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The Acoustic Signature of a Contra-Rotating Propeller in Wetted Conditions

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ABSTRACT

Results of high-fidelity computations, using a Large-Eddy Simulation approach, are utilized to reconstruct the acoustic signature of a contra-rotating marine propeller in wetted conditions, by exploiting the Ffowcs Williams & Hawkings acoustic analogy.

The analysis of the flow physics demonstrates a substantial impact of the interaction of the tip vortices shed by the front and rear propellers on the topology of their overall wake. The system of isolated tip vortices, typical of conventional propellers, is replaced by isolated vortex rings, whose lobes originate alternatively from the tip vortices shed by the front and rear propellers, respectively. The shear between consecutive rings gives rise to isolated U-shaped lobes, which are regions of higher turbulent stresses. This shear promotes also a faster instability of the overall wake system, in comparison with that typical of isolated propellers working alone. Details on the flow physics of the near wake are reported in the works by Capone et al. (2021), Pereira et al. (2021) and Posa et al. (2024).

The recent literature (Ianniello 2016, Cianferra et al. 2019, Posa et al. 2022) pointed out the importance of the non-linear component of sound in the overall acoustic signature of marine propellers, which is often neglected in comparison with the linear one. The results of the present study highlight that in the particular case of contra-rotating propellers the role of the non-linear sound is even reinforced. This is the result of the increased vorticity and turbulence of the wake system, as a direct consequence of the enhanced levels of shear between the major wake structures shed by the two propellers of the contra-rotating system.

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