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Vortices and water waves

The study of rotational flows of an inviscid incompressible fluid with free boundary is of high theoretical and practical interest (e.g., the evolution of surface waves on the ocean, their approximation by model equations, the dynamics of wave interactions). The vorticity is the key quantity in the analysis of the fluid motion.

We consider a two-dimensional water-wave problem with a general non-zero vorticity field in a fluid volume with a flat bed and a free surface.

The nonlinear equations of motion for the specified surface and volume variables are expressed in closed form. These equations describe a complicated interaction between the surface and the volume, so that a simple reduction of the model only to the surface variables is not possible.

As an example we present a point vortex and its interaction with the free surface of the fluid. In the small-amplitude long-wave Boussinesq and KdV regimes, we obtain a simplified system of coupled equations for the motion of the vortex and the time evolution of the free surface.

References

D. Ionescu-Kruse, R. Ivanov, Nonlinear two-dimensional water waves with arbitrary vorticity,Journal of Differential Equations 368 (2023) Pages 317–349,
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