KOZWaves

Kiwi-Oz Waves Conference

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KOZWaves Conference

Newcastle, New South Wales
16–19 February 2014

Aust MS Australian Mathematical Society Inc.

CARMA

AMSI Australian Mathematical Sciences Institute

The University of Sydney

The University of Newcastle Australia

Contents

The editors have made minor typographical changes only to the submitted abstracts. The opinions, findings, conclusions and recommendations in this book are those of the individual authors.

Edited by Mike Meylan and Luke Bennetts

KOZWaves logo by `benpics.com`

1 Welcome

Welcome to the first international Australasian conference on wave science, KOZWaves, and welcome to Newcastle. We hope you enjoy your time here and that your schedule and the weather allows you to enjoy our wonderful beaches.

It is our pleasure to thank everyone that has helped ensure the success of this first KOZWaves conference, including the organising committee, our invited speakers, and those that have contributed abstracts and presentations. We realise that many of you have made long journeys to support this meeting.

It is an equal pleasure to thank the local Newcastle team, Juliane Turner and David Allingham, for the hard work they have put into helping to us organise KOZWaves.

Finally, we would like to thank the sponsors, without whose support we would have had a much less successful meeting.

We know from experience that informal interactions play and im-portant role in the success of any scientific meeting, and we hope that we all get a change to make new connections and strengthen old ones during our time here in Newcastle.

Mike Meylan and Luke Bennetts

Acknowledgements

The Organising Committee gratefully acknowledges the financial support of the School of Mathematical and Physical Sciences at the University of Newcastle, the Priority Research Centre for Computer-Assisted Research Mathematics and its Applications at the University of Newcastle, the office of the DVC (Research) at the University of Newcastle, the Australian Mathematical Sciences Institute, the Australian Mathematical Society, and the University of Sydney

Conference Dinner

The conference dinner will be held at Noah's on the Beach on Tuesday 18th February, with pre-dinner inks and canapés from 7.00pm with dinner starting at 7.30pm. The cost of the dinner and inks is included in your registration.

Morning and Afternoon Teas and Lunches

Morning and afternoon tea and lunch will be available at the venue. All refreshments are included in the registration fee.

WiFi

The wifi is through Ipera Communications. The username is Kozwaves and the password is Kozwaves14

Cover Photo

The cover photo was taken by Corbyn Bisschops at Newcastle Beach.

2 Timetable

Monday 17th February

8:00 am	Conference Registration
8:30 am	Conference Opening
Chair	Kohout
8:45 am	**Alexander Babanin** Third generation wave models based on observational physics [Page 9]
9:35 am	**Russel Morison** Incorporating breaking wave predictions in spectral ocean wave forecast models [Page 16]
10:00 am	**Bill Peirson** On the influence of small scale waves and microscale breaking on re-aeration of wind-forced water surfaces [Page 18]
10:25 am	Morning Tea
Chairperson:	Manasseh
10:50 am	**Alberto Alberello** Wave kinematics of random directional waves [Page 8]
11:15 am	**Michael Allis** Dynamic patterns and spatial characteristics of 3D deep water whitecaps [Page 8]
11:40 am	**Peter Hardy** Threshold latching of an oscillating water column [Page 12]
12:05 pm	**Ravina Pethiyagoda** Linear and nonlinear Kelvin ship waves: what's the angle? [Page 19]
12:30 pm	Lunch
Chair	Pierson
1:15 pm	**Richard Manasseh** Contained inertia waves and their nonlinear transitions [Page 14]
1:40 pm	**Neal Moodie** Practical applications of wave model output for the marine community [Page 16]
2:05 pm	**Aihong Zhong** Operational wave model in the Bureau of Meteorology [Page 23]
2:30 pm	**Arvin Saket** Evaluation of ECMWF wind data for wave hindcast in Chabahar Zone [Page 20]
2:55 pm	Afternoon Tea
Chair	Meylan
3:20 pm	**Benjamin French** Motions of a scale model ice floe in regular waves [Page 11]
3:45 pm	**Alison Kohout** The impact of Southern Ocean storms on sea ice [Page 13]
4:10 pm	**Vernon Squire** Why ocean waves propagating in ice-covered seas have suddenly become fashionable [Page 21]

Tuesday 18th February

Chair	Bennetts
8:30 am	**Paul Martin** N masses on a string [Page 14]
9:20 am	**Fabien Montiel** Propagation of a directional wave spectrum through random arrays of scatterers [Page 15]
9:45 am	**Malte Peter** Spectral analysis of wave propagation through disordered multiple-row arrays of scatterers [Page 18]
10:10 am	Morning Tea
Chair	Montiel
10:50 am	**Anne-Sophie Bonnet-Ben Dhia** Mathematical contributions to the modelling of sign-changing index materials [Page 10]
11:40 am	**Mike Smith** Spectrum shifting and lifting in photonic crystals with negative-index materials [Page 20]
12:05 pm	**Camille Carvalho** Revealing guided modes in a plasmonic waveguide using perfectly matched layers at the corners [Page 11]
12:30 pm	Lunch
Chair	Chung
1:15 pm	**Vincent Pagneux** Effect of symmetry defect on the edge resonance in elastic plate [Page 17]
2:05 pm	**Richard Manasseh** The self-consistent model for multiple scattering applied to bubble acoustics [Page 13]
2:30 pm	**Xavier Barthelemy** Highly non-linear unsteady surface waves properties: kinematics and slowdown [Page 9]
2:55 pm	Afternoon Tea
Chair	Peter
3:20 pm	**Hyuck Chung** Attenuation of ocean waves due to random perturbations in the seabed profile [Page 11]
3:45 pm	**Sebastian Rupprecht** Modulation of water waves by a rough floating thin elastic plate [Page 19]
4:10 pm	**Kenneth Golden** Homogenization for sea ice [Page 12]
7:00 pm	Conference Dinner

Wednesday 19th February

Chair	McPhedran
8:30 am	**Natasha Movchan** Modelling of the dynamic response of structured solids: localisation and transmission resonances [Page 17]
9:20 am	**Duncan Joyce** An integral equation method of homogenization [Page 12]
9:45 am	**Ruth Voisey** Infinite periodic approximant structures as representations of quasiperiodic structures in acoustic multiple scattering [Page 22]
10:10 am	**Chris Poulton** Stimulated Brillouin scattering: harnessing the interaction between sound and light in nanophotonics [Page 19]
10:35 am	Morning Tea
Chair	Smith
11:00 am	**Graeme Milton** The searchlight effect in hyperbolic media [Page 15]
11:50 am	**Christian Wolff** Numerical treatment of spontaneous emission from finite photonic crystals [Page 22]
12:15 pm	**Victoria Andrew** Acoustic wave scattering from doubly periodic arrays and the efficient evaluation of the 3D doubly periodic Green's function [Page 9]
12:40 pm	Lunch
Chair	Poulton
1:20 pm	**Tom Shearer** Antiplane elastic wave cloaking using metamaterials, homogenization and hyperelasticity [Page 20]
1:45 pm	**Simon Marmorat** Time domain computation of the scattering of waves by small heterogeneities [Page 14]
2:10 pm	**Lindsay Botten** Semi-analytic methods for modelling 2D and 3D photonic and metamaterial structures [Page 10]
3:00 pm	Conference Closing

3 Abstracts

Wave kinematics of random directional waves

Alberto Alberello, A. Chabchoub, M. Onorato, A. Babanin, A. Toffoli
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10:50 am Monday

The inclusion of at least the second order effects is considered necessary to obtain an accurately representation of ocean waves. While this is true for the surface elevation, very little is known concerning the velocity potential and hence the kinematics of the wave field. Here we attempt to investigate the role of second and higher order nonlinearity on the velocity. Particular emphasis is given to the effect of the wave directional spreading on nonlinear wave-wave interaction. The second order, which represents the most obvious effect of nonlinearity in the ocean, have been computed with a perturbation method. An Higher Order Spectral Method (HOSM), which takes into account nonlinear wave dynamics and hence modulational instability processes that are regarded as being responsible for the generation of extreme waves is used to compute both water elevation and velocity potential too. Different initial random directional seas have been considered and Monte Carlo simulations have been performed to study the statistical properties of wave kinematics. Results show that the statistical properties of the wave kinematics is significantly affected by the wave directional spreading. Departure of the tail of the probability distribution from Gaussian statistics already starts at second order and are further amplified by higher order nonlinear effects. The increase of the orbital velocity under a trough is mainly an effect of the second order contribution, the growth of the crest velocity is mainly due to a third order effect. Nevertheless the directionality of the wave field, together with the water depth, can strongly affect the relative importance of second, third and higher order contribution on the wave kinematic.

Dynamic patterns and spatial characteristics of 3D deep water whitecaps

Michael Allis, M. Allis, W. Peirson, M. Banner
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11:15 am Monday

The breaking and overturning of ocean waves is the primary mechanism for the transfer of gas, energy, water vapour and momentum between the ocean and the atmosphere (Melville, Ann Rev Fluid Mech, 28, 1996). Ocean wave breaking is characteristically 3D as waves are driven from all directions by prevailing winds and break with complex behaviours and patterns.

We present laboratory measurements of characteristic patterns and spatial dimensions of whitecaps breaking under the influence of controlled convergent directional forcing. Within the complex breaking patterns, several interesting observations are made.

- The scales of wave breaking demonstrate that breaking width and swept area show a strong dependence on directional convergence while the average swept length of individual breakers has a weaker dependence.
- For the range of conditions tested, the imposed wave directionality does not initiate or change the number of breaking events in multiple-break sequences.
- The directionally forced wave groups exhibiting laterally oscillating crescentic breaking lobes (as per Su, JFM, 124, 1982). A length scale approximately 0.9 characteristic wavelengths was observed across all tests for oscillating lobe separation, with this length scale showing some dependence on imposed directionality and distance from breaking onset.

It is anticipated these results will benefit the parameterisation of breaking wave characteristics for future modelling applications.

Acoustic wave scattering from doubly periodic arrays and the efficient evaluation of the 3D doubly periodic Green's function

Victoria Andrew
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12:15 pm Wednesday

Reflection and transmission of a plane acoustic wave by a doubly periodic array of non-spherical, axisymmetric, sound-hard scatterers is considered. We investigate the particular case where the characteristic length scale of the scatter, a, is of the same order as the wave length of the incoming wave. The centre of the scatterers is located in a single plane, (x_1, x_2), at positions $x_1 = am$, $x_2 = bn$. The governing differential equation is expressed as a boundary integral equation, which, by taking advantage of the geometrical periodicity, can be reduced to an integral equation over a single scatterer, where the kernel is a doubly periodic Green's function. We exploit the axisymmetry of the scatterers to reduce the governing integral equation over the surface of the scatterer to an integral over a generating cross-sectional shape. We derive a coupled system of equations for each Fourier mode of the boundary pressure.

The main focus of this talk is the efficient evaluation of the doubly periodic Green's function. We show the convergence rate of the double sum over an elliptical region, and calculate the first order correction term by treating the double sum as a double integral in the region exterior to the ellipse. We quantify the effectiveness of this method by showing the absolute value of the periodic Green's function with and without the correction term.

Third generation wave models based on observational physics

Alexander Babanin, I. Young, W. Rogers, S. Zieger
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8:45 am Monday

Major update of the physics of the third generation models will be presented. The new source terms for wind input, white-capping dissipation, interaction of waves with adverse winds (negative input) and swell attenuation have been developed and implemented in WAVEWATCH-III and SWAN models. Physics and parameterisations for the new source functions are based on observations, which allowed us to reveal features and processes previously unknown and not accounted for in the default, largely speculative physics. The new versions of the models have undergone extensive testing by means of academic tests, regional and global wave hindcast, tropical cyclone modelling.

Highly non-linear unsteady surface waves properties: kinematics and slowdown

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2:30 pm Tuesday

Waves research has been undertaken for many decades in order to understand wave properties. In most of these studies, the assumption of steadiness has been made. This communication will review what happens to the generic behaviour when the hypothesis of steadiness is relaxed. A 3D numerical wave tank was used to simulate 2D and 3D wave groups generated by a wave paddle. A particular focus is taken on the kinematics of unsteady highly nonlinear wave groups. The notion of wave celerity is revisited, and even if the zero-crossing speed is roughly close to the linear prediction, crests and troughs locally undertake a leaning cycle going from forward to backward, resulting in a crests and troughs slowdown around some 10% to 20% of the linear velocity in some cases, in sharp contrast to the predictions of Stokes steady wavetrain theory. Our findings are validated in extensive laboratory and field observations. This behaviour appears to be generic to unsteady dispersive wave groups in other natural systems.

Mathematical contributions to the modelling of sign-changing index materials

Anne-Sophie Bonnet-Ben Dhia
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10:50 am Tuesday

In the last decade, a great interest has been devoted by physicists to negative index materials for their extraordinary properties. In particular, negative refraction phenomenon or existence of plasmonic surface waves occur when a negative index material is juxtaposed with a positive index material. The numerical simulation of such devices requires the resolution of Maxwell's equations with sign-changing dielectric permittivity and/or magnetic permeability. This raises unusual questions concerning the mathematical study of such models and the design of adapted methods for their approximation. Besides, interesting physical phenomena are hidden behind these theoretical difficulties. As an example, concerning the time-harmonic problem, we proved that usual results (well-posedness in standard energy spaces and stability of finite elements) can fail if the surface of the negative index material has geometrical singularities (like edges and corners). This is due to the presence of plasmonic black-hole waves which are seemingly absorbed by the corners. Taking into account this phenomenon requires new mathematical and numerical tools that we have developed and validated. This study and other mathematical contributions to the understanding of sign-changing index materials will be presented during my talk.

Semi-analytic methods for modelling 2D and 3D photonic and metamaterial structures

Lindsay Botten, K. Dossou, C. Poulton, F. Lawrence, B. Sturmberg, R. McPheadrn, M. de Sterke
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2:10 pm Wednesday

The most commonly used tools for modelling (periodic) photonic and metamaterial structures are the finite-difference time domain (FDTD) method and the finite element method (FEM). These purely numerical techniques, while important as general-purpose simulation workhorses, provide little physical or theoretical insight into the underlying scattering processes. In contrast, semi-analytical methods, afford a deeper understanding of these phenomena, and through this the ability to tailor/optimise device performance.

At the heart of such methods lies the representation of fields in the Bloch-mode basis of the structure, with the calculation of this basis via computational methods such as the FEM or the multiple method. From here, the scattering properties of a layered structure are elucidated through the calculation of reflection and transmission matrices, with the most fundamental of these being the interface Fresnel matrices, the calculation of which is undertaken in a least squares manner exploiting modal orthogonality. From here, it is a short step to the characterisation of a rigorous photonic impedance for the structure.

The talk will describe the theory and demonstrate its applicability with a range of applications including anti-reflection coatings for photonic crystals, the optimisation of silicon nanowire arrays for photovoltaic applications, and impedance modelling of 3D metamaterial devices.

Revealing guided modes in a plasmonic waveguide using Perfectly Matched Layers at the corners

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12:05 pm Tuesday

We consider a cylindrical waveguide of axis z made of a dielectric material with a cylindrical metal inclusion. We assume that, in a given frequency range, the metal's permittivity $\epsilon = \epsilon(\omega)$ is a negative real number. We consider the time-harmonic scalar model for Maxwell's equations. By looking for the guided modes $u(x, y, z) = \widetilde{u}(x, y)e^{i\beta z}$, $\beta \in \mathbb{R}$, we study first the linearized eigenvalue problem (dependence in ω of ϵ frozen): $A(\beta)\widetilde{u} = \omega^2\widetilde{u}$. For a chosen β, under some conditions on ϵ and the geometry, the operator $A(\beta)$ is self-adjoint with a discrete spectrum. Besides for a metal inclusion with corners, these properties can be no longer true due to singular phenomena occurring at the corners called black-hole waves. Consequently the eigenvalues are embedded in a continuous spectrum filling all the complex plane. Then a new functional framework and a specific numerical treatment at the corners are required: these tools allow us to recover a discrete spectrum revealing the real eigenvalues.

Attenuation of ocean waves due to random perturbations in the seabed profile

Hyuck Chung, L. Bennetts, M. Peter
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3:20 pm Tuesday

We employ linear wave theory to study long range attenuation of ocean waves caused by small, random perturbations in the seabed. The phenomenon in an example of localization in random media. A multiple-scale method is used, in which the solution is expanded over a local scale, on the order of the perturbations, and an observation scale. However, it is not clear how the properties of the random seabed profile, such as probability density, autocorrelation and spectral density, affect the expansion directly or indirectly. We will discuss how the solutions can be obtained numerically so that the effects of each instance of random seabed on the solution can be studied.

Motions of a scale model ice floe in regular waves.

Benjamin French, M. Meylan, L. Bennetts, L. Yiew, G. Thomas
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3:20 pm Monday

During July 2013, preliminary scale model experiments were undertaken at the Australian Maritime College in order to investigate the motions of scale model ice floes in regular waves. These tests were carried out with the strategic aim to conduct a further two experimental campaigns at the Australian Maritime College.

Two different ice floe models were constructed, one with a polystyrene edge barrier and one without. Both were constructed from closed-cell expanded PVC rigid sheets. The models were loosely tethered to the floor of the Model Test Basin with an elastic band and motions of the floes were measured by the Qualysis motion tracking system through a series of infrared cameras. The Model Test Basin was found to be suitable for modelling the motions of a 1:100 scale ice floe model over a range of frequencies (0.5 to 1.5 Hz model scale) and wave heights (20 to 80 mm model scale). The results of the tests presented here will be used to validate numerical models predicting ice floe motions in regular waves and also to aid in the design of an experimental setup to measure ice floe collisions at the Australian Maritime College.

Homogenization for Sea Ice

Kenneth Golden
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4:10 pm Tuesday

Sea ice is a multiscale composite, which is structured on length scales ranging from tenths of millimeters to tens of kilometers. 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. Theories of homogenization for composites can provide a rigorous framework for this important application as well as for treating sea ice over a range of scales. Here I will discuss some recent work on using techniques from homogenization and statistical physics for studying sea ice.

Threshold latching of an oscillating water column

Peter Hardy, B. Cazzolato, Z. Prime
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11:40 am Monday

This article will investigate latching of an oscillating water column (OWC) wave energy converter with variable geometry power take-off. Threshold latching strategies will be investigated, where the power take-off will remain latched until the pressure difference between the air in the OWC chamber and atmospheric reaches a set threshold. Two threshold latching strategies will be considered; one which attempts to improve the phase between the exciting force and water column velocity, and one which attempts to maintain a constant pressure difference across the turbine. Both strategies will be simulated over a range of power take-off geometries and threshold pressures to determine optimal capture width.

An integral equation method of homogenization

Duncan Joyce, W. Parnell, I. Abrahams.
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9:20 am Wednesday

Fibre reinforced composites (FRCs) are currently used in a multitude of applications in science, technology and industry as well as having potential in the context of metamaterials. Many techniques have been developed in an attempt to model their effective quasi-static properties on the macroscale from knowledge of the microstructure. Often the fibres can be assumed to be periodic and the methods of asymptotic homogenization (MAH), computational homogenization or equivalent eigenstrain are utilized. Such methods rely on computational evaluation of certain aspects of the problem (e.g. the cell problem in MAH).

In this talk, an alternative method shall be introduced, based on an integral equation formulation of Navier's equations in the context of antiplane shear (for ease of illustration) for low frequency wave propagation. The asymptotic scheme developed enables the derivation of new explicit analytical formulae, valid at arbitrary volume fraction, for the effective shear moduli in terms of parameters linked to specific physical phenomena (cross-sectional shape, phase properties, lattice type, etc.) thus providing greater insight than many extant methods.

It appears that the scheme is straightforwardly extended to higher dimensions in elasticity, the general transport problem and in some limits, the full elastodynamic problem to predict the onset of band-gaps.

The impact of Southern Ocean storms on sea ice

Alison Kohout, M. Williams, M. Meylan, S. Dean
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3:45 pm Monday

Ocean wave induced breakup of sea ice is a positive feedback process driving sea ice retreat, with waves breaking the sea ice increasing wave penetration away from the ice edge. Here we present new measurements of wave propagation through Antarctic sea ice. These show that large ocean waves, those with a significant wave height greater than 3 m, transport proportionally more energy than smaller waves. Large waves are able to penetrate hundreds of kilometers into the pack ice, further than was previously predicted by accepted theory, which presumed the energy from waves decayed exponentially in sea ice. Our observations show the energy decay to be exponential only for small waves and linear for large waves. This implies a more prominent role for ocean waves in sea ice breakup and retreat than previously thought. We test this by comparing observed Antarctic sea ice edge positions with changes in modelled Southern Ocean significant wave height between 1997 and 2009, and find the sea ice edge retreat (expansion) correlates with mean significant wave height increases (decreases). Our results highlight that with models failing to capture changes in sea ice in both polar regions, the absence of either explicit or parameterized ocean-sea ice interaction models may be a significant omission.

The self-consistent model for multiple scattering applied to bubble acoustics

Richard Manasseh
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2:05 pm Tuesday

Bubbles are natural oscillators owing to the compressibility of gas providing stiffness, and the surrounding liquid providing mass. The Euler equations of fluid motion can be reduced to nonlinear and linear oscillator equations quantifying this physics. The vibrations of bubbles millimetres in size, formed in oceanic and industrial flows, are in the audible range, while bubbles microns in size vibrate in the medical ultrasound range.

Multiple scattering when several bubbles are close is known to create shifts in bubble sound emission frequencies and response spectra. The self-consistent approach employs an unphysical dependent variable that is defined to represent the dynamics after the infinity of scattering interactions have occurred. It permits good prediction of some experimental data when bubbles are closely spaced, so that there is negligible delay in sound propagation between bubbles.

When bubble-acoustic interactions occur over a significant fraction of a wavelength, self-consistent theory needs to be modified to account for a finite sound speed. Collective wavelike behaviour of inhomogeneously-distributed groups of bubbles has been observed experimentally. Numerical results with a finite sound speed show a reasonable similarity to experiments. However, key features such as the observed wave speed remain difficult to predict analytically.

Contained inertia waves and their nonlinear transitions

Richard Manasseh, H. Blackburn, J. Lopez, P. Meunier, T. Albrecht
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1:15 pm Monday

A fluid-filled container in solid-body rotation is a system admitting inertia waves. These exist owing to the restoring effect of the Coriolis force. According to linear inviscid theory, eigensolutions can be found for simple container geometries such as cylinders. However, when such systems are forced in experiments, for example by precessing the container, a rich variety of phenomena appear, including catastrophic transitions to turbulence. Theory and experiments on this system are reviewed. The competing paradigms of weakly-nonlinear mode interactions and shear-layer instabilities are discussed. A new project intended to investigate the catastrophic transitions is introduced. The system has a number of engineering applications, including the stability of spinning spacecraft; and geophysical applications, such as the generation of the magnetic field of the Earth and flows inside stars and other astrophysical bodies.

Time domain computation of the scattering of waves by small heterogeneities

Simon Marmorat, X. Claeys, P. Joly
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Institut National de Recherche en Informatique et en Automatique, France
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1:45 pm Wednesday

This research is developed in the context of the numerical modelling of non-destructive testing experiments by ultrasounds. Some slowly varying background media may be disturbed by small heterogeneities presenting a strong contrast of physical parameters (for instance gravels inside concrete). Simulating the propagation of waves inside such medium is challenging for classical numerical tools, due to the small size of the heterogeneities. To reduce complexity and computational cost, we aim at proposing an approximate model 'easier' to solve than the original one, based on an asymptotic analysis of the problem. Some 1D and 2D numerical results will be be provided.

N masses on a string

Paul Martin
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8:30 am Tuesday

We consider problems of time-harmonic scalar waves interacting with N scatterers: they could be beads on a long string, for example. If the scatterers are identical and equally spaced, we obtain a problem that can be solved exactly. This is true when N is finite or infinite. Our interest is with disordered problems, where a periodic configuration is disturbed. For example, we could change just one scatterer in a finite periodic row. It turns out that this problem can be solved exactly. Similar problems where every scatterer in the row is disturbed are also discussed. The main tools used are perturbation theory and transfer matrices. The main motivation comes from a desire to understand the competition between wave propagation in almost-periodic structures and localization phenomena in random media.

The searchlight effect in hyperbolic media

Graeme Milton, R. McPhedran, A. Sihvola
Department of Mathematics
University of Utah, U.S.A.
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11:00 am Wednesday

Hyperbolic media in which the dielectric tensor has both positive and negative eigenvalues have been shown to defeat the diffraction limit, and allow features at very small wavelengths to be resolved as demonstrated through hyperlenses. Even in quasistatics the underlying equation resembles a wave equation. Whereas in a circular hole in a dielectric media has a simple dipolar field around it, we will see that a circular hole in an almost lossless hyperbolic media, has surrounding quasistatic fields which diverge along characteristic lines tangent to the hole, and which have finite total energy absorption along these lines, even as the loss in the media tends to zero. In a hyperbolic medium a dipole with small polarizability can dramatically influence the dipole moment of a distant polarizable dipole, if it is appropriately placed. We call this the searchlight effect, as the enhancement depends on the orientation of the line joining the polarizable dipoles and can be varied by changing the frequency. For some particular polarizabilities the enhancement can actually increase the further the polarizable dipoles are apart, like the way quarks interact more strongly the further they are apart.

Propagation of a directional wave spectrum through random arrays of scatterers

Fabien Montiel, V. Squire, L. Bennetts
Department of Mathematics and Statistics
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9:20 am Tuesday

A new method is proposed to simulate the propagation of a directional wave spectrum in a planar domain through an array of O(1000) scatterers. Our model consists of a harmonic potential planar field governed by the Helmholtz equation and a finite arbitrary array of sound-hard circular obstructions. We force the system with a plane wave defined by its frequency and angular spreading function. Our method requires that we subdivide the region of scatterers into adjacent infinite strips and solve the multiple scattering problem within each strip using the standard self-consistent method. Invoking the plane wave representation of the outgoing cylindrical wavefunctions, we are able to project the scattered circular wave components onto each strip boundaries as reflected and transmitted directional wave spectra. Discretising the angular range yields a numerical solution in the form of a scattering matrix associated with each slab. The solution for the full array of scatterers is then obtained using a recursive technique for multiple-row interactions.

The method offers an efficient deterministic framework to analyse plane wave propagation in very large random arrays of scatterers. In particular, we can track the attenuation of the wave energy and the widening of the angular spread, and use ensemble averaging to characterise the wave propagation properties of a complex medium. A relevant set of results will be presented to emphasise the efficiency of the method, and an example will be given that involves ocean waves travelling in the marginal ice zone, the medium for which the method was first conceived.

Practical applications of wave model output for the marine community

Neal Moodie, J. Evans
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1:40 pm Monday

The Bureau of Meteorology is Australia's national agency responsible for warning mariners and the community of dangerous or damaging waves affecting people and structures along the Australian coastline. As a new forecasting system is rolled out around the country, meteorologists at the Bureau are now able to graphically manipulate the gridded output from the wave models to provide text and map based marine services.

The Bureau's new approach provides wave forecasts for Australia's coastline on a six kilometre grid spacing rather than the usual 12 or 40 kilometres available from wave models. Forecasters can use specially designed grid-editing tools to add local scale features that wave models may , such as bays protected from the prevailing swell and refraction around geographic features and islands. The system can be programmed to highlight when forecast conditions are expected to exceed specific thresholds.

The Bureau's warning services to the community rely on wave modelling capabilities that range in scale from the open ocean down to the littoral zone. This complex information is translated into simple general messages for the community to act upon.

One of the priority areas of the Bureau's Marine Strategy is warnings for coastal and ocean hazards including storm surge inundation, rip currents and coastal erosion. The Bureau is currently consulting with stakeholders to identify thresholds, future demand for services and the associated challenges for wave modelling systems.

Incorporating breaking wave predictions in spectral ocean wave forecast models

M. Banner, **Russel Morison**
Mathematics / Science
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9:35 am Monday

Breaking of the dominant wind sea in strongly forced conditions increases the loadings and hazards for offshore operations. Reliable forecasts of the onset and severity of such conditions could provide useful forewarnings. However, the highly nonlinear nature of breaking in physical space presents substantial challenges for modelling the effects of breaking waves in current third generation spectral wind wave forecast models.

In this context, we report on recent progress in this direction using using our modelling framework for representing wave breaking in WaveWatch III. spectral breaking wave measurements are described briefly. We then present a detailed discussion of the predicted behaviour of these breaking wave properties over a wide range of wind forcing out to hurricane speeds and their impact on the wave field evolution. Also included in the presentation is a comparison of these forecast properties with data for the few data sets presently available.

Modelling of the dynamic response of structured solids: localisation and transmission resonances

Natasha Movchan
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8:30 am Wednesday

The talk presents analytical models of wave propagation in structured elastic solids. The emphasis is on localised dynamic modes associated with the presence of finite defects, as well as special dynamic features linked to the dispersion of elastic waves in periodic systems. Dynamic anisotropy is analysed for Bloch waves in periodic elastic lattices. A special class of star-shaped waveforms is discussed in connection with saddle points on the dispersion surfaces. This feature is also connected with the regimes that show negative refraction in transmission problems. Properties of Bloch waves are shown to be invaluable in the analysis of the dynamic response of elongated elastic systems like bridges and tall buildings. The spectral analysis of sophisticated finite systems becomes more transparent with the approximations based on the dispersion properties of Bloch waves existing in the corresponding periodic structures of infinite extent. Finally, flexural waves are considered in constrained elastic plates. Localisation is shown to be connected with special resonance transmission regimes. A novel phenomenon of Elasto-Dynamically Inhibited Transmission (EDIT) is identified and studied in detail. Analytical findings are accompanied by numerical simulations with applications in physics and continuum mechanics.

Effect of symmetry defect on the edge resonance in elastic plate.

Vincent Pagneux
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1:15 pm Tuesday

Lamb modes are propagation modes in a thick elastic plate. When the plate is semi-infinite, with a stress free edge, there exists a particular resonant behaviour, often called edge resonance. It occurs for 2D cases (plane strain and plane stress) but also for circular cylinder and around hole in 3D plate. The edge resonance is associated with symmetric Lamb modes (S_0, S_1, ...) and corresponds to a localized vibration of the free edge. The antisymmetric Lamb waves (modes A_0, A_1, ...) are not coupled to this resonance. In this study we consider the effect of symmetry defect on the property of the edge resonance. The defect induces a coupling between symmetric and anti-symmetric Lamb waves and it introduces a mixing of resonant and non-resonant characters (Fano resonance) of the reflection at the edge. The work will be focused on the different conversions of symmetric and anti-symmetric waves due to the coupling close to the Fano resonance.

On the influence of small scale waves and microscale breaking on re-aeration of wind-forced water surfaces

Bill Peirson, J. Walker and M. Banner
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10:00 am Monday

A detailed laboratory investigation of the mechanical and low solubility gas coupling mechanisms between wind and water has been undertaken using a suite of microphysical measurement techniques. Under a variety of wind conditions and in the presence and absence of mechanically-generated short waves, approximately fetch-independent surface conditions have been achieved over short laboratory fetches of several metres. The mechanical coupling of the surface is found to be consistent with Banner (1990) and Banner and Peirson (1998). Bulk observations of re-aeration are consistent with previous laboratory studies. The surface kinematical behaviour is in accordance with the observations of Peirson and Banner (2003). Also, their predictions of a strong enhancement of low solubility gas flux at the onset of microscale breaking is confirmed and direct observations show a concomitant onset of very thin aqueous diffusion sublayers. It is found that the development of strong parasitic capillary waves towards the incipient breaking limit does not noticeably enhance constituent transfer. Across the broad range of conditions investigated during this study, the local instantaneous constituent transfer rate remains approximately log-normally distributed with an approximately constant standard deviation of 0.62 ± 0.15(loge(ms-1)). Although wind-forced water surfaces are shown to be punctuated by intense tangential stresses and local surface convergence, localised surface convergence does not appear to be the single critical factor determining exchange rate. Larger-scale orbital wave straining is found to be a significant constituent transfer process in contrast to Witting (1971) findings for heat fluxes, but the measured effects are consistent with his model. By comparing transfer rates in the presence and absence of microscale breaking, low solubility gas transfer was decomposed into its turbulent/capillary ripple, gravity wave-related and microscale breaking contributions. It was found that an efficiency factor of approximately 17% needs to be applied to Peirson and Banner model, which is extended to field conditions. Although bulk thermal effects were observed and thermal diffusion layers are presumed thicker than their mass diffusion counterparts, significant thermal influences were not observed in the results.

References

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Spectral analysis of wave propagation through disordered multiple-row arrays of scatterers

Malte Peter, L. Bennetts
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University of Augsburg, Germany
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9:45 am Tuesday

Two different approaches are considered to determine the modal spectra of waves supported by multiple-row arrays of scatterers, which are randomly disordered around an underlying periodic configuration. One approach is based on localization theory, and the other is based on effective media theory. The approaches are implemented using random sampling. A form of the coherent potential approximation is also devised. Numerical comparisons are presented for the canonical problem of arrays of identical small acoustically soft circular cylinders and disorder in the location of the rows.

Linear and nonlinear Kelvin ship waves: whats the angle?

Ravina Pethiyagoda, S. McCue, T. Moroney
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12:05 pm Monday

Recently there has been some debate about the angle which characterises a Kelvin ship wave pattern. Linear theory suggests this angle is arcsin(1/3), while observations using Google Earth suggest a reduced angle that depends on the velocity of the ship. One explanation for this apparent contribution is provided by measuring the angle which for from the peaks of the waves. I will summarise some of this debate, and provide some simulations of Kelvin ship wave patterns which show how nonlinearity affects this angle.

Stimulated Brillouin scattering: harnessing the interaction between sound and light in nanophotonics

Chris Poulton
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10:10 am Wednesday

The interaction between electromagnetic and elastodynamic vibrations has a long and distinguished history, dating from the work of Brillouin in the early 20th century. More recently researchers have begun to rediscover these interactions in the context of nanophotonics, in which light is trapped or guided within structures that possess features that are typically as large as the wavelength of light (and sound) in the material. In this domain an important process is Stimulated Brillouin Scattering (SBS), which is a coherent interaction between the optical and acoustic modes in optical waveguides. SBS can lead to several interesting and unusual effects, including ”slow-light”, the slowing down of optical pulses to a fraction of the speed of light in vacuum. Here we discuss the physics behind SBS and present recent results for controlling the interaction in nanophotonics experiments. We review recent progress in harnessing SBS in nanophotonic waveguides for applications including on-chip Brillouin lasers, microwave photonic filters, and all-optical isolation.

Modulation of water waves by a rough floating thin elastic plate

Sebastian Rupprecht, L. Bennetts, M. Peter
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3:45 pm Tuesday

We consider a model of water-wave propagation in the ice-covered ocean. The model is two-dimensional - one horizontal dimension and the vertical dimension. Ice cover is modelled as a thin floating ’rough’ elastic plate. Roughness refers to small scale random variations in the mass and rigidity of the plate. The small scale variations cause long-range attenuation of the waves, and alter the wavelength. We apply a multiscale approach in which the velocity potential is expanded using the amplitude of the roughness. An envelope equation is derived that defines the modulation of the wave field. Numerical results will be presented at the conference, in addition to the details of the theory described in this abstract.

Evaluation of ECMWF wind data for wave hindcast in Chabahar Zone

Arvin Saket, A. Etemad-Shahidi, M. Hadi Moeini
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2:30 pm Monday

Due to the incompleteness of measured wave parameters, wave prediction plays a key role in the design of coastal and offshore structures. Since wind is the most important forcing term in the numerical wind wave model, the selection of appropriate wind source is a vital step in the wave modelling. In the present study; two wind sources i.e. the measured synoptic and the ECMWF data, were evaluated for wave simulation near the Chabahar zone. To simulate wave parameters the third generation spectral SWAN model was utilized. A combination of whitecapping dissipation coefficient and bottom friction factor was used for calibration of the model. The sensitivity analysis showed that other physical parameters have no specific effect on the wave characteristics. It was found that the SWAN model forced by ECMWF wind data predicted the south-west and west waves successfully while underestimated the east, south-east and south waves. This was mainly due to well prediction of south-west and west wind and underestimation of wind from the east to the south by the ECMWF model. In addition, it was revealed that synoptic wind data can be used as an appropriate wind source for wave hindcasting at the studied area.

Antiplane elastic wave cloaking using metamaterials, homogenization and hyperelasticity

Tom Shearer, W. Parnell
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1:20 pm Wednesday

We consider the problem of how to cloak objects from antiplane elastic waves using two alternative techniques. The first is the use of a layered metamaterial, whilst the second is the use of a hyperelastic cloak characterised by a Mooney-Rivlin strain energy function, extending previous work using a neo-Hookean material. Although not perfect, the Mooney-Rivlin material appears to be a reasonable hyperelastic cloak. This is encouraging for applications as the Mooney-Rivlin model is considered to be a more realistic constitutive model of rubber-like media than the neo-Hookean model. We quantify the effectiveness of the various cloaks considered by plotting the scattering cross section as a function of frequency, noting that this would be zero for a perfect cloak.

Spectrum shifting and lifting in photonic crystals with negative-index materials

Mike Smith, S. Guenneau, R. Craster
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11:40 am Tuesday

In this talk I will demonstrate that it is possible to engineer complete band gaps for photonic crystals with inclusions that possess negative permittivity, negative permeability, or are simultaneously negative. This occurs when the average refractive index over the Wigner–Seitz cell vanishes under integration, and does not necessarily correspond to vanishing effective parameters (i.e. homogenized values). An identical effect is observed for photonic crystal slabs of positive- and negative-index material, and phenomenon such as band folding has been seen in two-dimensional negative-index photonic crystals. There are a host of unknown behaviours in such designs and we attempt to provide a general framework for researchers to investigate negative-index designs. In particular, we provide a theoretical framework to compute the band surfaces of negative-parameter structures using multipoles, which requires a slight deviation from the usual approach for positive-index materials. High frequency homogenization is then used to validate the results. This work is done in collaboration with Sebastien Guenneau of the Institute Fresnel and Prof Richard Craster from Imperial College London.

Why ocean waves propagating in ice-covered seas have suddenly become fashionable

Vernon Squire
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4:10 pm Monday

The sea ice of the summer Arctic Ocean has changed over the last 30 or so years, from a near uninterrupted ice sheet punctuated by occasional pressure ridges and leads, to a heterogeneous melange of separate ice floes of different sizes and shapes present at spatially and temporally variable concentrations. Along with this change, the summer ice extent has shrunk by 55%, with concomitant reductions in ice thickness and ice strength. Positive ice-albedo feedback, exacerbated by a greater presence of ocean waves travelling though and generated within enlarged amalgamated fetches, has nourished the change — also observing that significant wave height has trended upwards over the period as a result of intensified winds. On entering ice fields waves are scattered by the floes, resulting in conservative attenuation and a change in their directional spread, and lose energy through a number of dissipative oceanographically-related processes. Importantly, it is the waves that fracture and break up the ice floes to create the distribution of sizes that is observed, and, in consort with currents and winds, waves move the floes laterally and assist melting. A deep storm in the centre of the Arctic basin in August 2012, for example, cleared 200,000 square kilometres of sea ice in just 3 days, yet the wind speeds were not atypical for the region. While these unprecedented changes to the sea ice cannot be ascribed exclusively to global warming, as natural meteorological cycles are also present, it is probable that climate change is the primary cause acknowledging that the Arctic and Antarctic are behaving quite differently in their respective responses.

Studies of wave propagation into and through ice fields have a venerable history that dates back at least to Shackleton, who observes in South: The Story of Shackleton's Last Expedition (1914–1917) 'A hastily shouted warning brought the men tumbling out, but fortunately the loose ice which filled the bay damped the wave down so much that, though it flowed right under the hut, nothing was carried away. It was a narrow escape, though, as had they been washed into the sea nothing could have saved them.' Greenhill assembled the first theoretical model in 1887, followed by some activity in the 50s partly as a result of polar operations during the war, but most advances came during the 1970s and 80s supported by intensive field campaigns, and in the last 20 years when the complementary fields of hyoelasticity and wave-ice interactions converged leading to unencumbered scientific advances. This progress has most recently evolved into a systematic investigation of how ocean wave interactions with sea ice can be embedded in an ice/ocean model or an oceanic general circulation model; first at high resolution in the Greenland Sea and later in other marginal ice zones around the Arctic basin, in a series of 3 research projects involving scientists from Norway, Canada, Australia and NZ. Contemporaneously, there is interest in how WAVEWATCH III and WAM can be modified to include sea ice in a more physically defensible way than currently.

The presentation will cover the reasons behind the sudden interest in how waves and sea ice interact, some of the mathematical developments that have been accomplished to bring us to our current state of understanding, and how these advances relate to modelling the evolution of real ice fields with near-operational forecasting and prediction systems such as TOPAZ for the North Atlantic European coastal Zones — a hybrid coordinate ocean model forced by ECMWF atmospheric fields. Currently 1D in regard to ocean waves, these complex models will benefit from recent innovations centred on fully 2D scattering in ice fields.

Infinite periodic approximant structures as representations of quasiperiodic structures in acoustic multiple scattering.

Ruth Voisey, I. Abrahams, W. Parnell
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University of Manchester, U.K.
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9:45 am Wednesday

Quasiperiodic structures are of great interest due to their deterministic yet random-like nature and their links to quasicrystals. The aperiodicity of the structure allows an understanding of wave propagation in random media, whilst the deterministic properties enable simpler computations. Quasicrystals have potential applications due to their structures and there is emphasis on this development in the literature.

Effective properties and pass/stop bands of infinite periodic structures can be determined using Bloch wave analysis. Due to the lack of periodicity in quasiperiodic structures the same analysis cannot be applied.

Periodic approximants of quasiperiodic structures can be constructed by approximating $\tau = \frac{1+\sqrt{5}}{2}$, the golden ratio, used in the construction of the quasiperiodic structure, by a rational number $\tau_n = \frac{\mathrm{Fib}(n+1)}{\mathrm{Fib}(n)}$. These structures have periodic unit cells containing a finite section (size dependent on n) of the quasiperiodic structure.

We discuss the analytic method for determining the effective properties of infinite periodic approximant structures with small scatterers. We show how the scattering compares for finite quasiperiodic and periodic approximant structures, and how well the effective acoustic properties of the infinite approximant structure represent those of the quasiperiodic structure. Results show a convergence of the first cut off frequency for the infinite approximant as n increases in the approximation τ_n. This implies infinite quasiperiodic structures can be well represented by periodic approximant structures with relatively small periods.

Numerical treatment of spontaneous emission from finite photonic crystals

Christian Wolff, A. Froelich, M. Wegener, K. Busch
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11:50 am Wednesday

One of the first reasons to study periodic dielectric structures (now known as photonic crystals) was the realization that they could exhibit a complete band gap, i.e. a frequency range without propagating modes, and that this lack of modes would suppress spontaneous emission in an infinite structure. In reality, however, every crystal is finite and has a surface. Optical surface states provide an additional channel for radiation to travel from an emitter inside the crystal to the unpatterned space outside. Here, we discuss the problem of quantifying these surface state contributions to the spontaneous emission from emitters close to the surface of a photonic crystal and the resulting radiation patterns in the unstructured space.

Operational wave model in the Bureau of Meteorology

Aihong Zhong
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2:05 pm Monday

The Australian wave model (AUSWAVE), based on the WAVEWATCH III model has been the operational sea-state model run by the National Meteorological and Oceanographic Centre (NMOC) since August 2010. The AUSWAVE system was initially forced by the "Australian Parallel Suite 0" (APS0) Australian Community Climate and Earth-System Simulator (ACCESS) Numerical Weather Prediction (NWP). This presentation covers the recent upgrade to the global wave model, which introduced APS1 ACCESS-G surface winds, rather than the previous APS0 version, and increased the wave model spatial resolution from the existing 1 degree to 0.4 degree, to match improvements in the resolution of the atmospheric forcing system. The performance of the new wave system will be assessed.

4 Abstract Index by Author