed predictions based on the classical linear and second order theory. Furthermore, comparisons with an equivalent breaking monochromatic wave suggest that the mechanism of formation of the rogue wave affects the velocity field and consequently the associated hydrodynamic forces.

This is a joint work with A Iafrati (CNR–INSEAN Marine Technology Research Institute), A Chabchoub (University of Tokyo), JP Monty, J Elsnab (University of Melbourne), JH Lee (University of Melbourne/Swinburne University of Technology), AV Babanin and A Toffoli (Swinburne University of Technology).

Stuart Anderson, University of Adelaide

Observing geophysical wave processes with HF radar

Abstract The development of ever more sophisticated mathematical models of geophysical wave behaviour confronts us with the challenge of validating the theory with experimental observations of commensurate detail and fidelity. While some wave processes can be studied in the laboratory, where many parameters are under direct control, others are not amenable to scale measurements and need to be observed in their geophysical environment. A common weakness of experimental observations of wave processes "in the wild" is under-sampling in space, time or both. Thus a premium can be placed on measurement technologies which provide synoptic spatial coverage with rapid sampling rates, as well as high sensitivity to the multiscale phenomena which usually attend geophysical flows. One such technology is HF radar, which is commonly known as 'over-the-horizon' radar because of its extended range coverage. Although the nominal spatial resolution of this class of radars is of the order of one kilometre, the scattering kernel is exquisitely sensitive to surface gravity waves and hence quite subtle properties of the wavefield can be observed, with the measurements corresponding to spatial averages of the quantities of interest over the radar resolution cell. When one considers that the area simultaneously observed by such a radar can be $10^4 - 10^7$ square kilometres, depending on radar design, with a global update rate measured in seconds or minutes, the unique capabilities of this technology become apparent. In this talk I shall describe some of the wave measurement activities carried out with HF radars in Australia, including studies of internal waves in both atmosphere and ocean, non-adiabatic evolution of wave fields under time-varying forcing, wave instability and recurrence.

Alexander Babanin, Swinburne University of Technology

Wave breaking, from statistics to dynamics

Abstract Wave breaking is one of the most significant dynamic processes at the ocean interface, and it influences the lower atmospheric boundary layer as well as the upper-ocean mixing. It moderates the air-sea interactions including exchanges of energy, momentum, heat, gas, moisture, and its knowledge is very important in remote sensing of the ocean, either as useful signal or strong unwanted noise. In finite-depth environments it can affect dynamics of the entire water column, impact on the bottom, facilitate sediment suspension and currents, and contribute to the wave setup.

In this paper, mechanisms responsible for wave breaking will be reviewed and discussed. Cases starting from academic one-dimensional laboratory tests to the continuous spectrum of two-dimensional wind-forced waves will be considered. Influences of wave directionality, wind forcing and extreme wind forcing will be highlighted. It will be argued that waves at the spectral peak and at shorter scales break due to different reasons.

Ben Binder, University of Adelaide

Predicting channel bed topography in hydraulic falls

Abstract In this talk, we consider inverse methods for predicting the channel bed topography in experiments of hydraulic falls. Both nonlinear solutions and weakly nonlinear approximations from Euler-based models are compared to experimental observations. Accurate nonlinear predictions for the maximum height of the topography and its constant horizontal level in the far-field are obtained, whilst the weakly nonlinear approximation is shown only to be a good predictor of the maximum height of the to-

pography. The error in the inverse predictions is examined and discussed.

Richard Blaikie, University of Otago

Super-resolution optical imaging using evanescent waves

Abstract Super-resolution optical imaging can be achieved in a number of ways, usually involving nonlinear materials in variations of fluorescent confocal microscopy. In applications, such as super-resolution lithography, alternative methods must be used, such as the use of evanescent waves with highly compressed transverse wavelengths compared to their free-space equivalents.

Using evanescent waves presents special challenges as they are normally tightly confined to an interface — either a dielectric-dielectric interface for evanescent waves generated by total internal reflection, or a metal-dielectric interface for surface plasmon polariton evanescent waves. In either case, the generation of practical, super-resolved images from the interference of evanescent waves and subsequent transfer into a recording medium requires care and attention to details that do not normally affect traditional optical imaging.

We have studied evanescent interference imaging using techniques borrowed from semiconductor photolithography, showing how to achieve super-resolution imaging and developing methods to improve image fidelity and depth of field. We have also demonstrated superlensing using silver-based multilayer systems, showing how image projection works in the evanescent regime. This talk will review the basic principles of super-resolution optical imaging using evanescent waves and describe our historical and recent achievements in turning these principles towards practical applications in sensing and photovoltaics.

Hyuck Chung, Auckland University of Technology

Acoustic scattering by an array of soft scatterers

Abstract The scattering of acoustic waves by an array of cylinders can be studied using boundary element, finite element, Green's function and addition theory methods. Each of them has advantages and disadvantages when dealing with various boundary conditions on the surface of the cylinders. In recent years, numerical computation methods and hardware have advanced so that large arrays can now be studied. In this talk, I will show how the methods for large arrays can be adopted for cylinders that have surface other than the acoustically-hard conditions. I will show how the solution methods developed for a single elastic cylinder 40 to 50 years ago can be incorporated into today's advanced computational methods for large arrays. It may be possible that these 'soft' cylinders have superior sound attenuation than hard cylinders. I will show how different softness or internal structures of the cylinders can affect the sound attenuation performance of large arrays.

Simon Clarke, Monash University

The forced coupled KdV equations as a model for internal waves in the atmosphere

Abstract The coupled KdV equations model the resonant interaction of two modes of long, weakly nonlinear waves. Such behaviour has been proposed as the generation mechanism for the Morning Glory roll cloud over Cape York. Here we derive a forced version of this equation to model internal waves propagating on two layer interfaces with velocity shear and uneven bottom topography. An algorithm is derived to obtain steady asymmetric solitary wave solutions of these equations. Finally, the various types of solitary wave solutions and their stability is considered.

This is a joint work with I Korostil.

Paul Croaker, University of New South Wales

Hybrid CFD-BEM and time-reversal techniques applied to flow-induced noise source localisation of a flat plate

Abstract A simulation-based analysis of the flow-induced noise produced by a sharp-edged flat-plate immersed in a low Mach number flow is presented. A hybrid Computational Fluid Dynamics (CFD) - Boundary-Element Method (BEM) technique is applied to predict the flow-induced noise source generated by flow around the plate, the interaction of the acoustic waves with the body and the far-field scattered acoustic pressure field. The aeroacoustic Time-Reversal (TR) source localisation technique was implemented by solving the 2-D Linearised Euler Equations (LEE). The far-field scattered acoustic pressure predicted with the hybrid CFD-BEM technique was applied as an input boundary condition during the TR simulation to localise flow-induced noise sources and identify the mechanism responsible for noise generation. This combination of CFD-BEM and TR techniques is applied to turbulent flow past a sharp-edged flat-plate at a Reynolds number of 5x105 and a Mach number $M = 0.1$. The TR source maps indicate the flow-induced noise source have a lift-dipole nature throughout the frequency range of interest. In particular, the predicted location of the dipole source was obtained near the Trailing-Edge (TE) of the flat-plate at mid-to-high frequencies. The mechanism of TE scattering was shown to dominate the noise production in the high-frequency range.

This is a joint work with A Mimani (University of Adelaide), and M Karimi, D Moreau, C Doolan and N Kessissoglou (University of New South Wales).

Boyin Ding, University of Adelaide

Sea-state based maximum power point tracking control of a fully submerged oscillating buoy

Abstract Optimal control has been studied for over two decades in the field of ocean wave energy extraction. However, most algorithms require not only extremely detailed models of the plant

but also wave prediction, leading to difficulties when implementing these algorithms in reality. This study investigates the use of maximum power point tracking (MPPT) control — a simple gradient-ascent algorithm well developed for solar and wind energy — on a novel wave energy converter comprising a fully submerged oscillating buoy and a tether coupled hydraulic power-take-off (PTO) unit. A study of the sensitivity of control to irregular wave fluctuations/variability was proposed to systematically determine the step size and update rate of MPPT controller. The world's first commercial scale fully submerged wave energy converter (WEC), Carnegie's CETO system, was used as a test case to assess the proposed methodology under passive damping control. Simulation results demonstrated that the MPPT damping controlled system designed based on the sensitivity study is more effective and robust compared to the fixed-damping system with a globally optimized generator damping. The power loss of the MPPT damping controlled system due to tracking and wave/sea state variability is 1.9% of the acausal optimal damping controlled system.

This is a joint work with B Cazzolato, M Arjomandi and P Hardy (University of Adelaide).

Mathias Fink, Institut Langevin, ESPCI Paris Tech

Wave control with space or time manipulations

Abstract Holographic devices as well as time-reversal mirrors are based on Huygens principles and wave field manipulation on spatial boundaries. They provided an elegant way to back propagate a wave field towards its initial source. It can be used to obtain an image of an object radiating a wave in a homogeneous medium. It can also be used to create, through any complex medium, a wave pattern of any required shape restricted by diffraction limits. Here we want first to revisit these approaches by introducing another point of view, the one that Loschmidt proposed in his famous argument to create a time-reversal experiment by inversing instantaneously all velocities of the particles in a gas. The extension of this concept to waves will be discussed through the concept of time boundaries manipulation. Experiments, conducted with water waves, validating this approach will be presented. They allow us to revisit the role of Huygens wavelets in diffraction theory. In the second part of this talk, we will discuss another approach to manipulate a wave field in reverberating medium by introducing tunable metasurfaces as spatial boundaries and we will emphasize this concept for microwaves.

Andrew Gibbs, University of Reading

Hybrid numerical asymptotic boundary element method for multiple scattering

Abstract We consider the problem of scattering of a time-harmonic incident plane wave, with wavenumber $k > 0$, by multiple sound-soft scatterers in two-dimensions.

For the case of a single convex scatterer, it has been shown that when a boundary element method with an enriched approximation space is used, the degrees of freedom required to maintain accuracy need grow only logarithmically with k. This is a significant improvement over standard schemes, in which the number of degrees of freedom must grow at least linearly with k. The choice of enrichment follows from the decomposition of the Neumann trace $\frac{\partial u}{\partial n}(\mathbf{x}(s)) = \Psi(\mathbf{x}) + v_+(s)\mathrm{e}^{iks} + v_-(s)\mathrm{e}^{-iks}$, where s parametrises the surface $\mathbf{x}(s) \in \partial D$ of the scatterer and $v_\pm$ represent the amplitude of the waves diffracted by the corners. Here Ψ represents the leading order high frequency behaviour corresponding to the reflected waves, and is commonly referred to as the "Geometrical Optics Approximation", which can be written explicitly in terms of the incident wave.

Here we derive an analogous representation for multiple scattering problems, which contains an additional term, accounting for the contribution to the solution arising from the presence of nearby scatterers. Exponential convergence in L^2 is observed, but with significantly fewer degrees of freedom than is required for a standard method.

Kenneth Golden, University of Utah

Waves and sea ice

Abstract The interaction of sea ice with various types of waves is important not only for the role of sea ice in the climate system, but in monitoring sea ice properties and processes. In many cases, particularly in remote sensing applications, the key issue is the interaction of an electromagnetic wave with the brine microstructure of sea ice. In this lecture we will explore homogenization problems for sea ice and its interactions with waves. In considering the effective complex permittivity of sea ice, for example, we will uncover universal behavior of eigenvalue statistics of the random matrices underlying rigorous representations of the effective parameter. Moreover, we will demonstrate related eigenvector behavior that is analogous to Anderson localization of electronic states in disordered quantum systems.

Marshall Hall, Marshall Hall Acoustics

Results obtained for resonance frequencies of finite in-vacuo cylindrical shells for three scenarios: Donnell-Mushtari model with and without bending, and Flugge model with bending

Abstract Two popular models for the equations of motion of a thin finite cylindrical shell are the (relatively) simple Donnell-Mushtari model, and the more complex Flugge model. The latter has been assessed in a number of reports as being more accurate than the former. These models each contain a term that represent the contribution of bending stresses. A study has been made of the resonance frequencies of an in-vacuo cylindrical shell for three scenarios: the Donnell-Mushtari model without the bending term, Donnell-Mushtari with bending, and the Flugge model with bending. The motivation for this study is that the Donnell-Mushtari model without bending leads to a Helmholtz equation for axial displacement, the phase velocity of which can be expressed analytically. It is not possible to obtain a corresponding equation, or

even a perturbation approximation, if the bending term is included in the equations of motion. It is therefore of interest to determine the accuracy of Donnell-Mushtari without bending, and this has been done by examining the resonance frequencies of two shells that are representative of a pile and a submersible vessel respectively. It is found that the frequencies are consistent to within 0.2 parts per thousand.

Peter Hardy, University of Adelaide

A maximum capture width tracking controller for a wave energy converter in stochastic waves

Abstract Optimal control of ocean wave energy converters (WECs) has been a popular field of research since the 1970's, however, a controller which is both efficient and practical is yet to be found. WEC controllers which maximise power on a wave-by-wave basis require accurate prediction of the incoming wave time-series which is currently not feasible. Motivated by the difficulty of wave prediction, non-model based adaptive controllers have been developed which optimise WEC power take-off (PTO) parameters for the present sea state. Maximum power point tracking (MPPT), a gradient-ascent type method commonly used in wind and solar energy converters, has been applied to WEC control in stationary sea states with some success, however, real ocean waves are not stationary and MPPT algorithms are known to become confused in changing environmental conditions.

This presentation will introduce a maximum capture width tracking (MCWT) controller, being an MPPT controller modified to account for incoming wave conditions as well as WEC power output. The MCWT controller will be applied to latching control of an oscillating water column with Wells turbine, optimising the latching time based on sea state. The performance of the MCWT latching controller will be compared to that of an MPPT latching controller in both stationary and transitioning sea states, where MCWT robustness in changing environmental conditions will be demonstrated. Finally, it will be shown that the proposed controller can yield optimal capture width within the bounds of uncertainty that optimal capture width can be known for a WEC in stochastic waves.

This is a joint work with B Cazzolato, B Ding and Z Prime (University of Adelaide).

Stuart Hawkins, Macquarie University

A numerically stable computational framework for the T-matrix

Abstract The T-matrix is an important tool for scattering simulations and is widely used in many applications including atmospheric science, meteorology, oceanography, and biology. The T-matrix originated a half century ago using the null field method but it is well known that the null field method is numerically unstable for particles that deviate significantly from a sphere. Related methods involving point matching have similar stability issues. An extensive literature has been devoted to modifying the null field method to overcome numerical stability issues. However, the null field method is not intrinsic to the T-matrix and in this talk we describe a completely new computational framework that is numerically stable for all scatterers. The key to our method is calculating the T-matrix in the far field instead of on the scatterer's surface. Using a recently developed object oriented toolbox we demonstrate the enhanced numerical stability of our method for scattering by geometries with various cross sections.

Roger Hosking, University of Adelaide

Modelling long wave forcing on the Ross ice shelf

Abstract In addition to the persistent local ocean swell, it has been noted that tsunamis and infragravity (IG) waves generated by storms at distant continental coasts impact Antarctic ice shelves, to an extent that may ultimately lead to their collapse. Recently, there has been a significant field project mounted to measure the response of the Ross ice shelf (RIS) to gravity wave forcing, accompanied by some interesting mathematical modelling. IG waves or tsunamis penetrate the surrounding ice floes much more readily than the significantly shorter wavelength local ocean swell, so the relatively thin RIS and its underlying sea water cavity (some few hundred metres thick and similarly a few hundred metres deep) may be modelled as a thin ice plate on shallow water, relative to incoming wavelengths of several kilometres. A simple one-dimensional model of the coupled ice-shelf/sub-ice-shelf cavity system represents the ice plate with one end fixed (at the grounding line) and the other free (at the seaward ice front), akin to a cantilever on an underlying fluid. Aspects of this rather simple mathematical model will be reviewed, in predicting the response of the system to relatively rather long incoming waves.

This is a joint work with LG Bennetts (University of Adelaide) and Y Watanabe (University of Hokkaido).

Weikang Jiang, Shanghai Jiao Tong University

Acoustic topology optimization of sound power using mapped acoustic radiation modes

Abstract An efficient approach for acoustic topology optimization to minimize the radiated sound power from a vibrating structure is described. The objective function of the topology optimization modifies the local stiffness at discrete locations on the surface of the structure. A sensitivity analysis is then implemented to further optimize the layout of the locations of the modified local stiffness. To speed up the computational process, the radiated sound power is computed based on mapped acoustic radiation modes. To demonstrate the acoustic topology optimization using mapped acoustic radiation modes, the radiated sound power of a compressor housing is examined. Based on results from the numerical model, the local stiffness of a compressor housing was experimentally modified. Good agreement in sound power reduction obtained both numerically and experimentally was observed for the overall trend of the sound power levels as a function of one-third frequency bands.

Mahmoud Karimi, University of New South Wales

Flow-induced noise prediction of a cylinder using a CFD-BEM technique

Abstract The flow-induced noise generated by a circular cylinder immersed in low Mach number flow is predicted using a hybrid computational fluid dynamics - boundary element method (CFD-BEM) technique. The fluctuating flow field is obtained using an incompressible CFD solver. A high-order reconstruction scheme is used to extract acoustic sources based on Lighthill's analogy from the flow field data. The outer surface of the cylinder is divided into a number of strips to produce a rotationally symmetric structure. Using a boundary element method, the aeroacoustic problem is formulated as a block circulant system. A discrete Fourier transform is then directly employed to solve the block circulant system. The results from the hybrid CFD-BEM technique are presented for turbulent flow past a circular cylinder, with Reynolds number based on the cylinder diameter of Re_D=46000 and Mach number M=0.21. The aeroacoustic results are compared with experimental data from literature.

This is a joint work with P Croaker and N Kessissoglou (University of New South Wales).

Jack Keeler, University of East Anglia/University of Adelaide

Stability of free surface flow over topography

Abstract The forced Korteweg De-Vries equation (fKdV) is used as a model to analyse the wave behaviour on the free surface in response to a prescribed topographic forcing. Recent work by Binder, Blyth & Balasuriya (2014) has shown that non-unique steady solutions can be found at critical Froude number, $F = 1$. This non-uniqueness is further demonstrated with a Gaussian type topgraphy where non-unique solutions are found and are classified according to a phase-plane analysis. We investigate the stability of these solutions through time-dependent calculations and by computing eigenvalue spectra of the linearised fKdV operator exploiting the Hamiltonian structure of the fKdV.The spectrum is computed numerically and spectral stability is determined if none of the eigenvalues lie in the right-half plane. Additionally, formal stability is demonstrated by showing that the second variation of the Hamiltonian is of definite sign. A direct comparison is made between these results and a suite of time-dependent calculations, and excellent agreement between predictions of the growth rates extracted from these calculations and the computed eigenvalues is confirmed.

Brian Kennett, Australian National University

Probing 3-D seismic structure beneath Australia

Abstract The earthquake belts around Australia provide a plentiful source of seismic waves that has been exploited in many different ways to extract information on the 3-D distribution of seismic wavespeeds beneath the Australian continent and its environs, particularly using portable deployments of seismic stations. Broad-scale structure has been determined using surface-wave tomography. The dense seismic station network in southeastern Australia, built up over two decades, provides tight horizontal resolution by exploiting the arrivals from distant earthquakes. Considerable progress has been made recently in the exploitation of ambient seismic noise via cross-correlation between stations to extract Green's functions with the stations as virtual source and receiver. Such work has markedly improved resolution of crustal structure and is beginning to shed light on the fine-scale structure in the mantle beneath.

Nicole Kessissoglou, University of New South Wales

Acoustic performance of locally resonant sonic crystals

Abstract Sonic crystals are scatterers arranged periodically in a homogeneous fluid medium, for which low noise transmission occurs in certain frequency bands known as stop bands. In the first part of this presentation, the acoustic performance of a simple square lattice sonic crystal using a range of analytical and numerical techniques is examined. The analytical techniques include the multiple scattering method and row homogenization based on effective medium approximation. The numerical approaches include the development of a finite element model using commercial software as well as an in-house boundary element method in which the periodic scatterers are represented as a block Toeplitz system due to the translational invariance of the free-space Green's function. The dispersion relation and transmission loss of the sonic crystal using the aforementioned approaches are compared. In the second part of this presentation, the numerical models are extended to consider locally resonant scatterers, resulting in the generation of band gaps around the resonator natural frequency in addition to the band gap due to the overall crystal periodicity. Finally, the application of locally resonant sonic crystals for practical, tailored noise control is discussed.

This is a joint work with GS Sharma, M Karimi, S Fard (University of New South Wales), A Skvortsov, I MacGillivray (Defence Science and Technology Organisation) and H Chung (Auckland University of Technology).

Yuri Kivshar, Australian National University

Recent progress in optical metamaterials

Abstract We will discuss several novel directions in the physics of metamaterials, more specifically hyperbolic, all-dielectric, and nonlinear metamaterials. In particular, we will discuss the properties of a novel type of magnetic hyperbolic metamaterials with negative components of the magnetic insusceptibility tensor, and specific features of the wave propagation in such media. Also, we will discuss the emergence of a new branch of resonant nanophotonics aiming at the manipulation of strong optically-induced electric and magnetic Mie-type resonances in dielectric and semiconduc-

tor nanostructures with high refractive index.

Richard Manasseh, Swinburne University of Technology

Issues of wave energy converter operation in arrays

Abstract The possible advantages and disadvantages of the operation of Wave Energy Converters (WECs) in arrays are reviewed. These are machines that extract renewable energy from ocean waves. Most WEC concepts rely on the principle of resonance, so that the machines are natural oscillators tuned to ocean wave frequencies. It has been recognised since the 1970s that once WECs are deployed in economically-significant numbers, in arrays or 'farms', they may interact with each other in complex ways. This interaction is due to the unavoidable coupling by sea-surface waves both radiated by the machine action and diffracted from the incident ocean swell. Multiple-scattering physics is thought to occur as in many analogous wave systems. In some cases, there are additional engineering connections between machines. Depending on the device characteristics, their number, spacing and orientation relative to the swell, models based on linear physics predict that the power extracted from the ocean could be substantially more — or less — than that due to the same number of independent machines.

This is a joint work with S De Chowdhury (Swinburne University of Technology).

Ross McPhedran, University of Sydney

Generalised Eisenstein series and displaced lattice sums

Abstract Lattice sums occur in the solution of many important problems in physics and engineering, and have much intrinsic mathematical interest in their own right. Here we investigate two classes of lattice sums, the first being a form of generalised Eisenstein series (GES), and the second taking the form of cylindrical harmonic sums. We demonstrate using a combination of Poisson's summation formula and residue theory that GES can be expressed in terms of derivatives of conventional Eisenstein series for non-conditionally convergent forms. When conditionally convergent, we demonstrate that Hecke's trick also extends to these GES and that a correction for the extraordinary contribution is obtainable using integral transforms and residue theory.

These GES feature in the recurrence relations of the second class of sums considered, which themselves arise from the evaluation of the Green's function for periodic problems satisfying the Helmholtz operator. Using multiset identities we show that lattice sums which are centred about high symmetry points in two-dimensional Bravais lattices can be expressed in terms of several sums which are centred about the origin. This is an important first step towards the development of asymptotic expressions for lattice sums at all frequencies, which are an essential element in low frequency descriptions of photonic crystals and metamaterials.

This is a joint work with PY Chen (Tel Aviv University) and MJA Smith (University of Sydney).

Fantai Meng, University of Adelaide

The resonant motion of 3 DOF mass-offset submerged buoy in regular waves

Abstract Since the Oil Crisis of the 1970s, wave energy has been regarded as a renewable power source. Compared with solar and wind energy, the power carried by wave oscillations are more continuous and predictable. Of all the Wave Energy Converter (WEC) categories, the point absorbing WEC is the most widely used in wave energy industry. This kind of device floats on the surface of the water or submerges below the water surface, held in place by cables connected to the seabed. Buoys use the rise and fall of swells to drive hydraulic pumps and generate electricity. For most published research on the point absorbing WECs with single-tether power take-off device (PTO), only heave motion was considered. This is mainly due to the fact that heave motion can easily transfer to the PTO.This presentation will demonstrate the concept of utilising asymmetric mass distribution to enhance coupling of buoy's motion, and consequently extract more energy from waves, compared to a generic buoy with uniform mass distribution.

This is a joint work with B Cazzolato, B Ding and Z Prime (University of Adelaide).

Michael Meylan, University of Newcastle

Extraordinary transmission, symmetry, Helmholtz resonators, and the Blaschke product

Abstract Extraordinary transmission is a phenomena in which perfect transmission of energy occurs at specific frequencies in a region frequency space with otherwise very low transmission. It was first observed in electromagnetic waves but seems to be a universal feature of wave problems, e.g. it appears in water waves or acoustic waves. I will show that the three key properties of a single mode of propagation, spatial symmetry, and a Helmholtz resonator lead to extraordinary transmission. The key mathematical tool used is the Blaschke Product which is a decomposition of analytic functions that are unitary on the real axis.

Graeme Milton, University of Utah

Transforming the wave equations of physics

Abstract I will show how the wave equations of physics can be transformed into new forms, and I will discuss the ramifications of this throughout science.

Akhilesh Mimani, University of Adelaide

An overview of aeroacoustic time-reversal

Abstract The acoustic Time-Reversal (TR) is a robust method operating in the time-domain used for solving inverse problems of source localisation. The TR technique has been used in diverse fields such as hydrodynamics, ultrasound medical imaging, diagnostic and nondestructive testing, long-range communication in deep underwater acoustics, in structural dynamics for health monitoring and in electromagnetic wave propagation. The application of TR in the field of aeroacoustics is relatively new and rather unexplored. However, due to progress in the development of high-resolution Computational Aeroacoustics (CAA) algorithms, its use to analyse flow-induced noise problems is gaining popularity. This talk presents an overview of the recent developments in aeroacoustic TR technique; however, it focuses primarily on the research carried out at Adelaide University and is subdivided into two parts. The first part discusses fundamental advancement in computational methods for implementing aeroacoustic TR simulation (through simulated data) such as the use of multiple arrays of microphones in a free-space and sponge-layer damping techniques to improve the capacity of TR as well as the effect of mean flow and reflecting surface on TR source resolution. The second part presents an application of aeroacoustic TR method to some experimental benchmark flow-induced noise problems (such as full-span cylinder, airfoil or flat-plate in cross-flow), a comparison of the experimental TR results with those obtained using the cross-spectrum conventional beamforming technique and scope of future experimental application of aeroacoustic TR method.

This is a joint work with CJ Doolan (University of New South Wales).

Dimitrios Mitsotakis, Victoria University of Wellington

A modifed Galerkin/finite element method for the Serre-Green-Naghdi system

Abstract We solve numerically the Serre-Green-Naghdi (SGN) system using a stable, accurate and efficient fully discrete numerical scheme based on a modified Galerkin/finite element method. Although the SGN equations contain third-order derivatives, the modified Galerkin/finite element method allows the use of Lagrange finite elements, and, when combined with explicit Runge-Kutta schemes for the discretization in time, approximate solutions of the SGN system with variable bottom are obtained efficaciously. Compared to other methods, such as finite volume and discontinuous Galerkin methods, that have been applied for the same system, finite element methods appeared to have certain advantages since they are not dissipative and also can approximate the high order nonlinear terms very accurately. After reviewing the properties of the proposed numerical scheme, a detailed study of the dynamics of the solitary waves of the SGN system over variable bottom topographies is presented. A numerical study of the various collisions of solitary waves with wall boundaries is being performed while in some cases a comparison with experimental data is presented.

Fabien Montiel, University of Otago

Attenuation and directional spreading of ocean waves in ice-covered seas

Abstract We propose a phase-resolving model that describes the evolution of an ocean wave directional spectrum in marginal ice zones (MIZs). The MIZ is constructed as an array of tens of thousands of compliant circular ice floes, with randomly selected positions and radii determined by an empirical floe size distribution. Linear potential flow and thin elastic plate theories model the coupled water-ice system. A dissipative force is included as a velocity dependent term in the thin plate model. A slab-clustering method is proposed to solve the time-harmonic multiple scattering problem under a multi-directional incident wave forcing. The attenuation and directional spreading are extracted from ensembles of the wave field with respect to realizations of the MIZ randomly generated from prescribed distributions. Our model is shown to reproduce the exponential attenuation of wave energy and directional spreading observed in real MIZs. Quantitative comparisons with field data from the 1980's are also reported.

This is a joint work with VA Squire (University of Otago) and LG Bennetts (University of Adelaide).

Johannes Mosig, University of Otago

Water wave transmission by an ice floe of random length using generalized polynomial chaos

Abstract Wave scattering models of ice-covered seas commonly assume that the constituent ice floes have idealized shapes, e.g. circular or square with constant thickness. However, real ice floes have more complicated shapes as a result of random breakup events that occur under wave action, followed by lateral melting or freezing and mechanical abrasion. As a first step to model the impact of shape irregularity on the scattering properties of ice floes, we consider a two-dimensional model of linear wave scattering by a single ice floe of random length, in which the length obeys a prescribed distribution. We seek to evaluate the resulting statistical distribution of the transmission coefficient T. Using the generalized polynomial chaos (gPC) and the stochastic Galerkin methods, together with a standard mode matching technique, enables us to compute the expectation, variance, and higher moments of T from a single system of deterministic partial differential equations, i.e. no sampling is required. Expectation and variance of T can also easily be computed using a Monte Carlo (MC) technique, which provides validation and allows us to show the efficiency of our method.

Filippo Nelli, Swinburne University of Technology

Wave transmission by an ice floe: An experimental perspective

Abstract Ocean waves play an important role in the dynamics of the marginal ice zone: an interface of scattered ice at the boundary of open waters and pack ice. Available models for estimating

wave transmission are conventionally based on wave scattering theory and linearization with respect to wave steepness and do not capture the full complexity of the wave-ice interaction. Additional sources of wave dissipation such as waves overwashing the floe are therefore excluded. Here we present an experimental perspective of the interaction between plane waves with variable steepness and a single ice floe. The primary aim is to assess the role of wave overwash in dissipating the incident wave. The ice floe is modeled by plastic plates with physical properties similar to sea ice. The floe is tested in three different configurations: (i) moored with barriers to prevent wave overwash above the floe (this test condition is the closest possible configuration to the linear model); (ii) moored without barriers; and (iii) freely floating. The latter two configurations allow waves to overwash the floe. Results indicate that the amount of wave energy dissipation is correlated to the depth of the overwashed layer and the intensity of wave activity on the floe.

This is a joint work with A Toffoli (Swinburne University of Technology), D Skene and LG Bennetts (University of Adelaide), JH Lee and JP Monty (University of Melbourne) and MH Meylan (University of Newcastle).

Jane O'Neill, University of Liverpool

Active cloaking of rigid inclusions in Kirchhoff plates

Abstract We describe in detail an analytic algorithm for cloaking rigid inclusions from flexural waves in thin elastic plates. Our algorithm provides an approximate cloaking by annulling selected propagating terms from the scattered field so that an outside observer is unaware of the objects presence. This is done by tuning the amplitudes of several active sources located in the exterior of the scatterer. For the case of a circular clamped inclusion, the method is fully analytical and effective cloaking is achieved with just six active sources. The algorithm is generic and is shown to work for an arbitrarily shaped scatterer with a smooth boundary.

William Parnell, University of Manchester

Elastodynamic metamaterials: Passive and active cloaking, configurable media and invariance

Abstract Significant interest has surrounded the field of metamaterials over the last decade. Research into *elastodynamic* metamaterials is becoming increasingly important due to its applicability in a wide range of fields including vibration elimination, wave filtering and redirection, and even noise reduction from household appliances. The theory is rich in the sense that a number of issues arise that are not present in the equivalent acoustic and electromagnetic cases. Here we shall describe a number of problems in this realm.

We begin with an overview of passive elastodynamic cloaking, describing the state-of-the-art techniques including static cloaking, neutral inclusions, transformation elastodynamics, the subsequent need for "unnatural" materials and a mechanism that circumvents this difficulty called *hyperelastic cloaking*.

Following this the concept of *active* cloaking will be covered where an active wave field nullifies the incident field in some region but this active field must not be present in the far-field. The cases of the Helmholtz equation and flexural waves in thin-plates will be described. Limitations will be discussed and some ideas as to how these may be overcome will be presented.

Configurable or tuneable metamaterials, those that can either adapt or be adapted to their environment will then be discussed. The notion of a phononic switch in the realm of body and flexural waves is presented and experiments on the latter will be described.

The talk will finish with some new ideas on invariant elastodynamics — nonlinear materials that can retain their elastodynamic response under deformation, opening up the possibility for the study of nonlinear metamaterials.

William Perrie, Bedford Institute of Oceanography

Wave-ice interactions in the marginal ice zone

Abstract WAVEWATCHIII (WW3) is the 3rd generation operational state-of-the-art forecast model for many operational marine forecast offices, internationally. Here, we describe preliminary adaptations for WW3 for wave scattering in the marginal ice zone (MIZ) following Masson and LeBlond (1989, JFM), Perrie and Hu (1996, JPO) and Meylan and Masson (2006). Presently, no practical methodology has been developed to directly incorporate this sort of wave-ice attenuation/scattering model into WW3. The inclusion of wave-ice scattering in wave models was developed by the authors in an earlier implementation using a simple 2nd generation wave model. One limitation is that rigid floes were assumed, whereas ice floe flexure can be dominant in some MIZ situations, e.g. for large floes (Meylan and Squire 1996). However, this methodology can predict many features observed in measurements such as the roll over effect and the dependence of wave scattering on wave period. Moreover, the change from rigid to flexural ice floes is feasible in this formulation. We update and optimize this model approach for wave-ice attenuation/scattering. The resulting model system is validated with in situ and satellite remotely sensed MIZ data, from recent field experiments, including a storm in the Greenland Sea in February 2012.

Malte Peter, University of Augsburg

Stability of resonant loads on line arrays with respect to positional disorder

Abstract It is well-known that finite arrays of identical scatterers arranged in straight lines and with constant spacing experience exceptionally high loads at certain frequencies. This phenomenon is related to array trapped modes and has been intensively investigated for the case of plane linear water waves incident on rigid bottom-mounted cylinders using methods based on local expan-

sions of the solution (e.g. interaction theories). We consider a different approach based on analysis of the spectrum of modes supported by a single scatterer, which gives new insights and, in particular, allows for investigation of the stability of the resonant loads with respect to positional disorder.

This is joint work with LG Bennetts (University of Adelaide) and F Montiel (University of Otago).

Ravindra Pethiyagoda, Queensland University of Technology

The apparent wake angle of a ship travelling in a fluid of finite depth

Abstract For more than a century the characteristic wedge shape associated with the wake of a ship in infinitely deep water was accepted to have a half angle of arcsin$(1/3) \approx 19.47°$, known as Kelvin's angle. Over the past one or two years, however, this idea has been challenged by numerous papers documenting apparent wake angles less than Kelvin's angle, at least for sufficiently fast-moving "ships". One key observation is that the apparent angle we see in practice can be defined using the highest peaks of the wake. For finite depth flows there is an analogue of Kelvin's angle, here referred to as the caustic angle, that varies with the Froude number, F, a nondimensional measure of speed. Using linear water wave theory, we calculate the apparent wake angles and the caustic angles for a variety of ship speeds and fluid depths and shed light on some seemingly contradictory results between these two measures.

Tony Roberts, University of Adelaide

Macroscale modelling via patches of nonlinear wave simulations

Abstract The multiscale gap-tooth scheme is built from given microscale simulations of complicated physical processes to empower macroscale simulations. By coupling small patches of simulations over unsimulated physical gaps, large savings in computational time are possible. Here we discuss generalising the gap-tooth scheme to the case of wave-like systems. Classic macroscale interpolation provides a generic coupling between patches that achieves arbitrarily high order consistency between the multiscale scheme and the underlying microscale dynamics. Eigen-analysis indicates that the resultant gap-tooth scheme empowers feasible computation of large scale simulations of wave-like dynamics with complicated underlying physics. For an example, we implement numerical simulations of dam-breaking by the gap-tooth scheme.

Sebastian Rupprecht, University of Augsburg

Effective versus individual waves for a rough thin elastic plate problem

Abstract We extend the study of Bennetts et al. (Quart. J .Mech & App. Maths., 2015), who showed that individual wave fields attenuate far slower than the effective, i.e. mean, wave field for the problem of free-surface waves over a rough seabed in intermediate depth, to wave propagation through a rough thin elastic plate in vacuo. The roughness is modelled as small amplitude, continuous variations in the wavenumber of the propagating wave. It results in exponential attenuation of the wave envelope on large observation scales. We use ensembles of 100s to 1000s of numerical solutions for randomly generated realisations of the roughness profile to show that attenuation rates are far smaller for individual waves than for the effective waves here, too.

Furthermore, we apply a multiple-scale method, similar to the one introduced by Mei & Hancock (J. Fluid Mech., 2003) for the free-surface setting mentioned above, to the thin elastic plate problem to derive a semi-analytic expression for the attenuation rate of the effective wave field.

This is joint work with MA Peter (University of Augsburg), LG Bennetts (University of Adelaide) and H Chung (Auckland University of Technology).

Matthieu Sellier, University of Canterbury

Flow domain identifcation in three-dimensional creeping flows

Abstract We present a method to reconstruct the three-dimensional flow domain in thin gravity-driven film flows. Based on the lubrication approximation, we derive a system of equations which allows to determine the flow between the substrate topography and the free surface only with the knowledge of the free surface velocity field. The film thickness reconstruction is followed by the reconstruction of the internal pressure field and the free surface position. A numerical algorithm for each solution step is derived and each step is underpinned with an example. Trench and bump topographies are tested in different shapes. Finally, we show the robustness of the numerical solution to external perturbations in the form of noisy input data which occurs in experimental setups.

This is a joint work with C Heining (University of Bayreuth).

Özgür Selsil, University of Liverpool

Resonant regimes in active cloaking problems for flexural waves

Abstract Although active cloaking is inherently broadband, difficulties can arise at resonant regimes where there exist sudden changes in scattering properties of the object to be cloaked. We derive a novel method for active cloaking of coated inclusions for flexural waves in Kirchhoff plates at resonant frequencies. This method involves passive techniques to tame the regions of steep gradient in scattering from the inclusion. We then apply an active cloaking algorithm to provide effective exterior cloaking, and note highly localized fields within the inclusion. This renders the object invisible to an observer sufficiently far away from the object and active sources.

The work is an extension of that presented in talk "Active Cloaking of Rigid Inclusions in Kirchhoff Plates " by O'Neill *et al.*.

Nataliia Sergiienko, University of Adelaide

An optimal arrangement of mooring lines for the three-tether submerged point-absorbing wave energy converter

Abstract Point-absorbing wave energy converters (WECs) with a single-tether mooring are capable of extracting power from heave motion, but they do not utilise the full energy harvesting potential. One of the possible ways to increase the total power absorption is to add another controllable degree of freedom. These can be achieved by using a so-called 'tripod' configuration when the body is tied to three tethers attached to the power take-off systems at the sea floor. This paper investigates the optimal inclination of tethers considering three different approaches: a purely kinematic analysis, not taking into account the shape of the buoy; a kinematic analysis extended by the fluid particle motion; a dynamic analysis of spherical and cylindrical WECs, using a linear frequency-domain method. The results show that for a submerged sphere and for a submerged vertical cylinder with an aspect ratio of one, tethers should be orthogonal to each other, forming edges of the cuboidal vertex. Such a configuration of tethers provides for uniform performance of the WEC in all directions of motion. However, for the cylinders with an aspect ratio other than one, an optimal angle between the tethers depends greatly on the proportional relationship between the cylinder height and diameter.

This is a joint work with B Cazzolato and B Ding (University of Adelaide).

David Skene, University of Adelaide

Experimental and mathematical modelling of water wave overwash of a thin floating plate

Abstract Linear potential flow theory is used as standard to model wave interaction with thin floating plates. However, this neglects the overwash phenomenon. Overwash refers to the waves running over the surface of plates, as their edges dip in and out of the water. It can dissipate wave energy and produce high frequency wave components in the surrounding wave field. In this presentation a mathematical model for overwash will be presented and compared to laboratory experimental results. This comparison will then be used in order to discuss what future work needs to be undertaken in modelling overwash.

This is joint work with LG Bennetts (University of Adelaide), MH Meylan (University of Newcastle) and A Toffoli (Swinburne University of Technology).

Alex Skvortsov, Defence Science and Technology Group

Shallow water waves generated by localised turbulent flow

Abstract Small amplitude water waves generated by unsteady turbulent flow in shallow water are investigated numerically and analytically. It is assumed that the characteristic flow velocity is much smaller than the speed of sound in the water and the speed of shallow water waves. We employ the analogy between the process of the generation of shallow water waves and the radiation of vortex sound (acoustic waves generated by turbulent flow), initially pointed out by J.E. Ffowcs–Williams. We demonstrate that the far-field pressure fluctuations, distant from the turbulent flow, depend on three components: (1) rapidly decaying near field perturbations (solution of the Laplace equations), (2) acoustic waves (they appear due to compressibility of the fluid), and (3) slowly decaying interface perturbations (flow induced elevation of the free surface). By applying well-known scaling relations for vortex sound we analyse the relative contribution of each component as a function of the distance from the flow, the flow parameters and the wave frequency. The results of the presented approach can be helpful for the rapid analysis and understanding of ship wake patterns in shallow water conditions.

This is a joint work with B Anderson and G Seil (Defence Science and Technology Group).

Michael Smith, University of Sydney

Metamaterial engineering of the electrostrictive effect

Abstract Electrostriction is a mechanical strain that arises in a material in response to an applied electric field. Under certain conditions, this strain can generate a propagating acoustic wave inside the medium, varying the optical properties of the material and scattering high-intensity incident fields. Typically this periodic variation is an undesired effect in optical systems, but it does in fact have useful practical applications, particularly in the design of nanophotonic devices. We provide a theoretical model for computing the electrostrictive response of a composite material with subwavelength structural features. We demonstrate that enhancement and suppression of electrostriction is achieved for certain material choices, which is extremely relevant for selectively tuning nonlinear optical effects, such as stimulated Brillouin scattering (SBS).

This is a joint work with BT Kuhlmey and CM de Sterke (University of Sydney), C Wolff, M Lapine and CG Poulton (University of Technology Sydney).

Paul Smith, Macquarie University

Rounding sharp-cornered scatterers: Dependence of diffraction on the radius of curvature

Abstract In studying acoustic or electromagnetic wave diffraction, the choice of an appropriate canonical structure to model the dominant features of a scattering scenario can be very illuminating. The study in this paper was originally motivated by the influence that the corners of buildings and their surface cladding have on electromagnetic wave propagation. In order to clarify the effect of corner rounding this paper examines the diffraction from cylindrical scatterers (of constant cross-section) which possess corners, that is, points at which the normal changes discontinuously. Specifically we develop a numerical method for the scattering of a plane wave normally incident on such cylindrical structures with soft, hard or impedance loaded boundary conditions. We then examine the difference between various test structures with corners and corners that have been rounded to assess the impact on near and far field scattering, as a function of the radius of curvature in the vicinity of the rounded corner point.

This is a joint work with AJ Markowskei (Macquarie University).

Dharma Sree, Nanyang Technological University

Sea ice model: Wavelength modulation under a finite length viscoelastic cover

Abstract A possible computational ice model for the wave interactions in polar seas is to describe the ice cover as a viscoelastic layer overlying the inviscid water. In the present study, we developed an experimental approach using oil-doped Polydimethylsiloxane (PDMS) material that would enable the verification of the model predictions in the laboratory. The rheological results showed that the mechanical behaviour of the oil-doped PDMS material was close to a Voigt solid. The experimental measurements included wave gauge data on the incident and transmitted waves, as well as ultrasonic gauge data on the displacement of the viscoelastic layer at different locations. Together they showed an obvious modulation of the wave number in the cover region, with wave lengthening or shortening dependent on the viscoelastic properties. We showed that the magnitude of the modulation in wave number can be linked quantitatively to the viscoelastic model predictions by Wang and Shen (2010).

This is a joint work with AWK Law (Nanyang Technological University) and HH Shen (Nanyang Technological University/Clarkson University).

Alessandro Toffoli, Swinburne University of Technology

Non-Gaussian properties of wind-generated waves: An experimental model in circular wave flume

Abstract The probability of occurrence of extreme, rogue waves in wind-generated fields is investigated experimentally in a unique circular wave flume. The facility allows infinite fetches, ensuring full development of the wave field. Water surface elevation was measured at several cross-sections under the effect of different wind speeds, ranging from 2 m/s to 6 m/s (as measured at 0.3 m from the water surface). While low winds ensure that waves develop without reaching the breaking onset, highest wind conditions are heavily affected by breaking dissipation. Test were repeated few times to properly assess statistical uncertainties. Results show that the kurtosis of the surface elevation, a measure of the percentage of extremes in a wave record, gradually increases in time with the evolution of the wave field. Deviations from Gaussian/Normal statistics are observed to be a function of wind speed. The maximum departure from Normality was recorded for wind speed of 4 m/s (the maximum wind with no breaking dissipation), where the evolution of kurtosis resembled the one induced by quasi-resonant wave-wave interactions.

This is a joint work with D Proment and H Salman (University of East Anglia), and M Manfrin and M Onorato (University of Turin).

Elena Vinogradova, Macquarie University

A rapidly convergent regularized algorithm for transmission line properties of arbitrarily disposed multi-cylinder systems

Abstract An efficient analytical-numerical method is developed for analysis of multi-conductor transmission lines. The shield and inner conductors are represented by cylinders with an arbitrarily profiled smooth contour.

The method is based on a mathematically rigorous generalization of the so-called Method of Regularization (MoR) earlier developed for the analysis of potential and wave scattering problems for canonically shaped conductors and screens. The problem is posed as a classical boundary value problem in which the solution is represented in terms of single-layer potentials. This produces coupled integral equations of the first kind with unknown functions related to the charge densities.

Semi-analytical inversion of the singular part of the relevant operator (with proper expansion of all functions into series) transforms the initial equations into coupled systems of infinite systems of linear algebraic equations of the second kind. Due to the mathematically proved guaranteed fast convergence of the truncated equations we have powerful computational tool for studies of the multi-conductor systems; there are no limitations on relative location of conductors and their closeness to the walls of the shield.

The developed algorithm is applied to calculate the characteristic impedance for various multi-conductor transmission lines.

This is joint work with G Safonova (Macquarie University).

Hugh Wolgamot, University of Western Australia

Rings of cylinders and motion trapping

Abstract Recent work has demonstrated that rings of 8 truncated cylinders heaving in phase can behave as a (very-)near-motion-trapping structure for certain geometries. The range of geometric parameters for which this occurs has not previously been investigated. However, it is known that annular shapes of rectangular cross-section are true motion-trapping structures (for appropriate parameter choices). This paper therefore investigates how the motion-trapping behaviour of rings of truncated cylinders is affected as additional cylinders are added, and the geometries are changed, using a semi-analytical potential flow approach. Ultimately the importance of symmetry and the relevance or other-

wise of the 'limit' of a solid ring are of interest.

Ying Wu, King Abdullah University of Science and Technology

Effective medium for periodic structures

Abstract In this talk, I will review our work on the homogenization schemes for periodic structures and their applications on metamaterials. I will focus on the coherent potential approximation and show how it can lead to a formula that can predict the effective medium parameters for metamaterials beyond the long wavelength limit, where resonance occurs. The formulae for different types of waves, such as electromagnetic, acoustic and elastic waves, and different geometries including isotropic and anisotropic structures will be presented. The applications of the effective medium theory on the design of emerging materials with intriguing properties, like negative refraction, zero-index and linear dispersion, will be demonstrated. I will also briefly talk about the effective medium theories based on multiple-scattering, field-averaging and Green's function methods, and discuss the pros and cons of them.

This is joint work with X Zhang (King Abdullah University of Science and Technology), Z Zhang, CT Chan and P Sheng (Hong Kong University of Technology), Y Lai (Soochow University), J Li (University of Birmingham) and J Mei (South China University of Technology).

Lucas Yiew, University of Adelaide

A theoretical and experimental model of wave-induced floe-floe collisions

Abstract Wave-induced mechanical interactions between ice floes are not yet included in contemporary large-scale sea ice models. We develop an idealised theoretical/numerical model to simulate non-rafting collisions between two ice floes, due to plane incident wave forcing. Slope-sliding theory is used to model the motions of floes. It contains three semi-empirical tuning coefficients for drag, added mass, and collision restitution (i.e. amount of energy conserved during a collision). These coefficients are tuned using data from laboratory wave basin experiments. In this talk, we will discuss the experimental methods used to validate the collision model. We will consider the effects of the three tuning coefficients on the collision behaviour. We will also identify the limits of slope-sliding theory, and discuss the next steps towards incorporating potential-flow theory into the model.

This is a joint work with LG Bennetts (University of Adelaide) and MH Meylan (University of Newcastle).

Stefan Zieger, Bureau of Meteorology

Forecasting sea state for north west WA in the tropical cyclone season

Abstract Wave forecasts for north west WA issued by the Bureau of Meteorology are largely limited to the resolution of the global (1/2 degree) and regional (12 km) operational wave model products. Because of this relatively coarse resolution these products are limited in accuracy during tropical cyclone (TC) season. Forecasting sea state is part of a project to improve tropical cyclone forecasting for north west WA, which focuses on the development of a sophisticated and highly accurate sea state forecast for the TC season. For this purpose a dedicated high-resolution grid was nested in the global domain. The new domain is forced with winds from a high-resolution atmospheric model that is able to represent the track, intensity and structure of a TC system. The performance of the system was tested globally with the next generation global atmospheric model and for a number of TCs that occurred in the 2014/15 season. Initial validation show improved results when compared to current products from the operational centre. Once in operation, the system will provide a forecast of sea state for north west WA twice-daily.

This is a joint work with J Kepert and D Greenslade (Bureau of Meteorology).

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Practical information

The conference will be held on the University of Adelaide's North Terrace campus. The next page shows a map of the campus with the conference locations indicated.

Welcome BBQ

A welcome BBQ will be held from 5pm to 8pm on Sunday 6th December in the Hub Eastern Courtyard. This green dot on the campus map indicates the courtyard. To find it, enter Hub Central and follow the signs.

Sessions

All sessions will be held in the Horace Lamb lecture theatre. The red dot on the map indicates the lecture theatre.

General meeting

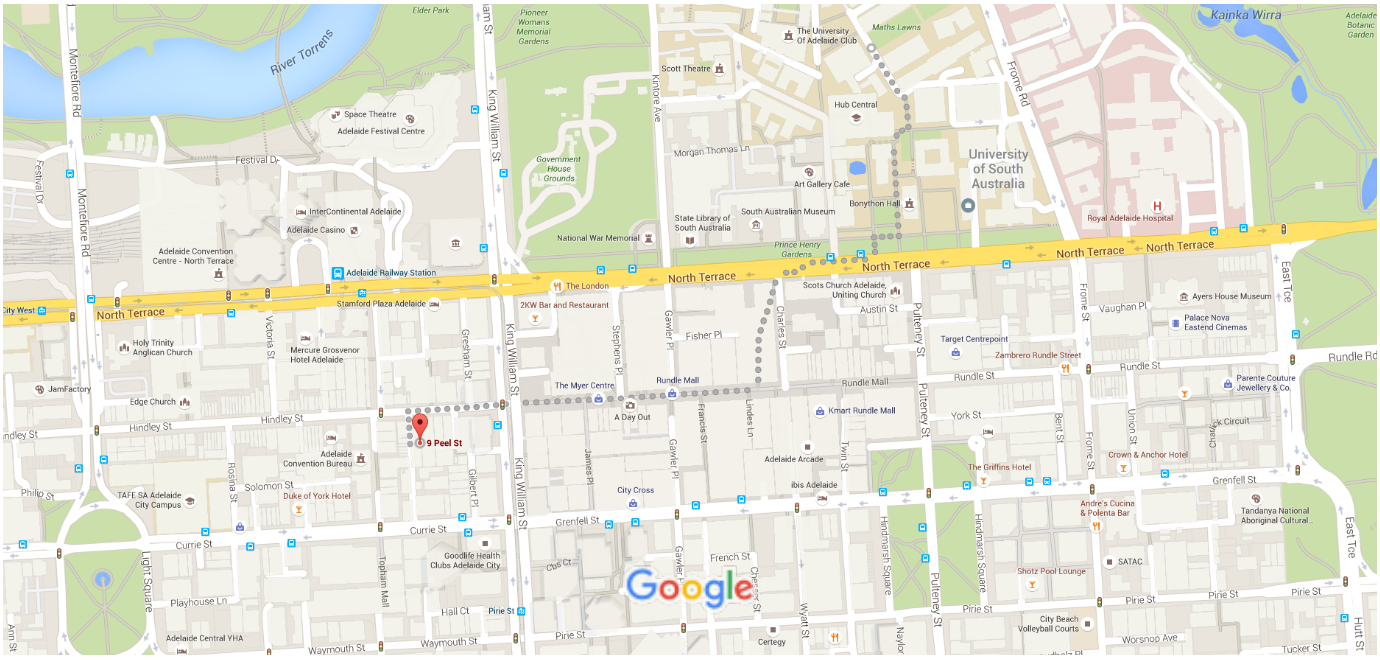
A general meeting will be held at 6pm on Monday 7th December in the level 7 conference room of the Ingkarni Wardli building. All those interested in the future of the conference are encouraged to attend. The yellow dot on the campus map indicates the Ingkarni Wardli building.

Coffee and lunches

Coffee and lunches will be provided in the Atrium between the Ingkarni Wardli and Engineering North buildings. Coffee will be available before the first session each day.

Conference dinner

The conference dinner will be held from 7pm on Tuesday 8th December at the Peel St restaurant, 9 Peel St, Adelaide CBD. The cost of the dinner is included in the registration. The restaurant is a 15 minute walk away from the conference venue. The map below shows directions from the conference venue to the restaurant.



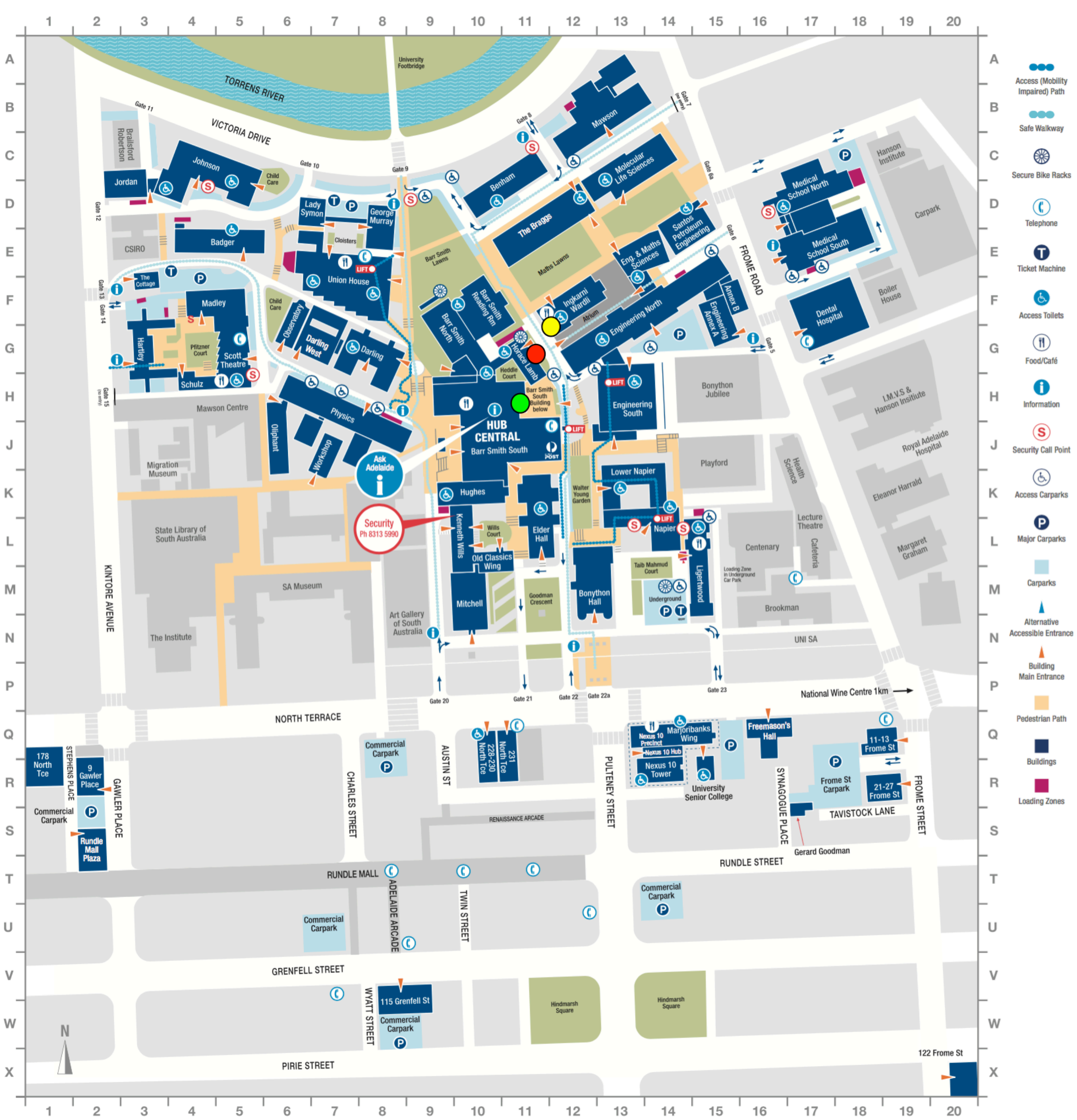
Map data ©2015 Google 200 ft

WiFi

Account: `KOZWaves` Password: `kozwaves2015`

For visitors to Adelaide with time to spare

Please see the Adelaide visitor guide.



THE UNIVERSITY of ADELAIDE

BUILDINGS	GRID
Badger	E5
Barr Smith Library	G10
Barr Smith South	J10
Benham	D10
Bonython Hall*	M12
Darling	G8
Darling West*	G7
Dental Hospital	F17
Elder Hall*	L11
Engineering Annex A**	G15
Engineering Annex B**	F15
Engineering & Math. Sciences	E13
Engineering North	G14
Engineering South	H13
Freemason's Hall	Q16
11-13 Frome Street**	Q19
21-27 Frome Street**	R19
122 Frome Street	X20
9 Gawler Place	R2
George Murray**	D8
Gerard Goodman*	S17
115 Grenfell Street	W8
Hartley	G3
Horace Lamb	G11
Hughes	K10
Ingkarni Wardli	F12
Johnson	C4
Jordan	D3
Kenneth Wills*	L10
Lady Symon*	D6
Ligertwood	M15
Lower Napier	K13
Madley*	F4
Marjoribanks Wing	Q14
Mawson*	B12
Medical School North	D17
Medical School South	E17
Mitchell**	M10
Molecular Life Sciences	C13
Napier	L14
Nexus10 Tower	R14
178 North Terrace (Terrace Towers)	R1
228-230 North Terrace	Q10
231 North Terrace* (Elizabeth House)	Q11
251 North Terrace (Carpark)	Q15
Observatory (Child Care Centre)*	G6
Old Classics Wing**	L10
Oliphant	J6
Physics	H7
Rundle Mall Plaza	S2
Santos Petroleum Engineering	E14
Schulz	H4
Scott Theatre	G5
The Braggs	D12
The Cottage**	F3
Union House	F7
University Senior College*	R15
Workshop*	J7

ACCESSIBLE INFORMATION

- * Partly accessible
- ** Not accessible

Access path from upper to lower levels of campus via lifts:
East path - Use Napier to Lower Napier to Engineering South lifts
Central path - Use external glass campus lift behind Hub Central
West path - Use Union House lift to and from Level 4

Note: An electric wheelchair battery charging point is available at Security (Kenneth Wills)

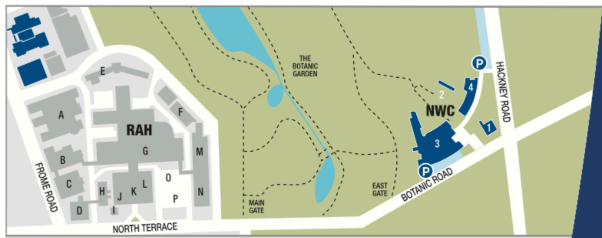
GENERAL FACILITIES	GRID	
Accommodation Services	F7	Union House, L4
Ask Adelaide (Information)	J10	Hub Central, L4
Bank ATMs	F8	Union House, G
	J10	Hub Central
	H11	Barr Smith South, L4
Bookshop (Unibooks)	F8	Union House, L1
Chapel	D6	Lady Symon, B
Child Care Centre - Toddlers	G6	Observatory
Child Care Centre - Kindergarten	D5	Johnson, G
Counselling & Disability Service	G11	Horace Lamb, G
General Store	J11	Barr Smith South, L1
Hub Central	J10	Barr Smith South, L3 & 4
International Student Centre	L10	Old Classics, L5
Library (Barr Smith)	G10	Over Bridge
Office for Future Students	K10	Hughes Building, L6
Post Office	K11	Hub Central, L4
Prayer Room (Muslim)	F8	Union House, L6
	Q11	231 North Tce, G
Student Centre - Ph 8313 5208	L10	Kenneth Wills, L4
Student Travel Association (STA)	F8	Union House, L4
Students' Association (SAUA)	F8	Union House, L1
University Health	H11	Barr Smith South, L1

EATING PLACES		
Aroma Café	F11	Ingkarni Wardli, G
Grass Roots on Stage	H3	Schulz, G
Hub Central - Grass Roots	J10	Barr Smith Sth, L4
- Taste Baguette		
- Penang Hawkers		
Pulteney Street Café	Q13	Marjoribanks, G
Mayo Café (Grass Roots)	F7	Union House, G
Uni Bar	F7	Union House, L5
University Club	F7	Union House, L4

OPEN SPACES	
Barr Smith Lawns	E9
Goodman Crescent	M11
Heddle Court	H11
Maths Lawns	E12
Pfitzner Court	G4
Taib Mahmud Court	M13
Walter Young Garden	K12
Wills Court	L10

PARKING ON CAMPUS

Weekdays 8:00am to 4:30pm - permit only.
After hours 4:30pm to 8:00am and weekends within white lined areas only - by purchase of ticket from machine.



KEY FOR ROYAL ADELAIDE HOSPITAL INSET

- A IMVS/Hanson Centre
- B Eleanor Harrald
- C Margaret Graham
- D Women's Health Centre
- E Residential Wing
- F North Wing (QRS)
- G Emergency Block
- H Allied Health
- I Sheridan
- J McEwin
- K Main Entrance
- L Bice
- M East Wing
- N East/Services Wings Link
- O Staff Car Park
- P Visitors Car Park

NATIONAL WINE CENTRE

1. Yarrabee House
2. The Stables
3. The National Wine Centre
4. Industry House