Blog: Directionally Spread Surface Wavepackets subject to an Abrupt Depth Transition (ADT)

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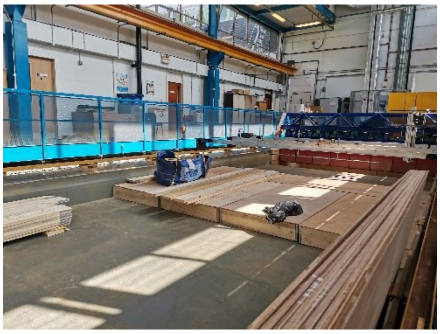
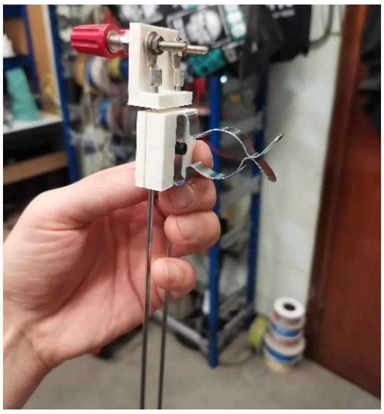
Rogue waves have the potential to catastrophically damage offshore structures and cause loss of life and hence are the subject of significant research effort. One recent mechanism proposed for the formation of such waves is interaction with an abrupt depth transition (ADT). Recent research in this area has shed light on this formation mechanism along with an understanding of the nature of the wave conditions that can occur. Specifically, free second-harmonic waves are released at the ADT and interact with the main wave train creating an interference pattern atop the ADT. At the antinodes of the second-order beating pattern very large wave crests are observed and the probability of encountering a rogue wave increases drastically (probabilities 100 times larger than would be expected are reported in [1]).

The vast majority of our current understanding on wave-ADT interaction is based on unidirectional waves normally incident to the ADT. This project aimed to extend this understanding to the more realistic case of directionally spread and obliquely incident waves. Experiments were planned for the University of Manchester Wide Flume where angled wave components can be generated. In order to carry out experiments in a wide flume, a wide false floor was required. This was designed to be constructed out of marine ply and scaffold boards and ballasted with gravel. 3.2 tonnes of gravel were required to ballast the floor.



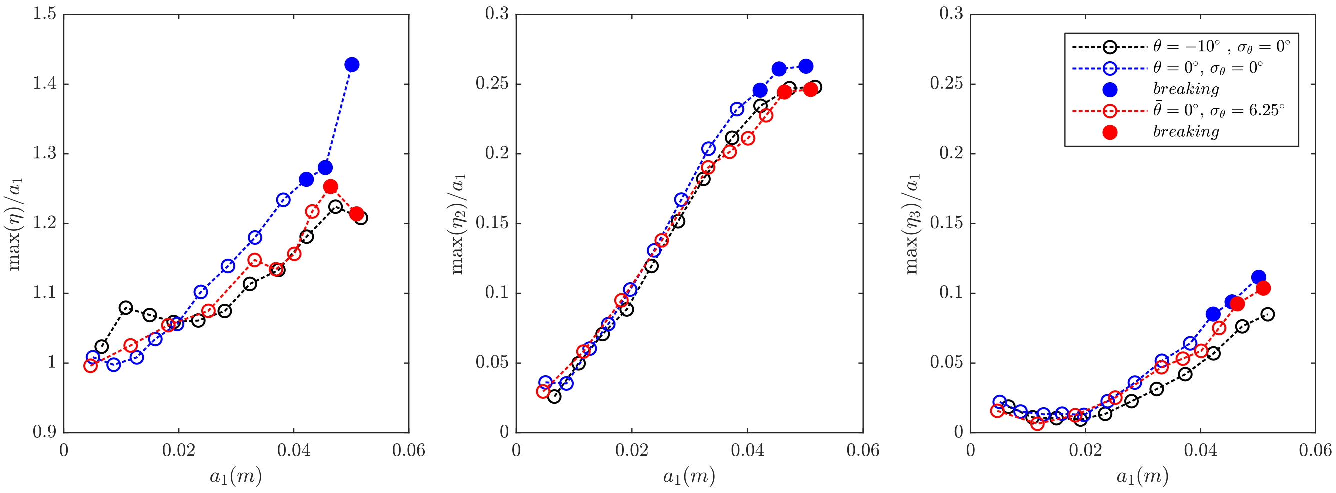
In addition to the false floor, new wave gauges were designed, 3D printed, and constructed to enable appropriate measurement of the area of interest. A new frame for wave gauge calibration was also constructed to enable calibration of all gauges together. Around this time, Miss Charlotte Moss joined the group and began helping with the experiments and will continue research in this area as part of her PhD.



After ironing out some remaining issues with wavemaker sensors, leaks, and synchronisation, we began the experimental campaign. The plan consisted of three main sets of tests:

1. Unidirectional, directionally spread and oblique wavepackets of constant amplitude: to understand the effect of directionality on the free-bound interaction
2. Wavepackets of increasing amplitude (unidirectional, spread and oblique): to understand the nature and role of higher harmonics, building on understanding from [2] for regular waves
3. Directionally spread and unidirectional irregular waves: to quantify the difference in (extreme) wave statistics in directional conditions

Analysis is ongoing, which will be supported by numerical modelling and theoretical work. Preliminary analysis indicates that directional spreading and oblique angles of incidence slightly reduce the peak values of surface elevation and the magnitude of harmonics (see below), resulting in a difference in the deeper-side amplitudes associated with the onset of wave breaking. Once analysed appropriately, the results will improve our understanding of the physical mechanisms at play in realistic 3D waves. This improved understanding will enable more appropriate and safe structural design of offshore structures along with operational procedures for locations near to ADTs.



From a development perspective, the project has also enabled me to develop the tools (sea generation, analysis, synchronisation etc.) and measurement techniques used in the laboratory. This will be beneficial to subsequent research and student projects in the laboratory, of which many are being planned.

References

[1] Y. Li, S. Draycott, Y. Zheng, Z. Lin, T. A. A. Adcock, and T. S. van den Bremer, "Why rogue waves occur atop depth transitions," *J. Fluid Mech.*, vol. 919, pp. 1–11, 2021.

[2] S. Draycott, Y. Li, P. K. Stansby, T. A. A. Adcock, and T. S. van den Bremer, "Harmonic-induced wave breaking due to abrupt depth transitions: An experimental and numerical study," *Coast. Eng.*, vol. 171, p. 104041, 2022.