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Water waves interacting with a current of constant vorticity: estimating the vorticity of the wave field

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During the last ten years, the topic of water waves interacting with sheared current has drawn a lot of attention, since the interaction of water waves with vorticity was recently found to be significant when modeling the propagation of water waves. In this framework, the configuration involving constantly sheared current (indeed a constant vorticity) is of special interst, since the equations remain tractable. In this framework, it is demonstrated that the flow related to water waves can be described by means of potential theory, since the source term in the vorticity equation is proportionnal to the curvature of the current profile (Nwogu, 2009).

In the mean time, the community often wonders if this argument is valid, since the existence of a perfectly linearly sheared current is purely theoretical, and the presence of the vorticity within the wave field can be external (through wave generation mechanisms, for instance). Thus, this work is dedicated to investigate the magnitude of the vorticity related to the wave field, in conditions similar to this analytical case of constant vorticity.

This approach is based on the comparison of experimental data, and three models. The first model is linear, supposing a constantly seared current and water waves described by potential theory. The second is fully nonlinear, but still supposing that water waves are potential, and finally, the third model is fully nonlinear, but solves the Euler equations, allowing the existence of vorticity related to the waves. The confrontation of these three approaches with the experimental data will allow to quantify the wave-related vorticity within the total flow, and analyze its importance as a function of nonlinearity and vorticity magnitude.

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