領域論壇：工程力學與計算

Session: Engineering Mechanics and Computation

Venue: 數學館 M310

Time	Speaker	Title of the Talk	Chair
13:50–14:40	陳陽泉	Fractional Calculus: The Core Motivation and Real Applications	王謹誠
14:15–14:40	羅弘岳	Applied Mathematics and Water Wave Mechanics	王謹誠
14:40–15:05	蔡加正	The eigenfunction matching method for water wave scattering by variable structures and bottoms	王謹誠

Fractional Calculus: The Core Motivation and Real Applications

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Abstract

Fractional calculus is about differentiation/integration of non-integer orders. Rejecting fractional calculus is like saying there is no other numbers between two neighboring integers. In this tutorial talk, I will explain the core motivation of fractional calculus by first showing the "core motivation" of (integer-order) calculus invented by Newton and Leibnitz which could be traced back to the time of Heraclitus of Ephesus. My concise messages are that the "integer order calculus" is driven by "the desire and the need" of "quantification of changes" while "non-integer order calculus" is by "the desire and the need of understanding complexities". I then propose the FOT – fractional order thinking and the "better than the best" type of defense of fractional calculus. I will also show some compelling applications in real world as time allows.

References

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[2] H. Sun and Y. Zhang and D. Baleanu and W. Chen and Y. Chen, *A new collection of real world applications of fractional calculus in science and engineering*, Commun. Nonlinear Sci. Numer. Simul., 64 (2018), 213–231, `https://doi.org/10.1016/j.cnsns.2018.04.019`

Applied Mathematics and Water Wave Mechanics

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Abstract

Historically speaking, there is a close tie between applied mathematics and water wave mechanics. In this talk, a brief introduction to the mathematical modelling of water waves will be presented. Particular interest will be paid to the study of tsunamis generated by an underwater landslide. By analyzing the Laplace equation subject to linearized boundary conditions and also the linearized wave equation, several insights can be gained into the wave generation process of landslide tsunamis: 1) the tsunami generated by an underwater landslide consists of a free wave component that propagates freely and a locked wave component that follows the landslide; 2) the leading wave of the free wave component is primarily governed by the volume enclosed by the landslide, not its exact shape; 3) the locked wave component posesses the same amount of wave energy as the free wave component; 4) the locked wave component may appear deceivingly small in wave amplitude but with large flow velocities; 5) a maximum total wave energy exists as a function of the landslide travel time, which corresponds to the worst-case scenario. This talk shall outline the mathematical derivation for the above findings and seeks to highlight the practical value of the mathematical analysis.

Keywords water wave mechanics, tsunamis, Laplace equation, wave equation

The eigenfunction matching method for water wave scattering by variable structures and bottoms

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Abstract

In this talk, I will introduce my recent studies on the eigenfunction matching method (EMM) for solving problems of water wave scattering. These include problems of viscous or inviscid waves scattering and/or breaking by arbitrary bottoms, tension-leg, and/or surface-piercing structures. The Bragg reflections of oblique water waves by series of periodic surface-piercing structures and bottoms are also reported. By the assumption of small wave amplitude, the linear wave theory is employed in the EMM formulations. In the solution procedure, the tension-leg or surface-piercing structures and bottoms are sliced into a number of shelves separated by abrupt steps. On each shelf, the solution is composed of eigenfunctions with unknown coefficients that represent the wave amplitudes. By the conservations of mass and momentum, a system of linear equations is obtained and then solved by a sparse-matrix solver. The proposed EMM is validated by several examples in the literatures. Numerical results indicate that the EMM are accurate up to four decimal places.

Keywords: Eigenfunction matching method; Step approximation; Tension-leg structure; Surface-piercing structure; Weak viscous Bernoulli's equation; Oblique wave; Bragg reflection; Wave breaking