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COMPUTATION OF SHIP MOTION IN WAVES, USING CARTESIAN CUT-CELLS

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Ice accretion is a well-known issue for vessels that operate in cold marine environments. The accumulation of ice on ships is the result of the liquid freezing in form of spray, produced either by wave impact on the structure, or arising from droplets generated from the wind-waves interaction. The largest contribution to icing is made by the waves-structure collision, where the spray droplets can deposit on the ship's structure and build up large ice loads very quickly. Thus, it is of great importance to have a good insight of the generation and characterization of wave impact sprays. However, this topic has received little attention due to its complexity. Our work aims to address this issue by means of numerical simulation methods. The challenges of the numerical study of wave impact sprays are twofold: the first concerns the numerical representation and solving of the waves-structure interaction, and second, the generation of droplets and their possible accretion on the vessel. The present work focuses on the computation of ship motion impacted by waves using an in-house CFD code.

The mass and momentum conservation equations are solved using the finite volume approach, with application of Cartesian Cut-cells method for the treatment of cells containing both fluid and solid. Interface tracking is ensured by the level set method and the ghost fluid method is used to handle sharp discontinuities at the liquid/gas interface. A coupled level set-VOF method is used for mass conservation. Several validations have been made to ensure the accuracy of the numerical methods [1,2]. The ship solid surface is represented by a level set function, which is computed from a Standard Triangle Language (STL) file format [3]. The STL file encodes the surface geometry of a 3D object, and it stores the information of each triangle that is used to tessellate the 2D outer surface. A simple and efficient approach is proposed in our work, that allows to extract the level set from the STL file and insert it into the Cartesian mesh. To reduce the complexity of the dynamic interaction between the waves and the vessel, two assumptions are made. First, the vessel is assumed rigid, with mass and mass distribution known. Second, the vessel motion induced by the wave impact is considered small enough such that the centripetal effects can be neglected. The conservation of angular momentum will then allow to obtain three coupled equations for the time variation of the angular velocity, related to the inertia tensor of the ship and the torques of fluid forces acting on the solid. Their resolution describes the motion of the ship generated by the wave impact.

The study of droplets generation from the wave impact and their accretion on the vessel is one of the perspectives of this work.

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