SJTU COMPUTATIONAL MARINE HYDRODYNAMICS LAB
上海交大船舶与海洋工程计算水动力学研究中心

The 8th Symposium on Computational Marine Hydrodynamics

第八届 CMHL 船舶与海洋工程计算水动力学国际研讨会

(The 8th CMHL Symposium 2025)

Beijing Time 09:00-18:50, Jan. 17, 2025

Mixed Webinar and In-Person Meeting

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CMHL
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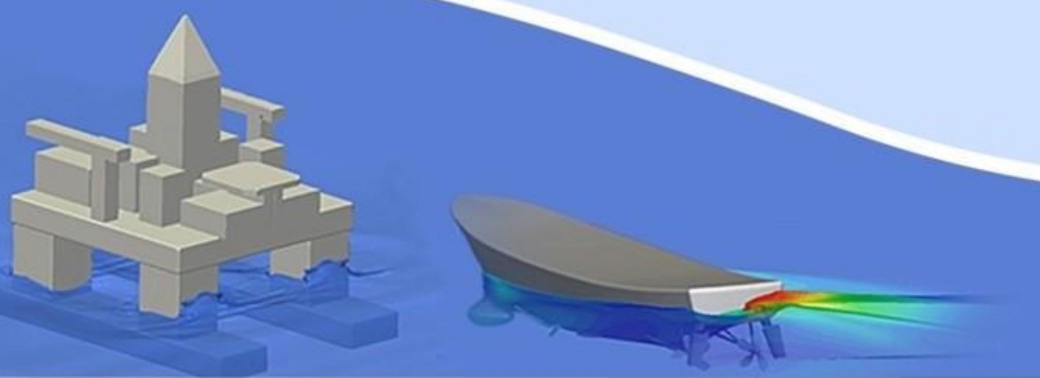

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Organized by

Computational Marine Hydrodynamics Lab (CMHL)

Co-Organized by

Journal of Hydrodynamics (JHD)

Taihu Laboratory of Deepsea Technological Science

National Key Laboratory of Hydrodynamics

Preface

Welcome to the 8th CMHL Symposium 2025 online virtual meeting!

Computational Marine Hydrodynamics Laboratory (CMHL) was founded by Prof. Decheng Wan in 2006. To meet the requirements of marine structures design for digitization, refinement, intelligence and system synthesis, CMHL has long been devoted to the researches of advanced CFD methods for marine hydrodynamics, developments of CAE software and platform, as well as applications of CAE software for complex flows in the fields of integrated ship, marine structures, underwater vehicles, offshore renewable energy devices, etc.

CMHL Symposium (Symposium on Computational Marine Hydrodynamics) is named after "CMHL". The first CMHL Symposium was held in 2018, since then it has been held every year to provide a forum for promoting scientific advancement, technological progress, information exchange, and innovative cooperation among scientists, researchers, engineers, developers, modellers and users of CAE software for solutions of marine hydrodynamics and other related fields. It is an attractive event opening to scientists, scholars, engineers, students, developers and users from universities, institutes as well as industries to exchange ideas and share recent advances on computational marine hydrodynamics and applications of CFD simulations for naval architecture and ocean engineering.

Many outstanding and reputable professors and experts on computational marine hydrodynamics, including Prof. Frederick Stern from University of Iowa, USA, Prof. Krish T Sharman from the University of Massachusetts Amherst, USA, Prof. Hamn-Ching Chen from Texas A&M University, USA, Prof. Chaoqun Liu from University of Texas at Arlington, USA, Prof. Michel Visonneau from Centrale Nantes, France, Prof. David LE TOUZÉ from Ecole Centrale Nantes, France, Prof. Moustafa Abdel-Maksoud from Hamburg University, Germany, Prof. Bettar el Moctar from the University of Duisburg-Essen, Germany, Prof. Xiangyu Hu from Technical University of Munich, Germany, Prof. Hrvoje Jasak from University of Cambridge, UK, Prof. Atilla Incecik from University of Strathclyde, UK, Prof. Mehmet Atlar from the University of Strathclyde, Prof. Gavin Tabor from University of Exeter, UK, Prof. Qing Xiao from Strathclyde University, UK, Prof. Jun Zang from University of Bath, UK, Prof. Rickard Bensow from Chalmers University of Technology, Sweden, Prof. Eugenio Oñate from Universitat Politècnica de Catalunya (UPC), Spain, Prof. Gabriel Weymouth from Technische Universiteit Delft, Netherlands, Prof. Carlos Guedes Soares from the Universidade de Lisboa, Portugal, Prof. Takanori Hino from Yokohama National University, Japan, Prof. Tomoki Ikoma from Nihon University, Japan, Prof. Changhong Hu from Kyushu University, Japan, etc., had delivered very excellent and splendid invited presentations in the previous CMHL symposiums. Several papers based on the invited keynote presentations had been published in Journal of Hydrodynamics as a special column for the CMHL symposium.

The coming 8th CMHL Symposium 2025 organized by CMHL and co-organized with *Journal of Hydrodynamics (JHD)*, *Taihu Laboratory of Deepsea Technological Science*, as well as *National Key Laboratory of Hydrodynamics of China* will be taken place via mixed webinar and in-person meeting on Jan. 17, 2025. There will be one plenary lecture with 60 minutes and ten invited keynote presentations with 45 minutes, covering a wide range of hot topics. Many advanced and innovative numerical methods for marine hydrodynamics will be presented and excellent applications of CFD in ship and ocean engineering will be also presented. In addition, the symposium also includes many interesting topics such as CFD in aerodynamics, biologically inspired flows, machine learning and AI, which provides a good opportunity for researchers in computational marine hydrodynamics to learn the best practices from other related fields and make cross-disciplinary exchange.

The 11 distinguished speakers are well renowned professors, expert and young scholars from all around the world. Some of them are world-renowned experts and professors of high rank in the field of computational marine hydrodynamics, while others are outstanding experts or active young scholars in the fields of numerical simulations. The 8th CMHL Symposium will undoubtedly be a splendid academic event in the history of the CMHL Symposium, and benefit every listener and audience a lot once more.

Wan Decheng

Prof. Dr. Decheng Wan
Chair of the 8th CMHL Symposium 2025
Director of Computational Marine Hydrodynamics Lab (CMHL)
Shanghai Jiao Tong University

In-Person Meeting Information

The in-person meeting venue is set up at Room No. B-208 in Ruth Mulan Chu Chao Building (Mulan Building) of Shanghai Jiao Tong University, Dongchuan Road 800, Shanghai 200240, China.

Online Webinar Meeting Information

Tencent Meeting Webinar (ID: 203 808 619) has been set up for the online virtual meeting of the 8th CMHL Symposium 2025 during 09:00-18:50 (GMT+8, Beijing time) of Jan. 17, 2025. You can scan the following QR code or click the following link to join in the Webinar 30 minutes early as planned.

https://meeting.tencent.com/dm/POWyVPU28FYb

We also prepare three live broadcasts of the 8th CMHL Symposium 2025 on the Bilibili website, KouShare website and Fangzhenxiu website. In case the above Tencent Meeting room are full and you cannot join in, you can watch the live stream online via the following QR code or links:

Bilibili: http://live.bilibili.com/24017914
KouShare: https://www.koushare.com/live/details/39700
Fangzhenziu: https://www.fangzhenxiu.com/live/1319342447483617280

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Instruction for Invited Speakers

Plenary lecture is allocated 60 minutes (50-min presentation + 10-min discussion) and each keynote presentation is allocated 45 minutes (40-min presentation + 5-min discussion). The invited speakers are suggested to join in above Webinar 30 minutes before your scheduled presentation.

Program of the 8th CMHL Symposium 2025

Beijing Time 09:00-18:50, Friday, Jan. 17, 2025, Mixed Webinar and In-Person Meeting

09:00-09:05 Opening Speech **Prof. Decheng Wan**

Plenary Lecture Chair: Prof. Decheng Wan

09:05-10:05 Plenary Lecture

High-Fidelity CFD, CSD, FSI, and MDO for Planing Hull and Flexible Plate Hydro-Elastic Slamming and Multi-Phase CFD KCS Plunging Breaking Waves

Prof. Frederick Stern, The University of Iowa, USA.

Keynote Presentation Chair: Assoc. Prof. Jianhua Wang

10:05-10:50 Keynote Presentation 1 (Jan. 17, 11:05-11:50 Korea Time)

Hydro-dynamic Analysis & Model Test for Floating Structures

Dr. Byoung Wan Kim, Korea Research Institute of Ships & Ocean Engineering (KRISO), Korea.

10:50-11:35 Keynote Presentation 2

Tidal Turbine Hydrodynamics

Prof. Ignazio Maria Viola, School of Engineering, University of Edinburgh, UK

11:35-12:20 Keynote Presentation 3 (Jan. 17, 14:35-15:20 Sydney Time)

Three-Dimensional Numerical Simulation of a Cylindrical Oscillating Water Column (OWC)

Prof. Ming Zhao, School of Engineering, Design and Built Environment, Western Sydney University, Australia

12:20-13:30 Break for Lunch and Rest

Keynote Presentation Chair: Prof. Ignazio Maria Viola

13:30-14:15 Keynote Presentation 4

URANS-Based Statistical Analysis of 5415M Course Keeping in Stern-Quartering Waves at Sea State 7: Data-Driven Modeling of Ship Responses and Identification of Severe Events

Dr. Matteo Diez, Senior Research Scientist, CNR-INM, National Research Council – Institute of Marine Engineering, Italy

14:15-15:00 Keynote Presentation 5

Three-Dimensional Sharp-Interface Fluid-Structure Interaction Method with GPU Acceleration and its Hydrodynamic Application

Dr. Jianjian Xin, Associate Researcher in the Institute of Naval Architecture and Ocean Engineering, Ningbo University, China

Keynote Presentation Chair: Dr. Matteo Diez

15:00-15:45 Keynote Presentation 6

Recent Advances in Smoothed Particle Hydrodynamics for Resolving Gas-Liquid-Structure Coupling Dynamics

Dr. Pengnan Sun, Associate Professor at School of Ocean Engineering and Technology of Sun Yat-sen University, China

15:45-16:30 Keynote Presentation 7 (Jan. 17, 08:45-09:30 France Time)

Nonlinear Wave Modelling with High-Order Spectral Method and Applications to Ocean Engineering

Prof. Guillaume Ducrozet, Ecole Centrale Nantes, France

Keynote Presentation Chair: Dr. Liushuai Cao

16:30-17:15 Keynote Presentation 8 (Jan. 17, 09:30-10:15 Germany Time)

A History of Research on Ocean Waves from Three Perspectives - Engineering, Geophysics and Mathematics

Dr-Ing. Robinson Perić, Institute for Fluid Dynamics and Ship Theory (FDS), Hamburg University of Technology (TUHH), Germany

17:15-18:00 Keynote Presentation 9 (Jan. 17, 09:15-10:00 UK Time)

Turbulent Flows around Arrays of Sharp-Edged Cylinders

Prof. Zhengtong Xie, Aeronautics and Astronautics, University of Southampton, UK

18:00-18:45 Keynote Presentation 10

Super-Resolution Reconstruction of Incompressible Turbulent Flow Using Deep Learning

Dr. Maokun Ye, Computational Marine Hydrodynamics Laboratory (CMHL), Shanghai Jiao Tong University, China

18:45-18:50 Closing Speech Prof. Decheng Wan

Introduction of Invited Speakers and Presentation Abstracts

09:05-10:05 Plenary Lecture

High-Fidelity CFD, CSD, FSI, and MDO for Planing Hull and Flexible Plate Hydro-Elastic Slamming and Multi-Phase CFD KCS Plunging Breaking Waves

Prof. Frederick Stern, The University of Iowa, USA.

Brief CV of Invited Speaker:

Prof. Frederick Stern is internationally recognized expert in ship hydrodynamics: computational methods, modeling, wave basin, towing-tank and flume experiments; experimental/ computational uncertainty analysis/ quantification; and deterministic/ stochastic shape optimization. He has authored, co-authored, or edited: 7 international conference proceedings/ books; 6 book chapters; 5 committee reports and 12 Quality Manual Procedures for the 21st–25th International Tow ing Tank Conference; 22 NATO AVT final report chapters; 178 journal articles; 4 moderate review journal articles; 2 online archive articles; 249 conference proceeding papers, and 56 reports. Prof. Frederick Stern is chair of the Steering Committee of the International Workshop on CFD in Ship Hydrodynamics since 2015 and is also a permanent member of the SNH-ONR Paper Selection Committee since 2005.

Abstract:

The physics and modeling of slamming and breaking waves are challenging subjects in ship design. Herein the interest for the former is its high priority for high-speed planing craft as slamming loads are a critical factor in the ability for achieving weight reduction; whereas for the latter is plunging breaking ship waves

as currently only spilling and quasi-steady plunging breaking ship waves have received attention. The focus is on the demonstration of high-fidelity simulation capability supported by advanced ML&AI, MDO, and multi-phase methods via its application to complex "real world" problems with available experimental data for validation. Slamming studies initially focused on rigid body motions and loads for semi-planing (Athena) and planing (GPPH) hulls with the assessment of experimental and CFD capability for calm water resistance, sinkage, and trim and regular head waves resistance, heave, pitch, and slamming load types and pressures [1-5]. These studies were then extended for one- and two-way fluid-structure interaction (FSI) studies and multidisciplinary design optimization (MDO) for weight reduction applied to grillages subject to slamming loads in both regular and irregular waves [6, 14-15], including data clustering studies to identify slamming types in irregular waves [16]. Most recently the research was extended for the Digital Design concept [22] with MDO studies for weight reduction for the entire GPPH structure in regular head waves [17], as highlighted in Figs. 1 and 2. In parallel, fundamental studies of one- and two-way FSI for vertical and oblique flexible plate slamming were conducted, including V&V, the investigation of hydroelasticity parameters, and stagnation flow Bernoulli equation and conservation of energy analysis for physical understanding [7]. These studies required the development of a non-intrusive nonlinear structural ROM for partitioned two-way FSI [20], which provided very accurate results [18]. The investigations included additional studies of the effects of the plate aspect ratio, the use of anisotropic plates, and MDO for the reduction of the stress induced by the slamming load and the weight [19], as highlighted in Fig. 3. Wave breaking ship flow studies initially focused on spilling and quasi-steady plunging breaking waves [8-10]. Building on fundamental research for plunging breaking waves [11-13], recent studies for KCS plunging breaking waves have identified the organized oscillations, air tubes, and vortical structures, which constitute the important underlying physics [21], as highlighted in Fig. 4. Future research involves hydro-structural data-driven MF-MDO of high-speed small crafts via multi-loop digital design, multi-phase flexible plate slamming including wave impact, and improved turbulence models for breaking waves.

References

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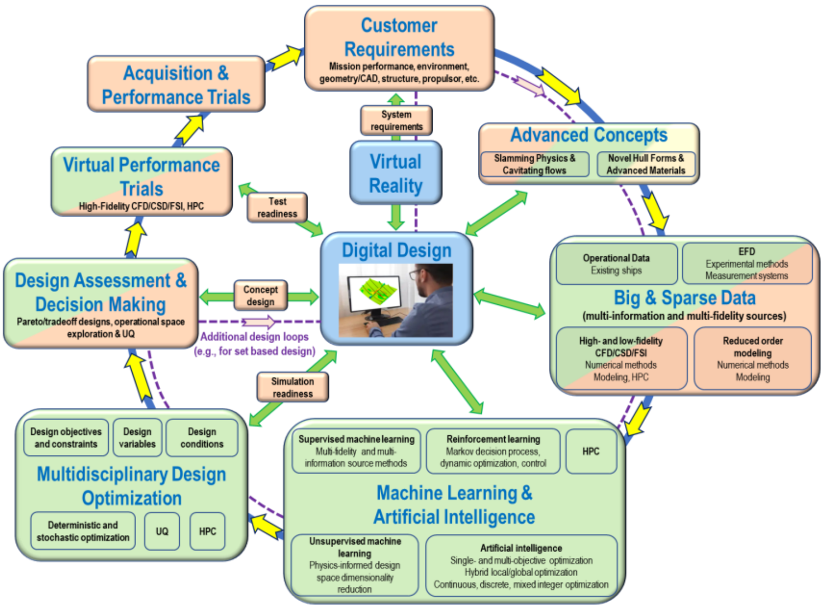

Fig. 1. The Digital Design Process

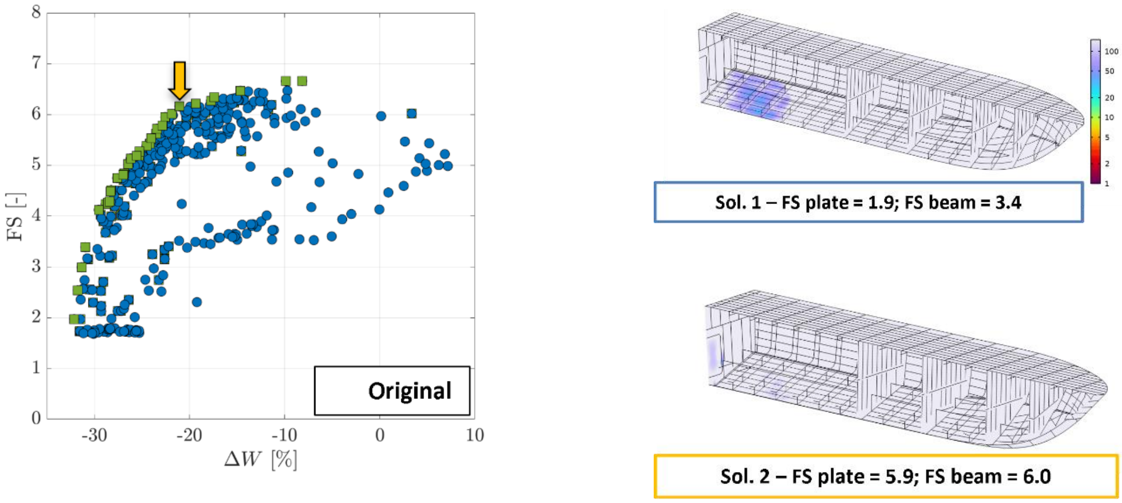

Fig. 2 Digital Design GPPH

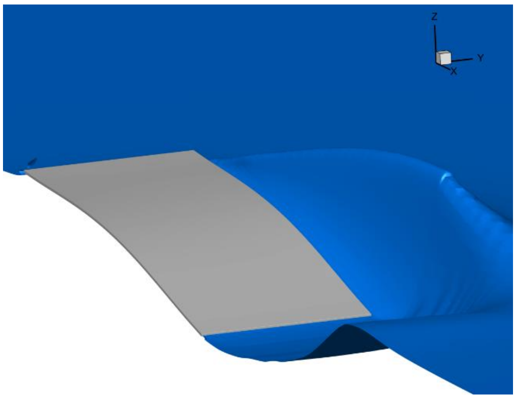

Fig. 3 Flexible Plate Slamming

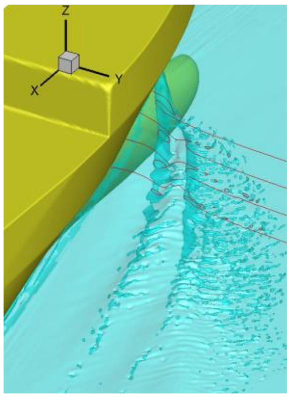

Fig. 4 KCS Plunging Breaking Wave

10:05-10:50 Keynote Presentation 1 (Jan. 17, 11:05-11:50 Korea Time)

Hydro-dynamic Analysis & Model Test for Floating Structures

Dr. Byoung Wan Kim, Korea Research Institute of Ships & Ocean Engineering (KRISO), Korea.

Brief CV of Invited Speaker:

Dr. Byoung Wan Kim received his BS from Dept of Civil Engineering in Yonsei University (1990~1997), and got his MS & PhD from Dept of Civil & Environmental Engineering in KAIST (1997~2003), and was a visiting Scholar in Dept of

Civil Engineering in Texas A&M University (2011~2012), and now is a principal researcher in KRISO (2003~Present).

Abstract:

Hydro-dynamic analysis is a key step in design of floating structures. Floating body motions, structural forces and mooring line tensions are obtained from hydro-dynamic analysis and the design performances are checked by evaluating the hydro-dynamic responses. Another key step is a model test. Model test is carried out to evaluate the hydro-dynamic responses experimentally. In this study, the basic procedure of hydro-dynamic analysis and some numerical methods for hydro-dynamics such as HOBEM (Higher Order Boundary Element Method), convolution and FEM (Finite Element Method) are briefly discussed. Basic steps for model test such as tilt test, free-decay test, wave calibration, mooring system calibration, regular RAO (Response Amplitude Operator) test and test in irregular waves are summarized. Some results of hydro-dynamic analyses and model tests by KRISO are also discussed for VLFS (Very Large Floating Structures), FPSO, SEMI, container, sea-fastening, multi-body system, and FOWT (Floating Offshore Wind Turbine).

10:50-11:35 Keynote Presentation 2

Tidal Turbine Hydrodynamics

Prof. Ignazio Maria Viola, School of Engineering, University of Edinburgh, UK

Brief CV of Invited Speaker:

Ignazio Maria Viola is Professor of Fluid Mechanics and Bioinspired Engineering at the School of Engineering of the University of Edinburgh; Distinguished Visiting Professor at Tsinghua University; Adjunct Professor at the University of Bologna; and Fellow of the Royal Institution of Naval Architects (RINA). He publishes in Nature, Nature Communication, eLife, Renewable Energy, Journal of

Fluid Mechanics, etc. For his publications, he was awarded two RINA Medals of Distinction and one Medal of Exceptional Merit, a Gold Rating for the Best Journal Article by the International Marine Energy Journal, as well as the Covid-19 Hero Medal of the School of Engineering of the U. of Edinburgh for significant contribution to solving Covid-19 challenges. He is the Functional Vice President Alt. of Knowledge Management of the Society of Naval Architects and Marine Engineers (SNAME), and a member of several Executive Committees, including the GERA section of the American Physical Society, the UK Fluids Network, and the UK Robotics and Autonomous Systems Network. He is Editor-in-Chief of the Journal of Sailing Technology, Associate Editor of the Journal of Offshore Mechanics and Arctic Engineering (ASME), and of the Journal of Ocean Engineering and Marine Energy (Springer).

Abstract:

Tidal energy is a reliable and predictable energy source that is currently mostly untapped. Regions such as the UK, the Atlantic coast of the EU, and both the Atlantic and pacific coasts of North America, are rich of this energy source. The first tidal turbine farms have been deployed in the last ten years, but for this energy sector to continue to grow, new technology must be developed to decrease the levelised cost of energy. In this talk, we will describe recent progress on the hydrodynamics of tidal turbines, including the analysis of the major sources of unsteady loadings, new morphing blade technology to mitigate load fluctuations, and current research in permeable tips to mitigate risk of cavitation. We will also discuss the numerical methods that we use for this analysis, including blade element momentum theory, Reynolds-averaged Navier-Stokes Simulations, and Large Eddie Simulations.

11:35-12:20 Keynote Presentation 3 (Jan. 17, 14:35-15:20 Sydney Time)

Three-Dimensional Numerical Simulation of a Cylindrical Oscillating Water Column (OWC)

Prof. Ming Zhao, School of Engineering, Design and Built Environment, Western Sydney University, Australia

Brief CV of Invited Speaker:

Prof. Ming Zhao joined Western Sydney University Australia in 2011. He is currently the director of the academic program of mechanical engineering and the leader of the hydraulic research group in his university. He has published over 200 papers in top journals and received 6 research grants from Australia Research Council. Prior to joining Western Sydney University, he received his PhD degree and did his postdoctoral research at Dalian University of Technology from 1997 to 2003, and worked at the University of Western Australia University as a research assistant professor for six years from 2005 to 2011. He as supervised totally over 20 PhD students to completion and many of his PhD students are currently working as academics in local, international universities and industry.

Abstract:

A three-dimensional computational fluid dynamic (CFD) model is developed for simulating a cylindrical Oscillating Water Column (OWC) device for harvesting wave energy. The single-phase CFD model solves the Reynolds-Averaged Navier-Stokes (RANS) equations using the finite element method for simulating the wave motion and uses an aerodynamic model to simulate the flow through the air turbine. The model is implemented to simulate wave energy harvesting of a cylindrical OWC device. Through harmonic decomposition, it is found that the first harmonic wave surface elevation oscillates like a piston in the OWC chamber. However, both the amplitude and phase of the second harmonic wave surface elevation vary significantly along the wave direction in the OWC chamber, demonstrating a sloshing mode of the second harmonic. This study further proved the reduction of the capture width ratio caused by the transverse sloshing mode when the wavelength is the same as the wave flume width. The effect of the width of the wave flume on the peak CWR is found to be negligibly small when the wave flume width is three times the OWC diameter.

13:30-14:15 Keynote Presentation 4

URANS-Based Statistical Analysis of 5415M Course Keeping in Stern-Quartering Waves at Sea State 7: Data-Driven Modeling of Ship Responses and Identification of Severe Events

Dr. Matteo Diez, Senior Research Scientist, CNR-INM, National Research Council – Institute of Marine Engineering, Italy

Brief CV of Invited Speaker:

Matteo Diez is a Senior Research Scientist at CNR-INM, National Research Council-Institute of Marine Engineering, Rome, Italy, where he leads a research group in multidisciplinary analysis and optimization. His research focuses on simulation-based design optimization methodologies, aiming at the affordable use of high-fidelity prime-principle based solvers in ship hydrodynamics and fluid structure interaction for both deterministic and stochastic applications. He is author of more than 100 papers published in peer-reviewed international journals (including Computer Methods in Applied Mechanics and Engineering, Engineering with Computers, Ocean Engineering, Structural Multidisciplinary Optimization, Marine Structures, Applied Soft Computing, ASME Journal of Verification, Validation and Uncertainty Quantification) and international conference proceedings. He is Editorial Board Member at Nature Portfolio‘s Scientific Reports. He has been Adjunct Professor at the Università Iuav di Venezia, Università degli Studi Roma Tre, and the Istituto Nazionale di Architettura, IN/ARCH. He has been Visiting Research Scholar at the University of Iowa under ONR support. He has been co-chair and technical team member of several activities on deterministic and stochastic optimization for vehicle design within NATO Science and Technology Organization Applied Vehicle Technology Panel. He has been principal investigator of ONR-funded NICOP (Naval International Cooperative Opportunities in Science and Technology Program) grants. He received his M.Sc. degree in Mechanical Engineering from Università degli Studi Roma Tre in 2003 and his Ph.D. degree in Mechanical and Industrial Engineering from the same University in 2007, with a thesis on multidisciplinary optimization methods for conceptual aircraft design.

Abstract:

The prediction and analysis of ship behavior in heavy weather conditions are critical for ensuring operational safety and performance. This study focuses on the course-keeping performance of a free-running naval destroyer (namely the 5415M model) operating in irregular stern-quartering waves at Sea State 7, a highly challenging scenario characterized by significant wave heights and near-resonant roll conditions. Using Unsteady Reynolds-Averaged Navier-Stokes (URANS)

simulations, the ship's responses are evaluated in terms of six degrees of freedom motion and rudder actions. In this study, the URANS simulations are conducted with the CFDShip-Iowa code with a total grid size of approximately 45 million points and considering up to 132 encounter waves, resulting in significant computational costs nearing one million CPU hours. The CFD results are validated against experimental fluid dynamics (EFD) data. Key results highlight the ability of the URANS solver to accurately reproduce statistical properties of incoming waves and ship motions, including expected values, standard deviations, and probability distributions. Validation metrics confirm remarkable agreement between CFD and EFD data across most motion variables, with notable success in capturing the bi-modal roll behavior observed in experiments. The analysis emphasizes severe roll motions and capsizing events, leveraging advanced data-driven techniques to characterize motions' coupling and identify severe events. Dynamic mode decomposition (DMD) is applied to EFD and CFD time histories, uncovering the fundamental modes of motion and correlations that govern the ship's dynamic response in such conditions. Furthermore, the k-means clustering facilitates the identification of wave sequences that lead to severe events, enabling their deterministic reconstruction for focused analysis using regular wave computations. This process provides critical insights into the causal mechanisms behind extreme ship motions and supports the development of predictive capabilities. In addition, the study discusses data-driven modeling techniques, including DMD, feedforward neural networks (FNN), and recurrent neural networks (RNN), to enable real-time forecasting (nowcasting) of ship motions and trajectories. Here, by training on simulation data, these methods demonstrate their ability to provide short- and medium-term predictions of ship responses with good accuracy. Data-driven methods enable fast, computationally efficient predictions that can be deployed within digital twin frameworks for naval vessels, offering new opportunities for real-time monitoring, control, and optimization, enabling near real-time predictions and decision-making in high-sea states, providing critical support for operational safety and mission success.

14:15-15:00 Keynote Presentation 5

Three-Dimensional Sharp-Interface Fluid-Structure Interaction Method with GPU Acceleration and its Hydrodynamic Application

Dr. Jianjian Xin, Associate Researcher in the Institute of Naval Architecture and Ocean Engineering, Ningbo University, China

Brief CV of Invited Speaker:

Dr. Jianjian Xin currently holds the position of Distinguished Associate Researcher in the Institute of Naval Architecture and Ocean Engineering, Faculty of Maritime and Transportation, Ningbo University, where he serves as a supervisor for both master's and doctoral students. Dr. Xin graduated from Wuhan University of Technology with a Ph.D. in Naval Architecture and Ocean Engineering in January 2019. Since his doctoral studies, Dr. Xin has been engaged in the computational fluid dynamic (CFD) methods and their hydrodynamic applications. He has developed a three-dimensional (3D) multiphase fluid-structure interaction (FSI) computational method with GPU acceleration for complex flows in the field of hydrodynamics such as biomimetic propulsion, vortex-induced vibration, flow-induced oscillation, large-amplitude sloshing, ship entry/exit slamming, and wave- rigid/flexible-structure interaction. Over the past five years, Dr. Xin has published near 20 papers as the first or corresponding author in famous journals, including Ocean Engineering, Applied Ocean Research, Physics of Fluid, .and Computer Physics Communications, etc.

Abstract:

Complex rigid or flexible dynamic boundary flows are prevalent in the fields of Naval Architecture and Ocean Engineering, such as vortex-induced vibrations of riser, wave-floating structure interaction, and water impact of trans-medium vehicles. Furthermore, with the continuous development of the deep-sea resource exploration, marine structures are becoming larger, thinner, and more flexible. The large-displacement and large-deformation responses of structures become increasingly pronounced. To simulate flows around large-displacement rigid body or large-deformation flexible boundaries, the immersed boundary method where the body boundaries move in a background Cartesian grid is usually adopted offers distinct advantages. This talk focuses on a GPU accelerated multiphase fluid structure interaction (FSI) computational model based on a sharp interface immersed boundary method and their hydrodynamic applications. The first part will commence with an overview of the research background and significance, highlighting the FSI computational framework. In the second part, the present FSI computational model is explored in details, including a three-dimensional (3D) robust ghost cell method (GCM) for complex rigid or flexible boundary flows, a wall modeled large eddy simulation within the GCM framework for considering the relatively high Reynolds number flows, a gradient augment level set (GALS)

method for capturing nonlinear free surface, an absolute nodal coordinate formulation (ANCF) based finite element method for large-deformation response, and a CUDA GPU parallel framework for accelerating computational speed. The implemented models are validated against many test cases. Then, the third part will be dedicated to the hydrodynamic applications of these computational methods, including the water impact of the ship section and cylinder with multiple degree-of-freedom (DOF) motion, nonlinear sloshing of a 3D prismatic tank with or without a baffle, wave-structure interaction, vortex induced vibration, flow induced oscillation, and 3D fish swimming. The talk will be concluded with the computational challenges and the future directions of research.

15:00-15:45 Keynote Presentation 6

Recent Advances in Smoothed Particle Hydrodynamics for Resolving Gas-Liquid-Structure Coupling Dynamics

Dr. Pengnan Sun, Associate Professor at School of Ocean Engineering and Technology of Sun Yat-sen University, China

Brief CV of Invited Speaker:

Pengnan Sun is an associate professor and doctoral supervisor at School of Ocean Engineering and Technology of Sun Yat-sen University, where he also serves as the director of the Ocean-Connect Supercomputing Center. He earned his doctoral degree from Harbin Engineering University in 2018. From 2013 to 2015, he worked at CNR-INM in Italy. Following that, he conducted postdoctoral research at École Centrale de Nantes in France from 2018 to 2020. He is recognized as one of the top 2% of research scientists globally and listed among the young talents of the Association for Science and Technology of China. In 2024, he received the Guangdong Outstanding Young Scholar Fund. His research focuses on the development of meshfree numerical methods, particularly Smoothed Particle Hydrodynamics (SPH), and the application of these methods in developing CAE software to solve fluid-structure interaction issues in ship and ocean engineering. He has published over 80 academic papers in peer-reviewed journals, including Journal of Computational Physics (JCP) and Computer Methods in Applied Mechanics and Engineering (CMAME), and has accumulated more than 3,500 citations on Google Scholar. Dr. Sun has received several academic awards, including the 2022 EABE "Best Paper Award," the 2020 SPHERIC Online "Best Presentation Award," and a High

Citation Award from the Journal of Hydrodynamics. He serves on the editorial boards of six academic journals, such as the Journal of Marine Science and Application and the Journal of Hydrodynamics. Additionally, he is a member of both the steering committee and scientific committee of SPHERIC, an international organization representing the community of researchers and industrial users of SPH. In this capacity, he chaired the 2024 SPHERIC Zhuhai International Workshop, which attracted more than 180 scholars in the field to discuss the latest developments in SPH theory, numerical methods, and applications.

Abstract:

Smoothed Particle Hydrodynamics (SPH) is a mesh-free Lagrangian method adept at simulating free-surface and interfacial flows. Its capability to accurately and automatically track fluid-structure and multi-phase interfaces makes it particularly advantageous for addressing complex fluid-structure interaction (FSI) problems which often involve large deformations, moving boundaries, multi-media interactions, strong convection, and intense free-surface splashing. Over the past 30 years, significant advancements have been made in addressing common issues associated with traditional SPH models, including pressure noise, volume non-conservation, poor computational stability, challenges in simulating turbulence at high Reynolds numbers and so on. These advancements have established the mesh-free SPH method as a leading algorithm in FSI hydrodynamics. This presentation will focus on the introduction of a robust multiphase δ+-SPH model designed to tackle challenging gas-liquid-structure coupling problems. First, the historical development of SPH in hydrodynamics will be reviewed, highlighting advanced technologies that enhance simulation accuracy and stability. Following this, we will present recent developed gas-liquid-structure coupling techniques that enable the simulation of multiphase flows with high density ratios and varying compressibility. Finally, we will demonstrate extensive simulations and validations of complex gas-liquid-structure coupling scenarios, including rolling wave slamming with air cushioning effects, violent liquid tank sloshing with air bubble capture, cavitating bubbles around hydrofoils, droplet icing, water drops from air tankers in high-speed airflows and so on. The numerical results and validations will show that the advanced multiphase δ+-SPH model, enhanced with innovative numerical techniques, offers significant advantages for simulating gas-liquid-structure interactions. This model is poised to become a vital component in the future development of industrial CAE software for addressing such multiphase FSI challenges across various fields.

15:45-16:30 Keynote Presentation 7 (Jan. 17, 08:45-09:30 France Time)

Nonlinear Wave Modelling with High-Order Spectral Method and Applications to Ocean Engineering

Prof. Guillaume Ducrozet, Ecole Centrale Nantes, France

Brief CV of Invited Speaker:

Prof. Guillaume Ducrozet studied Hydrodynamics and Ocean Engineering at Ecole Centrale Nantes, France. He got his MSc in 2004 and completed his PhD in 2007, on deterministic nonlinear wave modeling with High-Order Spectral (HOS) methods. He occupied different post-doctoral positions, including a 1-year stay at Denmark Technical University (DTU, Denmark) in 2009. He became Assistant/Associate Professor at Ecole Centrale Nantes in 2010, and Full Professor of Ocean Engineering in 2023. Since 2022 he has been the deputy director of the research Laboratory on hydrodynamics, energetics, and atmospheric environment (LHEEA), a joint research unit of Ecole Centrale Nantes and CNRS. His research topics cover various aspects of ocean engineering with expertise in the numerical modeling of nonlinear ocean waves thanks to pseudo-spectral methods (HOS) and in the coupling between such methods and high-fidelity solvers for wave-structure interactions (Navier-Stokes Finite Volume methods, SPH). He uses numerical models together with experiments for different objectives, ranging from the understanding of the physics of waves (nonlinear wave interactions, rogue waves) up to the practical applications in seakeeping. He is the author of 55+ publications and is the main developer of the open-source High-Order Spectral models HOS-ocean and HOS-NWT.

Abstract:

This talk will propose an overview of the capabilities and limitations of High-Order Spectral (HOS) models for non-linear waves deterministic modeling. It will take as a basis the open-source solver HOS-ocean developed in Ecole

Centrale Nantes (France). Recent developments toward the inclusion of additional physical phenomena into the HOS models will be presented: wave-bottom and wave-current interactions, wave breaking, etc. Finally, the typical use of HOS solvers in the context of ocean engineering will be introduced, with a focus on wave-structure interactions. An efficient coupling strategy will be presented and different applications proposed.

16:30-17:15 Keynote Presentation 8 (Jan. 17, 09:30-10:15 Germany Time)

A History of Research on Ocean Waves from Three Perspectives - Engineering, Geophysics and Mathematics

Dr-Ing. Robinson Perić, Institute for Fluid Dynamics and Ship Theory (FDS), Hamburg University of Technology (TUHH), Germany

Brief CV of Invited Speaker:

Robinson Perić is a postdoctoral researcher at the Institute for Fluid Dynamics and Ship Theory at Hamburg University of Technology. He has studied Computational Engineering (B.Sc.) at the Friedrich-Alexander University Erlangen-Nuremberg and Theoretical Mechanical Engineering (M.Sc.) at Hamburg University of Technology, both with specialization on computational fluid dynamics. He received his PhD at Hamburg University of Technology on the topic: Minimizing undesired wave reflection at the domain boundaries in flow simulations with forcing zones. His research interests center around theoretical, experimental and computational fluid dynamics, with special focus on their application to naval and ocean engineering problems. His publications include research on optimizing boundary conditions for wave-generation and wave-damping in flow simulations, interface-sharpening schemes for multiphase flows, ship maneuvering in nonlinear waves, rogue waves, extreme-wave impacts, cavitation, turbulent flows, aerodynamics and wave energy conversion. The study of ocean waves is one of his main research interests.

Abstract:

Knowledge about ocean waves is important for engineers in the maritime field, especially in ship hydrodynamics and ocean engineering. Classical investigations include computing seakeeping behavior of ships and wave loads on offshore structures, which are routinely performed during design with different tools (empirical methods, potential flow, computational fluid dynamics, etc.). Such topics are typically well covered in standard curricula for engineering students in these disciplines. However, today there is an increasing interest in nonlinear phenomena related to ocean waves. This includes investigation of ship maneuvers in realistic, short-crested seas, extreme-wave impacts on offshore structures, or the study of wave-wave interactions and wave breaking to develop improved models for weather and climate simulations. Such topics are less frequently covered in engineering curricula, partly because they are based on progress made in other disciplines. Research on ocean waves profited from developments in different fields, where it was pursued with different research interests and partly independently from each other. Therefore, the aim of this talk will be to give a brief account of the history of research on ocean waves from three perspectives: engineering, geophysics and mathematics. Main contributions from each field will be highlighted and discussed regarding their relevance for state-of-the-art ship hydrodynamics and ocean engineering. An outlook will outline the benefits from a closer collaboration between these fields.

17:15-18:00 Keynote Presentation 9 (Jan. 17, 09:15-10:00 UK Time)

Turbulent Flows around Arrays of Sharp-Edged Cylinders

Prof. Zhengtong Xie, Aeronautics and Astronautics, University of Southampton, UK

Brief CV of Invited Speaker:

Prof. Zheng-Tong Xie (ZX) is a full Professor of Aeronautics and Astronautics at the University of Southampton (UoS), leading research in environmental and urban fluid dynamics. ZX received his academic degrees at Shanghai Jiao Tong University (1986-1995). ZX worked at the Institute of Mechanics, CAS from 1995-2000. Since 2000, he worked in the University of Surrey, and then the

University of Southampton. His research interests include turbulent flow around bluff bodies, computational fluid dynamics, and fast computation in large-scale problems. ZX is the PI of several projects funded by the research councils. Currently, ZX is the PI of EPSRC funded-project FUTURE (EP/V010514/1, Jun 2021 - Jun 2024), and the PI of NERC funded-project ASSURE (NE/W002841/1, Dec 2021 - Nov 2025). ZX has published more than 50 papers. The synthetic turbulence generation method developed by ZX and his team has been implemented in the releases of several widely used CFD packages and many in-house codes worldwide, demonstrating its excellent performance for high-fidelity simulations. He is a Fellow of the Royal Meteorology Society and a Fellow of the Royal Aeronautical Society.

Abstract:

The talk reports our latest research on flows around arrays of sharp-edged cylinders with various sizes and arrangements. Key parameters analyzed include the dimensionless vortex shedding frequency (Strouhal number), and the location where individual wakes merge. Results show that for smooth and turbulent inflows in different angles of incidence, the Strouhal number, based on the freestream velocity and an effective cluster size proposed in this study, closely resembles that of an isolated square cylinder. The Strouhal number is primarily influenced by the solid portion of the array's cross-section, with minor adjustments for porosity. For turbulent inflows with an integral length scale exceeding the cluster size, the Strouhal number decreases markedly compared to smooth inflow cases, indicating a significant influence of inflow large-scale turbulence on cluster dynamics. This study demonstrates the cluster effect of an array of cylinders and proposes a simple approach to quantify this effect.

18:00-18:45 Keynote Presentation 10

Super-Resolution Reconstruction of Incompressible Turbulent Flow Using Deep Learning

Dr. Maokun Ye, Computational Marine Hydrodynamics Laboratory (CMHL), Shanghai Jiao Tong University, China

Brief CV of Invited Speaker:

Dr. Maokun Ye is currently a Post-Doc researcher at Computational Marine Hydrodynamics Laboratory (CMHL), Shanghai Jiao Tong University (SJTU). He received his BSc in Naval Architecture and Ocean Engineering from Dalian University of Technology (DUT), and his MSc and PhD in Ocean Engineering from Texas A&M University (TAMU). His research interest includes high-fidelity CFD simulations of wind turbine wake, aerodynamics of floating offshore wind turbines, application of machine-learning methods in complex fluid dynamics problems and optimization-related tasks.

Abstract:
Turbulent flows, especially at high Reynolds numbers are resource-demanding to resolve using numerical simulations. Due to the multi-scale nature of fully turbulent flows, the spatial resolution in an LES calculation needs to be extremely high, and this results in a formidable number of computational grids, e.g., to the order of 100 million. Therefore, to obtain high-resolution flow field from low-resolution flow data is of great practical interest for turbulent flow predictions. In this talk, we propose a data-driven modeling framework for super-resolution reconstruction of turbulent channel flow from low-resolution flow field, in which the elliptic nature of the mass-conservation in incompressible fluids is leveraged to enhance the performance of neural networks. Specifically, inspired by the attention mechanism which is frequently adopted in natural language processing or time series analysis to capture global correlations among variables, we input pressure data obtained from globally distributed sensors as additional features to infer the local flow quantities, i.e. three instantaneous velocity components. By adopting this strategy, the global correlations among different spatial points are readily taken into account. This work first introduces the generation of high-fidelity training data set by using LES calculations, and the low-resolution flow field is obtained from the high-fidelity field by applying spatial filters. Then, a neural network mapping relation from the low-resolution flow field to the high-resolution flow field is established. Finally, the reconstructed flow fields are visualized and discussed.

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