Mathematical Methods for Marine Sustainability

Mathematical Theory of Long Waves in Coastal Hydrodynamics

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Background and motivation

- Ph.D. in Mathematics, earned from the Université de Tours-Institute Denis Poisson (France) in collaboration with the Lebanese University. Successfully defended on December 9, 2019.
- Research focuses on partial differential equations (PDEs).
- Specialized in dynamic properties of solutions to asymptotic nonlinear water-wave equations and nonlinear dispersive PDEs arising in fluid mechanics and oceanography.

Project description

- The project aims at bridging the fields of theoretical partial differential equations, applied mathematics and numerical analysis to enhance the understanding of wave-induced processes in shallow water dynamic.
- Exploring both the theoretical and numerical capabilities of accurate asymptotic water-wave models.
- A key focus is on providing rigorous asymptotic data on wave-induced pressure forces and loads.
- The project aims to improve numerical models by incorporating stabilizing energy balance equations
- The effectiveness of these enhanced models will be tested through proof-of-concept studies and practical applications in marine sustainability.

Main questions

At the mathematical level, the key challenge lies in addressing the validity and accuracy of the model compared to the original water-wave equations. To tackle this, two fundamental questions arise:

- Can we solve the original water-wave equations on the same time scale as the asymptotic model?
- Is the model a good approximation to the solution, and if so, how close is it to the actual water-wave equations?

Aims (and/or milestones)

- Long-time existence of asymptotic shallow water models
- Developing theoretical estimates for mechanical balance components
- Availability of estimates and of reliable and accurate numerical simulations

Marine sustainability

From the point of view of beach sustainability, understanding sediment dynamics driven by wave action in the nearshore zone is crucial. Recent research has focused on the impact of infragravity waves on nearshore circulation patterns, rip currents, and dune dynamics. To accurately capture these processes, longer time integrations of several hours or more are necessary, necessitating improvements in the time of existence to accommodate longer wave periods.

Highlighted results (and/or activities)

Publications: 6 published papers (scan QR code)

Invited research stay at Universita Politecnica delle Marche, Department of Civil and Building Engineering and Architecture (DICEA), Ancona, Italy (3 weeks). Matteo Postacchini. *"Conducting experimental studies on the wave-induced drift of buoyant particles".*

Conference: - Second Norwegian meeting on PDEs, University of Bergen, Norway.

- CoastLab24 conference, Delft, The Netherlands

- The Bergen-Lund-Trondheim seminar, Bergen Norway

Supervisory team

Supervisor: Henrik Kalisch, Professor and Associate Head, Department of Mathematics at UiB.

Co-supervisors: Mostafa Bakhoday Paskyabi, Associate Professor, Geophysical Institute, UiB.

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