How can a heaving wave energy converter (WEC) be modelled accurately in operational and extreme sea states?

**Modelled WECs and PTO-systems**

**Heaving WEC**
- Flat shape increases radiation effect
- Based on commercial
- WECs: Carnegie, SINN Power

**PTO-system**
- Linear PTO-system
- Coulomb damping, as a simplified model of a hydraulic PTO-system

**Using the numerical model, WEC-Sim**
- Model PTO-system
- Time domain
- Calculate absorbed power

**Comparing WEC-Sim vs. DualSPHysics**
- WEC-Sim overestimates heave motion of WEC at resonance due to non-linear effects.
- Vorticity in close proximity of the WEC is visible in DualSPHysics. This vorticity increases with increasing relative velocities and causes energy losses.
- DualSPHysics applies correct wave-shape according to Stokes 2nd order theory.
- Optimal PTO-damping for linear or Coulomb PTO-system seems to be larger in DualSPHysics than in WEC-Sim.
- DualSPHysics can be used to estimate the drag coefficient of the WEC. Viscous drag can be included in WEC-Sim, resulting in more realistic results.

**DualSPHysics**
- DualSPHysics applies the Smoothed Particle Hydrodynamics method (SPH), a Lagrangian meshless method.
- DualSPHysics discretizes the fluid in particles: physical quantities are computed as an interpolation of the values of neighbouring particles.
- Allows calculations of WECs in extreme sea states.

**Using the numerical model, DualSPHysics**
- Coupled with Chrono Engine: allows modelling effect of PTO-system
- Time domain

**Effect of the PTO-system on the non-linear effects**
- Adding a PTO-system causes a phase shift of the WEC’s heave motion relative to the wave elevation. This increases the relative velocities between WEC and water particles, resulting in higher vorticity.
- Difference between linear damping and Coulomb damping still to be further investigated.

**Future work**
- Add a drag coefficient in WEC-Sim to consider the effect of viscous drag.
- Compare the modified wave field with both PTO-systems in DualSPHysics with the results from linear calculations.

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