A Generic Wave Generation and Wave Relaxation Framework

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Abstract

The purpose of this abstract is to present the state of development of a generic wave generation routine. At present no generic implementation for the generation of regular or irregular waves are available to be used together with the multiphase solvers such as interFoam or rasInterFoam. The only available method is the one presented by [1] using groovyBC. This was seen to have limited applicability for complex wave theories such as higher order waves theories or irregular wave trains.

The present implementation consists of a number of parts, namely (1) a set of boundary conditions for velocity, phase fraction and normal pressure gradient, (2) an abstract class for the wave theory, (3) derived hereof a number of wave theories, (4) a method for relaxing the waves at inlets and outlets, (5) a geometric class evaluating face/volume intersections with a given surface, and (6) a preprocessing tool used to specify a given wave theory throughout the computational domain. The method for choosing a given wave theory is strongly inspired from the method used for e.g. turbulence models. The code structure of the implementation is presented.

At the boundaries and inside the relaxation zones the wave theory needs to be evaluated as a function of space and time, however only for cells which are below the water surface. For this purpose the intersection between the surface and a face or a computational volume is found and the wave theory is evaluated in the wet center of the face/volume. The relaxation zone is implemented using an approach different from [1], namely using an explicit weighting technique such as used by [2]. The user is not restricted to a given number of relaxation zones and the implementation allows for the relaxation zones to be used both at inlets and outlets, see an example in figure 1. Here the inlet relaxation zone is colored green and two outlet relaxation zones are colored red and yellow respectively. At the tip of the arrows in figure 1 the solution is not relaxed, and at the tail of the arrows the solution equals the target solution in the relaxation zones.

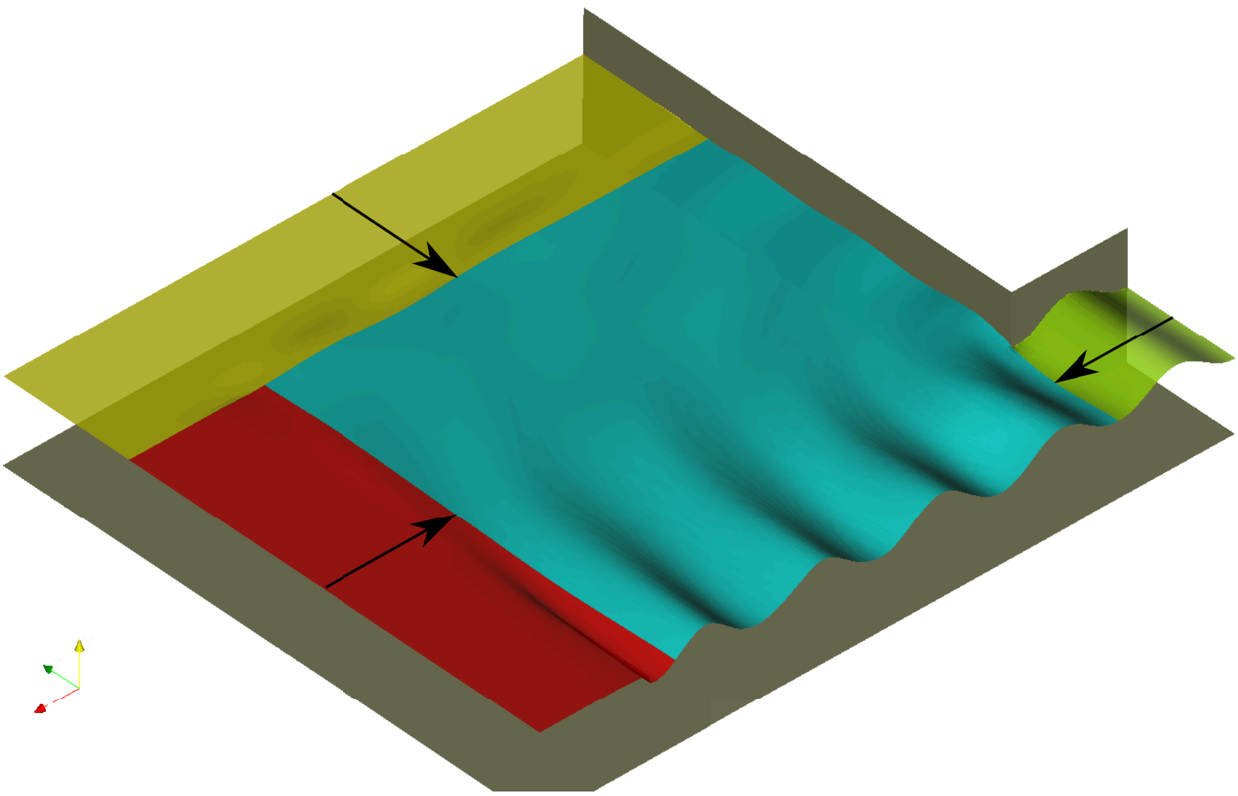

Figure 1: Diffraction of surface water waves through a breakwater gap. The three relaxation zones are the green, yellow and red areas respectively. Arrows indicate the direction of zero relaxation.

Example of the use of the different wave theories and the use of the relaxation zones is considered. The results are compared with analytical and experimental results. Also modeling of wave forces from over-turning phase-focused waves on bottom mounted cylinders, see [3], is presented. Finally the amount of reflection from an outlet relaxation zone is quantified.

The generic implementation in OpenFoam makes it straight forward to implement new wave theories to be used in the present framework, as the boundary conditions and relaxation zone technique only implements the abstract base class, (2). Thus merely knowing the temporal and spatial variation of the velocity and pressure fields together with the surface elevation allows for the addition of complex wave theories within hours and still having the full functionality of the framework.

Key words: Wave generation, relaxation zones, wave modeling, validation

References

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