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Weakly nonlinear solution of the Cauchy-Poisson boundary value problem in the presence of uniform vorticity

Andreas Holm Akselsen and Simen Ådnøy Ellingsen
NTNU, Department of Energy and Process Engineering, Trondheim, Norway (andreas.h.akselsen@ntnu.no)

We investigate the weakly nonlinear dynamics of gravity ring waves at infinite depth under the influence of a shear current varying linearly with depth. The shear field makes this problem three-dimensional in nature and, though it cannot be treated using potential theory, a solution is permitted via integration of the Euler equations. These solutions are derived to second order of the perturbation amplitude.
To second order, irrotational wave dynamics interact with the background vorticity field in a way that creates new vortex structures. A notable example of this is the large parallel vortices which drive Langmuir circulation as oblique plane waves interact with the ocean current. Such interactions are found to also generate near-field vortex structures in the Cauchy-Poisson problem, and create additional groups of dispersive ring waves.
The second order solution is derived in a general manner which accommodates any initial condition through mode coupling over of the full wave spectrum. It is therefore applicable to a vast range of problems including special cases of resonance.