Nonlinear Waves – Theory, Computation and Real-World Applications

Sanya, 7-11 January, 2019

Title: Examination on the computation of nonlinear wave forces for moving bodies in the time-domain

Speaker: Bin Teng (Dalian University of Technology, China)

Abstract:
There are two difficulties in the computation of nonlinear wave forces on a moving body in the time-domain on the potential flow theory, one is the computation of the partial derivative of velocity potential on a moving body surface, and the other is the singular integration of spatial derivative of velocity potential at the edge of a non-smooth body.

To examine the availability of various existed methods, five numerical formulations are implemented to compute nonlinear radiation forces on smooth and non-smooth bodies in the time domain, and only nonlinear radiation force components are adopted for the examination to get rid of the effects of incident waves and linear components. It is found that for bodies with smooth surface, the nonlinear components of radiation forces obtained by all of the numerical formulations are close to each other, but large disperses exist for the results for the body with sharp edge. Examinations are also carried out for bodies with chamfered edge with small radii, and find that the indirect method based on the fluid momentum conservation are insensitive to the small edge radius, but the results from other formulations diverse when the edge radius approaches zero.

It is suggested to use the indirect method on the fluid momentum conservation for a body with sharp edge, or to replace the body surface by a body with small radius at its sharp edge.

Title: Mysterious wavefront and nonlinear effects

Speaker: Binbin Zhao (Harbin Engineering University, China)
Xiaobo Chen (Bureau Veritas DTRC – Singapore & Harbin Engineering University)

Abstract:
In the fore part of a train of progressive waves generated on water surface by harmonic motions of a wavemaker, the transient waveform ahead of wave train is often called wavefront. The recent analysis based on the method of contour integral in complex wavenumber plane in Chen & Li (2018) reveals the exact behavior of wavefront. Three classes of waves in different regions including wavefront in the fore part, steady-state waves behind and transient waves in between, are then demystified by describing their respective features. It is shown that the starting position of wavefront propagates at the very group velocity associated with the frequency of wavemaker and has an amplitude value which is not the maximum of wave train and larger than that (1/2) predicted by Miles (1962). The largest wave appears behind the wavefront and its position relative to wavefront draws back with time. Wavelengths of wavefront stretch out at the quadratic rate with the distance from wavemaker while amplitudes decrease linearly with distance from wavemaker. Furthermore, nonlinear waves are evaluated by using Green-Naghdi

theory presented in Zhao & Duan (2014). It is remarkable that nonlinear effect is most important in the transient zone and very weak in wavefront. More recent results will be presented in the workshop.

Title: Generation and propagation models of internal solitary waves in the South China Sea

Speaker: Shuqun Cai (South China Sea Institute of Oceanology, Chinese Academy of Sciences, China)

Abstract:
Internal solitary waves (ISWs) are the nonlinear large amplitude waves (in an order of about 100m) existing in the oceanic pycnocline, usually induced by tidal flows over a steep topography such as a ridge, a seamount, or a shelf break in the stratified ocean. ISWs are very active in the northeastern South China Sea (SCS). To study the ISWs' generation, propagation and evolution in the SCS, two types of ISW numerical models, including propagation models and generation/propagation models, are commonly used. In this report, we summarize some related numerical models developed and setup by our research group in studying the ISWs' generation, propagation and evolution in the SCS.

Title: Internal solitary waves propagating through a variable background density stratification and current

Speaker: Zihua Liu (University College London, UK)

Abstract:
Large amplitude, horizontally propagating internal wave trains are commonly observed in the coastal ocean. They are long nonlinear waves and hence can be modelled by equations of the Korteweg-de Vries type. However, typically they propagate through regions of variable background hydrology and currents, and over variable bottom topography. Hence a variable-coefficient Korteweg-de Vries equation is needed to model these waves. Although this equation is now well-known and heavily used, a term representing non-conservative effects, arising from forcing terms in the underlying basic state, has usually been omitted. In particular this term arises when the hydrology varies in the horizontal direction. Our purpose is to examine the possible significance of this term. This is achieved through analysis and numerical simulations, using actual density and current profiles from monthly averaged climatological data for some specific ocean cases of interest. We find that this new" term can be significant, and while the overall structure of the dynamical wave evolution remains essentially the same, the effect of this new term is essentially to change the wave amplitude, depending on both the background stratification and background current for both summer and winter scenarios.

Title: Critical free surface flow over localised topography

Speaker: Mark Blyth (University of East Anglia, UK)

Abstract:
Two-dimensional free-surface flow over a localised bottom topography at critical Froude number (F=1) is examined with an emphasis on calculating steady, forced solitary-wave solutions. In particular we focus on the case of a Gaussian topography. We study the flow in the weakly-nonlinear limit by way of the forced KdV equation, but also compute some fully nonlinear solutions using a conformal mapping method. Boundary-layer theory is used to construct asymptotic solutions in appropriate limits. One point of interest here is an internal boundary layer which mediates a change from an initial exponential decay of the free-surface to algebraic decay in the far-field. (Algebraic far-field decay is a characteristic feature of steady critical flow solutions.) Many solution branches are identified including branches with multiple waves trapped over the main part of the topography, which cannot be described by boundary-layer theory. Solutions on the first few branches are also found for the fully nonlinear problem. The stability of the steady solutions is also considered.

Title: Nonlinear interaction between higher harmonics and submerged obstacle in the presence of uniform current

Speaker: Dezhi Ning (Dalian University of Technology, China)

Abstract:
During wave transformation over a submerged obstacle, higher bound and free harmonic waves generated by a nonlinear shoaling effect may affect sailing conditions, especially when waves and currents are both present. In the present work, a 2D fully nonlinear numerical wave flume is developed to investigate the nonlinear interactions between a regular wave and a submerged obstacle in the presence of uniform currents. A two-point method is used to discriminate bound and free harmonic waves propagating upstream and downstream from the structure. The proposed model is verified against experimental and other numerical data for wave-current interaction without obstacles and nonlinear wave scattering by a submerged plate in the absence of currents. The first-order analysis for reflection coefficient and second-order analysis for second free harmonic downstream the obstacle are performed, respectively. It was found that the characterized length for the maximum reflection to occur is not sensitive to the current. The current has a stronger influence on the secondary free mode than on the first free mode. The second free harmonic wave amplitude is affected more by the opposing current than it is by the following current.

Title: Absolute and convective instability in electrohydrodynamic flow of a dielectric fluid subject to a crossflow

Speaker: Mengqi Zhang (National University of Singapore, Singapore)

Abstract:
We present a study of absolute and convective instabilities in electrohydrodynamic flow subjected to a Poiseuille flow (EHD-Poiseuille). Mathematically, the dispersion relation of the linearised problem is studied based on the asymptotic response of an impulse disturbance imposed on the base EHD-Poiseuille flow. Transverse, longitudinal and oblique rolls are investigated to identify the saddle point satisfying pinching condition in the corresponding

complex wavenumber space. The implication of the results for the flow dynamics in electrostatic precipitators is also discussed.

Title: Stability of deep-water waves with constant vorticity

Speaker: Sunao Murashige (Ibaraki University, Japan)

Abstract:
This work considers stability of two-dimensional periodic motion of deep-water gravity waves propagating on a vertically sheared current of constant vorticity using the unsteady hodograph method. It is shown that conformal mapping of the flow domain helps us numerically catch linear stability of large-amplitude motion.

Title: Internal waves under ice

Speaker: Emilian Parau (University of East Anglia, UK)

Abstract: Theoretical and experimental results will be presented on solitary waves travelling under ice. The ice in experiments is either continuous or broken. The experiments have been performed at HSVA Hamburg and they were supported by the European Community's Horizon 2020 Research and Innovation Programme through the grant to HYDRALAB-PLUS (leader Magda Carr, Newcastle).

Title: Three-dimensional flexural-gravity waves

Speaker: Olga Trichtchenko (Western University, Canada)

Abstract:
In this talk, we present solutions for models of three-dimensional nonlinear flexural–gravity waves, propagating at the interface between a fluid and an ice sheet. The fluid is assumed to be inviscid and incompressible, and the flow irrotational resulting in Euler equations. We present the details of the numerical method based on boundary integral equations used for computing both forced and solitary wave solutions, show results in different regimes, and compare different models for the ice sheet.

Title: Modulational instabilities of hydroelastic waves

Speaker: Tao Gao (University of Bath, UK)

Abstract:
In the autumn of 2017, a workshop on sea-ice phenomenon was held at Isaac Newton Institute for mathematical sciences in Cambridge. The programme covered a range of topics in floating

ice such as multi-scale modelling of ice characteristics and behaviour, ice-fluid interaction, ice-structure interaction, ice fracture and cracks and etc., cf. Smith et al. (Phil. Trans. R. Soc. A. 2018). In this talk, we focus on the problem of hydroelastic wave which is mainly concerned with the interactions between deformable ice sheets and water flows beneath. The recent advances in modelling the deformation of a thin ice sheet are presented. They are followed by an introduction to the linear and weakly nonlinear theory. A Nonlinear Schrodinger Equation is derived and used to conduct analysis of modulational instabilities. The analytical results are examined by fully nonlinear numerical computations.

Title: Nonuniqueness and symmetry breaking in gravity-capillary waves

Speaker: Jean-Marc Vanden-Broeck (University College London, UK)

Abstract:
Waves propagating at a constant velocity on the surface of a fluid of finite depth are considered. The flow is assumed to be potential and two-dimensional. Gravity and surface tension are taken into account.

It is well known that linear theory predicts only symmetric solutions. We shall review new and old results showing how nonlinearity introduces nonuniqueness and allows for the existence of new asymmetric waves.

Title: Two-dimensional gravity-capillary solitary waves on deep water: generation and transverse instability

Speaker: Yeunwoo Cho (Korea Advanced Institute of Science and Technology, Korea)

Abstract:
Two-dimensional (2-D) gravity–capillary solitary waves are generated using a moving pressure jet from a 2-D narrow slit as a forcing onto the surface of deep water. The forcing moves horizontally over the surface of deep water with speeds close to the minimum phase speed cmin=23cm/s. Four different states are observed according to forcing speeds. At relatively low speeds below cmin, small-amplitude depressions are observed and they move steadily just below the moving forcing. As the forcing speed increases towards cmin, nonlinear 2-D gravity–capillary solitary waves are observed, and they move steadily behind the moving forcing. When the forcing speed is very close to cmin, periodic shedding of a 2-D local depression is observed behind the moving forcing. Finally, at relatively high speeds above cmin, a pair of short and long linear waves is observed, respectively, ahead of and behind the moving forcing. In addition, we observe the transverse instability of free 2-D gravity–capillary solitary waves and, further, the resultant formation of 3-D gravity–capillary solitary waves. These experimental observations are compared with numerical results based on a model equation that admits gravity–capillary solitary wave solutions near cmin. They agree with each other very well.

This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2014R1A1A1002441).

Title: Numerical simulation of wave-induced mass transport under Eulerian description

Speaker: Xizeng Zhao (Zhejiang University, China)

Abstract:
The wave-induced mass transport is traditionally studied by physical experiment or theoretical analysis. In this study, the wave-induced mass transport and internal mixing under regular wave propagation in a flume are numerically investigated by an improved VOF (Volume of Fluid) method. A two-phase VOF method based on a multi-phase flow mathematical theory is used to track the free surface and water-water interface simultaneously under Eulerian description. The distribution of Lagrangian, Eulerian and stokes velocities under different regular wave conditions are numerically studied according to available physical experiment. The computed results of free surface and stoke drifts show good agreement with theoretical second-order irrotational solution and experimental data. The mass transport and internal mixing during the process of regular wave propagation and interaction with a submerged breakwater are further investigated. The distribution of two-liquid phase and water-water interface evolution during a long term simulation are presented. Violent water-water interface can be found even there is no regular wave breaking in the free surface.

Title: Hydrodynamic performance of an offshore-stationary OWC device with a horizontal bottom plate: experimental and numerical study

Speaker: Zhengzhi Deng (Zhejiang University, China)

Abstract:
As an example of multipurpose utilization of marine structures, the hydrodynamic performance of an offshore-stationary Oscillating Water Column (OWC) device with an immersed horizontal bottom plate was investigated through both experimental tests and numerical simulations. Based on the open source package OpenFOAM and toolbox waves2Foam, the numerical results were validated by comparing them with experimental data. The effects of the opening ratio (a), plate length (D), relative opening (ε), and water depth (h) on the energy absorption efficiency (ζ), transmission coefficient (C_t), and energy dissipation coefficient (C_D) were examined over a wide range of wave conditions. The results show that a relatively long bottom plate and small opening ratio is beneficial for both the energy extraction and wave-damping ability, especially for long waves. Increasing the relative vertical opening considerably improves the performance of multipurpose OWC devices. Moreover, the optimal structure configuration is found for parameters $a = 0.68\%$, $D = 2B$, and $\varepsilon = 1/2$.

Title: Integrable systems with peakons and cuspons

Speaker: Zhijun Qiao (University of Texas - Rio Grande Valley, USA)

Abstract:
In my talk, I will introduce integrable peakon and cuspon equations and present a basic approach how to get peakon solutions. Those equations include the well-known Camassa-Holm (CH), the Degasperis-Procesi (DP), and other new peakon equations with M/W-shape solutions. I take the CH case as a typical example to explain the details. My presentation is based on my previous work (Communications in Mathematical Physics 239, 309-341). I will show that the Camassa-Holm (CH) spectral problem yields two different integrable hierarchies of nonlinear evolution equations (NLEEs), one is of negative order CH hierarchy while the other one is of positive order CH hierarchy. The two CH hierarchies possess the zero curvature representations through solving a key matrix equation. We see that the well-known CH equation is included in the negative order CH hierarchy while the Dym type equation is included in the positive order CH hierarchy. In particular, the CH peakon equation is extended to the FORQ and other higher order peakon models with peakon and weak-kink solutions. In the end of my talk, some open problems are also addressed for discussion.

Title: Two-dimensional free surface disturbance due to point vortices

Speaker: Alex Doak (University College London, UK)

Abstract:
We start by considering the disturbance caused to the free-surface of a uniform stream of finite depth by a single fixed point vortex, in the case of no gravity and surface tension (free-streamline flow). This problem was solved analytically via Chaplygin's singular point method by Guverich [1]. We adapt this solution to allow for the inclusion of gravity. The new solution is expressed as an infinite series with unknown coefficients, which is truncated and resolved numerically. We then generalize Guverich's solution to allow for any distribution of fixed point vortices. Gravity is again included via a suitable adaptation of the exact free-streamline solution.

References
[1] Gurevich, M. I. 1963 Vortex near a free surface. Journal of Applied Mathematics and Mechanics 27, 1370-1376.

Title: Sufficiently strong dispersion removes ill-posedness in truncated series models of water waves

Speaker: Shunlian Liu (Hunan University of Science and Technology, China)

Abstract:
Truncated series models of gravity water waves are popular for use in simulation. Recent work has shown that these models need not inherit the well-posedness properties of the full equations of motion (the irrotational, incompressible Euler equations). We show that if one adds a sufficiently strong dispersive term to a quadratic truncated series model, the system then has a well-posed initial value problem. Such dispersion can be relevant in certain physical contexts, such as in the case of a bending force present at the free surface, as in a hydroelastic sheet.

Title: TBA

Speaker: Paul Milewski (University of Bath, UK)

Abstract: TBA

Title: On the Ostrovsky equation and “zero-mass contradiction”

Speaker: Karima Khusnutdinova (Loughborough University, UK)

Abstract:
In this talk, I will overview recent results related to the Ostrovsky equation [1]. Firstly, I will discuss the effects of the parallel shear flow on internal waves in a rotating ocean [2,3]. We found first examples when the shear flow can change the sign of the rotation coefficient in the Ostrovsky equation, leading to unusual dynamics. Secondly, I will discuss the dynamics of two distinct linear long wave modes with nearly coincident phase speeds, described by the system of coupled Ostrovsky equations. Finally, I will discuss how one can by-pass the so-called “zero-mass contradiction” in the class of periodic functions on a finite interval [4,5], recovering the well-known scenario [6] in the limiting case of localised solutions on the “infinite” interval.

References:
[1] L.A. Ostrovsky, Nonlinear internal waves in a rotating ocean, Oceanology 18 (1978) 119-125.
[2] A. Alias, R.H.J. Grimshaw, K.R. Khusnutdinova, On strongly interacting internal waves in a rotating ocean and coupled Ostrovsky equations, Chaos 23 (2013) 023121.
[3] A. Alias, R.H.J. Grimshaw, K.R. Khusnutdinova, Coupled Ostrovsky equations for internal waves in a shear flow, Physics of Fluids 26 (2014) 126603.
[4] K.R. Khusnutdinova, K.R. Moore and D.E. Pelinovsky, Validity of the weakly nonlinear solution of the Cauchy problem for the Boussinesq-type equation, Stud. Appl. Math. 133 (2014) 52-83.
[5] K.R. Khusnutdinova, M.R. Tranter, D'Alembert-type solution of the Cauchy problem for a Boussinesq-type equation with the Ostrovsky term, arXiv:1808.08150 [nlin.PS] (2018), submitted.
[6] R.H.J. Grimshaw, Adjustment processes and radiating solitary waves in a regularised Ostrovsky equation, Eur. J. Mech. B / Fluids 18 (1999) 535-543.

Title: Rogue waves and a novel wave-energy device: modelling, simulations and experiments

Speaker: Anna Kalogirou (University of East Anglia, UK)

Abstract:
We explore extreme water-wave amplification in crossing seas, which can lead to the formation of rogue waves at sea. We have recreated and modelled such crossing seas experimentally and

in simulations by using geometric channel convergence. First, amplification of a solitary-water-wave compound running into a contraction is disseminated experimentally. In further experiments, a bore-soliton-splash is observed with approximately tenfold maximum wave amplification. Subsequently, mathematical and numerical modelling approaches are developed and validated for amplifying nonlinear waves.

Wave amplification phenomena observed have led us to develop a novel wave-energy device; novelty features include the use of a contraction to enhance wave-buoy motion, and magnetically-induced energy generation. A laboratory proof-of-principle shows that our wave-energy device works. Furthermore, we develop a monolithic, mathematical model for the (potential flow) hydrodynamics, the buoy motion and the power generation by magnetic induction, satisfying one grand variational principle in its conservative limit. A direct and consistent discretisation of this comprehensive variational principle is then performed. Preliminary numerical simulations of a simplified (linear) wave-energy model will be presented. Further highlights to be discussed include: exact modelling of crossing seas using the Kadomtsev–Petviashvili (KP) equation, relevance of bore-soliton-splash to the devastating Tohoku tsunami run-up in 2011, and nonlinear wave-energy optimisation.

This is a joint work with O. Bokhove (University of Leeds) and W. Zweers (WowLab, Roombeek, The Netherlands)

Title: The generation and the interaction of multi-lumps for the KP1 equation

Speaker: Zhiming Lu (Shanghai University, China)

Abstract:
The interaction between the lump and the multi-lumps within the Kadomtsev–Petviashvili-1 (KP1) equation is studied both analytically and numerically. The dependence of the multi-lump structures on free parameters is discussed in details. Some interesting phenomena are obtained and demonstrated for the interactions of single lumps with each other and with a more complex object such as bi-lumps, as well as the interactions of bi-lumps with each other. Finally, the generation of these multi-lumps by a forced KP1 equation is discussed.

Title: Measuring waves using pressure

Speaker: Katie Oliveras (University of Washington, USA)

Abstract:
In this talk, I will discuss a new formulation of the fully nonlinear equations due to Ablowitz, Fokas, and Musslimani, and how it has helped us gain a better understanding of the role that nonlinearities play when measuring water-waves. In addition, I will show how we can use these this same formulation to solve various inverse problems related to water waves, and compare results with both numerical data and physical experiments.

Title: Numerical simulation of dead water resistance on a box structure in a two-layer fluid

Speaker: Ying Gou (Dalian University of Technology, China)

Abstract:
A 3-D time-domain numerical model by HOBEM method in linearized theory is developed to investigate the dead water resistance on a box-like structure moving with speed U along the upper layer of a two-layer fluid. The moving speed, Fr=U/c0 is varied in the range 0.3 to 1.2. The numerical results of dead water resistance are slightly smaller than the experimental date but have the same trend. The maximum peak of dead water resistance appears on Fr≈0.6 and much smaller than the critical speed Fr=1.0. The wave patterns on the interface are also shown.

Title: A high-order spectral method for nonlinear water waves interacting with a vertically sheared current

Speaker: Philippe Guyenne (Delaware University, USA)

Abstract:
A direct numerical method is proposed to simulate nonlinear water waves with constant nonzero vorticity in a channel of finite or infinite depth. Such a vortical distribution represents a shear current varying linearly in the vertical direction. Our method is based on the reduction of this problem to a lower-dimensional Hamiltonian system involving surface variables alone. This is made possible by introducing the Dirichlet-Neumann operator and associated Hilbert transform which are described via a Taylor series expansion about the still water level. Each Taylor term is a sum of concatenations of Fourier multipliers with powers of the surface elevation, and thus is efficiently computed by a pseudo-spectral method using the fast Fourier transform. The performance of this numerical model is illustrated by examining the long-time evolution of Stokes waves on deep water and of solitary waves on shallow water. It is observed that a co-propagating current has a stabilizing effect on surface wave dynamics while a counter-propagating current promotes wave growth. In particular, the Benjamin-Feir instability of Stokes waves can be significantly reduced or enhanced, possibly leading to rogue waves. Our simulations also suggest the existence of stable rotational solitary waves if the vorticity is not too large in magnitude.

Title: A fourth-order scheme for Navier-Stokes type equations and St Andrew's Cross

Speaker: Zhan Wang (Institute of Mechanics, Chinese Academy of Sciences, China)

Abstract:
A fundamental phenomenon in continuously stratified fluids is the so-called St Andrew's Cross, which is usually generated by a vertically oscillating circular cylinder in a uniformly stratified fluid in labs. To better understand St Andrew's Cross and related phenomena, high-resolution numerical schemes for investigating the generation and propagation of internal gravity-wave beams are required. Since gravity provides a preferred direction, the pseudo-spectral method based on the fast Fourier transform algorithm is not applicable, and high-order finite volume schemes become an appropriate choice. Popular schemes for the incompressible Navier-Stokes

equations, such as two-stage projection methods, are efficient but may suffer from numerical boundary layers and limited accuracy due to the fractional step nature. The pressure Poisson equation (PPE) method takes many advantages, since it can decouple the pressure and velocity field and treat a time integrator as black-box. In this talk, we propose a high-resolution finite volume scheme for simulating density stratified Boussinesq flows based on the Shirokoff-Rosales PPE reformulation. The scheme is of fourth-order accuracy in space and time, and is applicable to both two and three dimensions. Numerical experiments for St Andrew's Cross in uniformly/non-uniformly stratified fluids are carried out, and particular attention is paid to the real Brunt-Vaisala frequency in the South China Sea.

Title: Solitons and dynamics in some nonlinear integrable and non-integrable wave systems

Speaker: Zhenya Yan (Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China)

Abstract:
In this talk, we focus on some special nonlinear integrable and non-integrable wave systems such as the nonlinear Schrodinger (NLS) equation with some parity-time-symmetric potentials and nonlocal NLS equation. Particularly, their parity-time-symmetric solitons, rational solitons, and dynamical behaviors are analyzed.

Title: Asymptotic behaviors for energy-subcritical damped Klein-Gordon equations

Speaker: Lifeng Zhao (University of Science and Technology of China, China)

Abstract:
In this talk, we will investigate the long time behavior of damped Klein-Gordon equation in the energy subcritical case. In fact, we will establish the soliton resolution for this equation which means that the global bounded solution evolves into the super-position of moving solitons. Moreover, we will give some further information about the resolution.

Title: Boundary Integral equation method for fully nonlinear internal waves

Speaker: Zhen Wang (Dalian University of Technology, China)

Abstract:
The method of boundary integral method is employed to investigate the interfacial wave of stratified fluid. An integral-differential equation is formulated for the nonlinear interfacial wave, based on the incompressible potential flow theory, with the nonlinear boundary conditions at the interface. The fully nonlinear numerical results for the interfacial wave are compared when the point vortex is located in the upper layer liquid and in the upper layer liquid, respectively. And the linear analytical solutions for the interfacial wave are also compared about the location of the point vortex. We will discuss the influence to interfacial waves in terms of points vortex and topography.

Title: Rogue waves and integrable system

Speaker: Liming Ling (South China University of Technology, China)

Abstract:
Rogue wave phenomenon is a hot topic in recent years, which was provided in diverse fields. The universal model to describe this phenomenon is the integrable nonlinear Schrodinger equation (NLSE). Lots of exact solutions (rogue waves and high order rogue waves) are found to describe the phenomenon. These exact solutions are related to modulational instability analysis, i.e. these nonlinear waves can tell you how is the nonlinear instability process. Except the classical nonlinear Schrodinger equation, the rogue waves are found in the other integrable models possessing the modulational instability. It is interesting that they possess the similar structure as the NLSE. In this talk, I would like to give some reviews on this aspect.

Title: Well-posedness of electrohydrodynamic waves

Speaker: Jiaqi Yang (Institute of Mechanics, Chinese Academy of Sciences, China)

Abstract:
In this talk, we present some well-posedness results of electrohydrodynamic waves. We show the system of electrohydrodynamic waves is locally well-posed based on energy estimates in proper Sobolev spaces and careful examination of the Dirichlet-Neumann operators. Our results show that, a vertical electric field can destabilize the system but a tangential electric field can stabilize the system, which are consistent with the numerical and experimental results. This is a joint work with Prof. Zhan Wang.

Title: Modeling of droplet dynamics on a solid surface with insoluble surfactants

Speaker: Haihu Liu (Xi'an Jiaotong University, China)

Abstract:
Surface wettability plays an important role in natural and industrial processes, and surfactants can significantly alter the wetting properties by changing the local interfacial tension. Here a lattice-Boltzmann (LB) and finite-difference (FD) hybrid method, which was developed in our recent work for interfacial flows with insoluble surfactants, is extended to incorporate contact-line dynamics. A dynamic contact angle formulation that describes the dependence of local contact angle on the surfactant concentration is derived, and the resulting contact angle is enforced by a geometrical wetting condition with implementation following our recent work [Phys. Rev. E 92, 033306 (2015)]. We first simulate the static contact angles on a solid surface and the results show that the presence of surfactants can significantly modify static contact angle, especially when the surface is more hydrophilic or more hydrophobic. We then study the deformation and breakup of a surfactant-laden droplet on a substrate when subject to a simple shear flow, and compare the results with the case of clean droplet. It is found at low

values of Ca_e that the droplet eventually reaches a steady deformation and moves at a constant velocity. In either clean or surfactant-laden case, the contact-line capillary number (Ca_{cl}) of moving droplet linearly increases with Ca_e, but the slope is always higher in surfactant-laden case where the droplet exhibits a bigger deformation. When Ca_e is increased beyond a critical value (Ca_{ec}), the droplet cannot reach a steady deformation and the breakup would occur. The presence of surfactants is found to decrease the value of Ca_{ec}, but it shows a non-monotonic effect on the droplet breakup: it sometimes promotes and sometimes prevents the breakup.

Title：Stability and deformation of a viscous electrolyte drop in a uniform electric field

Speaker: Manman Ma (Tongji University, China)

Abstract：

We study the axisymmetric deformation and stability of an electrolyte drop freely suspended in an infinite dielectric medium subject to a uniform electric field. To model the electrolyte drop, ions are assumed to be at thermal equilibrium which enables the usage of Poisson-Boltzmann equation for the electric potential, which is further reduced to a modified Helmholtz equation via a small electric potential assumption in Debye-Huckel regime. As a result, boundary integral method is employed to solve the time-dependent low-Reynolds-number problem for the drop deformation with electric fields. The Green's function for the modified Helmholtz equation does not have any analytic closed form in axisymmetric case and is then evaluated accurately by using proper numerical quadratures. Deformation results for different conducting parameters of the droplet and dielectric ratios are also shown and analyzed systematically. Qualitative similarities are found between the drop with thick Debye layer and a perfect dielectric drop. Highly elongated drop can be obtained, with a very large tip curvature. Meanwhile, the presence of ions is seen to promote the elongation of the drop before breakup. This is a joint work with Qiming Wang and Michael Siegel.

Title: Linear and nonlinear waves in topological photonic materials

Speaker: Yi Zhu (Tsinghua University, China)

Abstract:

The past few years have witnessed an explosion of researches on topological phenomena in different fields. One hallmark is the existence of wave motions that are immune to defects and disorders. In this talk, I will introduce our recent progresses on the analysis of such novel and subtle wave dynamics in topological photonic materials. Specifically, we demonstrate the existence of Dirac points in the honeycomb lattices and the existence of topological edge modes by introducing a line defect. We then derive the corresponding envelope equations to understand these subtle topological wave dynamics. Both linear and nonlinear wave dynamics are investigated.

Title: The characteristics and mechanisms of vortex shedding in the ventilated cavitating turbulence flow

Speaker: Zhiying Wang (Beijing Institute of Technology, China)

Abstract:
Ventilated supercavitation is an efficient technology to reduce drag and makes the underwater vehicle realize high-speed. However, when the gas entrainment coefficient is not large enough to form ventilated supercavitation, it often accompanies with ventilated cavitating vortex shedding, which shows unsteady behaviors. I will mainly focus on the characteristics and mechanisms of vortex shedding in the ventilated cavitating turbulence flow by the experimental and numerical methods.

In the experiments, the high-speed video technology is used to obtain the flow patterns and a time-resolved particle image velocimetry (TR-PIV) technique is applied to capture the flow structures inside the ventilated cavity. A flow pattern map of ventilated cavitating flow at different flow conditions is obtained. They are classified into two principally different categories: vortex shedding type and relatively stable structures. Ventilated cavitation plays an important role in the vortex deformation and shedding. The large-scale vortices periodically shed from the bluff body in the turbulent wake. At relatively small gas entrainment coefficient, the vortex shedding frequency increases with the increase of gas entrainment coefficient, while the parameter of the vortex street remains almost unchanged. When a fixed cavity is attached the bluff body, the separation point moves backwards with the increase of gas entrainment coefficient, which leads to the decrease of vortex shedding frequency. In addition, the vortex street becomes narrow gradually. The proper orthogonal decomposition (POD) method is applied to identify the large-scale coherent structures. The lower POD modes stand for the large-scale coherent structures. With the increase of gas entrainment coefficient, the energy occupied by large-scale coherent structures decreases and the intensity of vortices decreases, which indicates that the formation of ventilated cavitation suppresses the vortex shedding.

In the numerical results, a bubble identification method is developed. The interaction between ventilated cavitation and turbulence is investigated. When the gas entrainment coefficient is small, the bubbles in the cavity tend to break up, due to the high turbulence intensity, and the number of bubbles increases. With the increase of gas entrainment coefficient, the turbulence intensity decreases, the number of bubbles decreases, and the diameter of bubbles increases. However, the shape of dimensionless bubble diameter distribution is almost invariable. Compared with the non-ventilated cavitating flow, the enstrophy not only distributes in the shear layer and the cavity closure region, but also exists in the cavity interface and the re-entrant jet region, which indicates that the instability of the cavity interface and the re-entrant jet are also the main reasons for the formation of vortices. With the increase of gas entrainment coefficient, the length of the cavity increases, and the turbulent kinetic energy weakens in the near wake region. In addition, the location of turbulent kinetic energy generation and dissipation gradually changes from the closure region to the cavity interface.