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. My research activity targets mainly the area of partial differential equations, my focus lies on studying dynamic properties of solutions to asymptotic nonlinear water-wave equations and nonlinear dispersive PDEs arising in fluid mechanics and oceanography.

Project description

This project aims to explore the theoretical and numerical capabilities of accurate asymptotic water-wave models. The insights derived from this investigation are crucial for coastal and nearshore marine sustainability applications. Understanding wave-induced loads is vital for marine sustainability, and this project seeks to provide rigorous asymptotic information about pressure forces and induced loads. Additionally, the project aims to enhance existing numerical models by incorporating stabilizing energy balance equations into the approximations. The effectiveness of these enhanced schemes will be evaluated through dedicated proof-of-concept studies and their application to practical cases in marine sustainability applications.

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 and dynamics of asymptotic shallow water models
- Loads on structures and mechanical quantities
- Stabilizing Boussinesq models for numerical treatments

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:

- B. Khorbatly. *Improved local existence result of the Green-Naghdi equations with the Coriolis effect*. Nonlinear Analysis: Theory, Methods & Applications. (2024)
- B. Khorbatly. *Exact traveling wave solutions of a geophysical Bousssineq system*. Nonlinear Analysis: Real World Applications. (2023)
- B. Khorbatly. *Symmetric waves are traveling waves of some shallow water scalar equations*. Mathematical Methods in the Applied Sciences. (2023)

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.

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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