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WAVE ENERGY CONVERTER MODELLING IN DUALSPHYSICS

Background on Smoothed Particle Hydrodynamics – DualSPHysics

- Discretization of domain in a set of **Lagrangian points**, or **particles**.
- Approximation of a generic function F at position r_a :

$$F(r_a) \approx \sum_b F(r_b).\frac{m_b}{\rho_b} W(r_a - r_b, h)$$

- Summation over all neighboring particles b that fall within the support of the Kernel, defined by the smoothing length h.
- W is defined as the **Kernel function**, usually cubic or quintic..

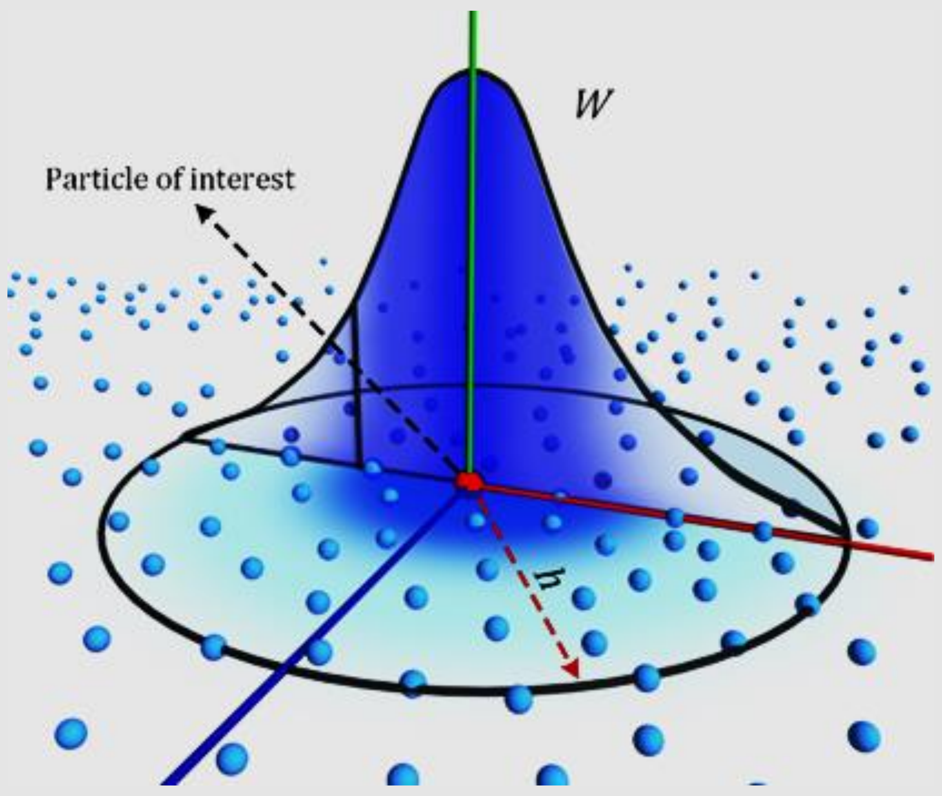

Fig. 1: Kernel function W with smoothing length h

- **Momentum conservation** equation in SPH:

$$\frac{dv_a}{dt} = -\sum_b m_b \left(\frac{P_b + P_a}{\rho_b . \rho_a} + \Pi_{ab} \right) \nabla_a W_{ab} + g$$

- **Continuity** equation in SPH:

$$\frac{d\rho_a}{dt} = \sum_b m_b v_{ab} . \nabla_a W_{ab}$$

Objectives and methodology

The main objectives of the WECANet COST Action CA17105 Short Term Scientific Mission were to acquire the skills to perform:

Basic simulations of Wave Energy Converters (WECs) in DualSPHysics:
- Standard WEC geometries and regular wave conditions.
- Wave tank/basin with attention to wave generation, propagation, reflection and absorption (passive and active).
- Post-processing tools for representation of motion data of floating objects, data of water surface elevation and data of acting forces.

Advanced simulations of WECs in DualSPHysics:
- User-defined WEC-geometries.
- Inlet/outlet open boundary conditions.
- Coupling with Project Chrono: Allows modelling of mechanical constraints, which is useful for PTO system modelling [2].
- Coupling with Moordyn: Allows simulation of moored floating structures, with defined mooring characteristics [3].

Results from basic simulations in DualSPHysics

Simulations were performed with a heaving cylinder in regular waves. Figure 2 shows a Paraview visualization of this test case.

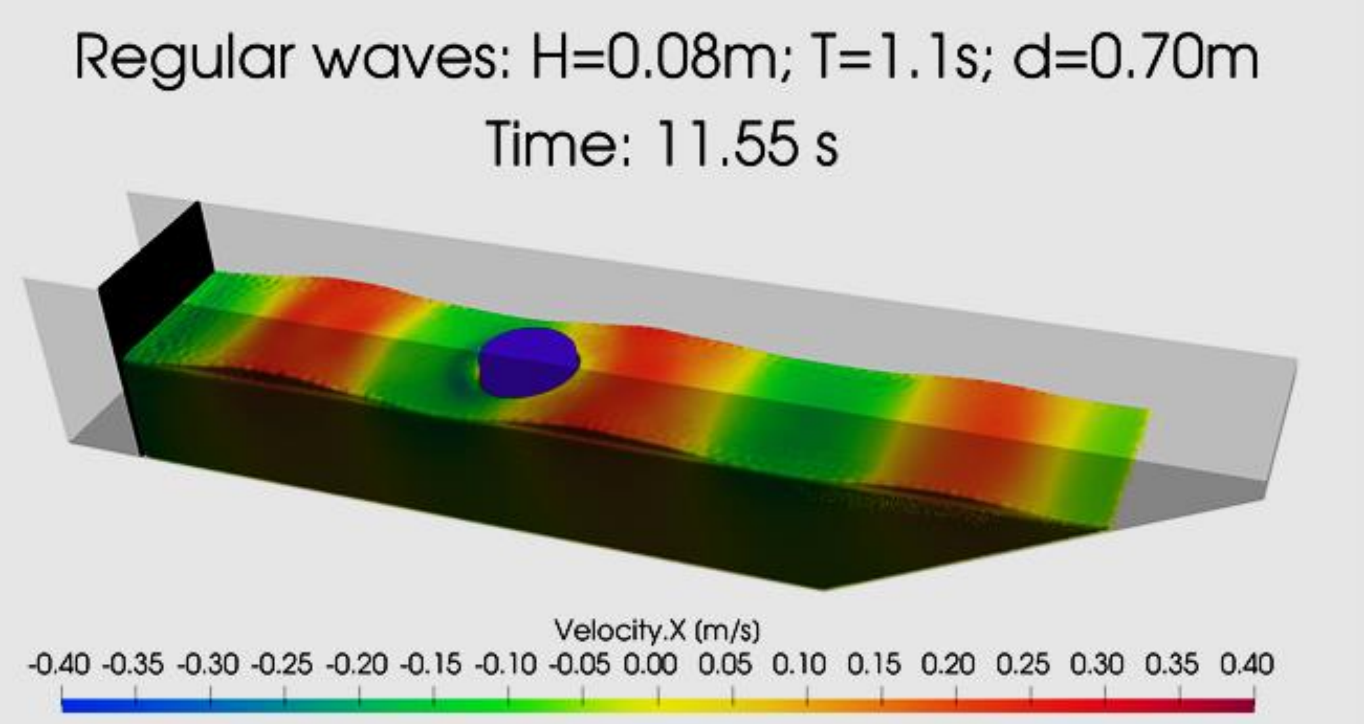

Fig. 2: Paraview visualization of wave velocities (in the wave propagation direction) of a heaving cylinder simulated in regular waves in DualSPHysics

Results from advanced simulations in DualSPHysics

The **coupling between DualSPHysics and Project Chrono** [2] allows the addition of mechanical constraints (hinges, springs, joints, etc.) to the domain, which can be used to study Power Take-Off systems of WECs. Figure 3 shows the connection of a floating box to the seabed with a linear spring, modelled in 2D in DualSPHysics.

The **DualSPHysics-MoorDyn coupling** [3] allows the addition of mooring lines to the domain, which can be used to study mooring configurations of WECs. The coupling was used to compare numerical results with experimental results of a moored floating box, connected to the seabed with 4 mooring lines [3]. Figure 4 shows this numerical set-up.

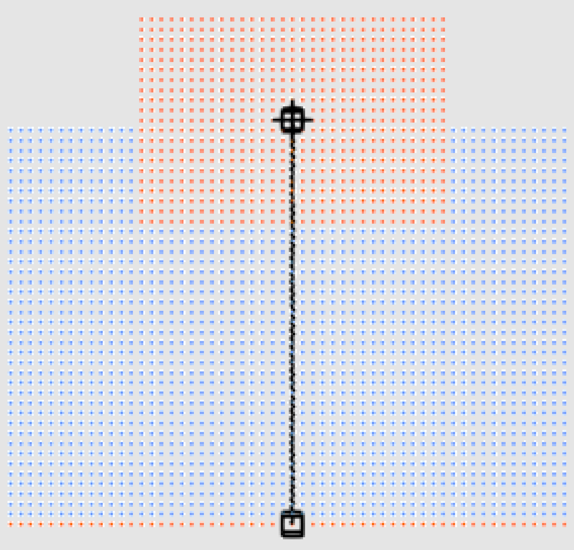

Fig. 3: Floating box connected to the seabed with a linear spring.

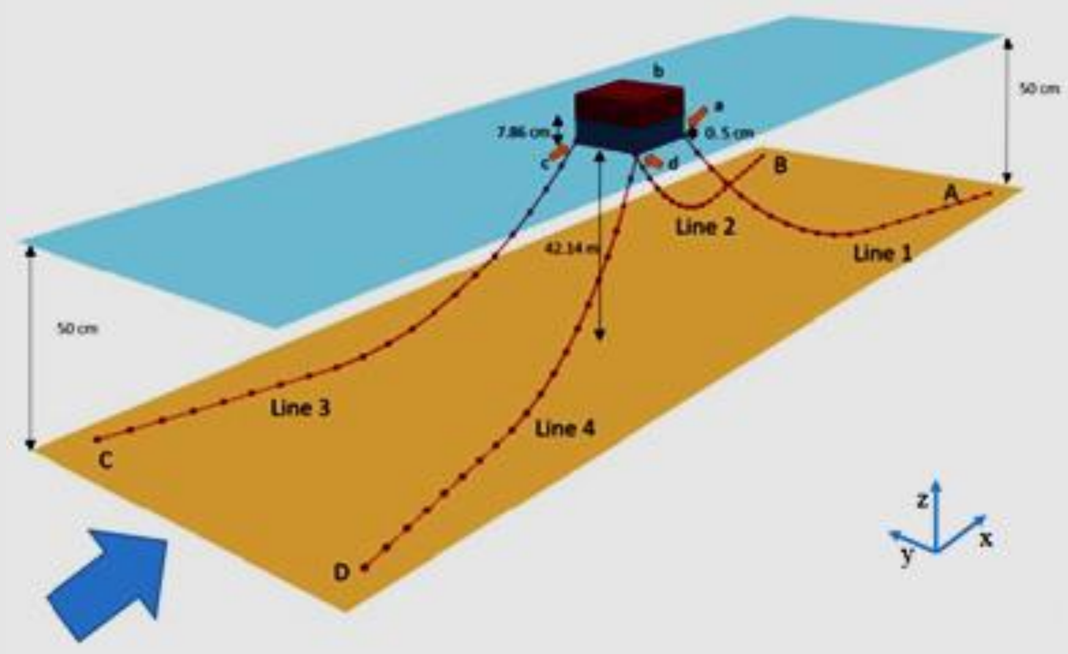

Fig. 4: Numerical set-up of the floating box moored with four lines [3]

Conclusion

The coupling with Chrono and MoorDyn proved to be applicable to model WECs with a PTO and mooring configuration, respectively. The conducted STSM provided the applicants an intensive training in DualSPHysics, which allows them to apply this numerical tool on their own wave energy converter research cases.

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