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Vorticity effects on nonlinear wave-current interactions in deep water

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The effects of uniform vorticity on a train of ‘gentle’ and ‘steep’ deep-water waves interacting with underlying flows are investigated through a fully nonlinear boundary integral method. It is shown that wave blocking and breaking can be more prominent depending on the magnitude and direction of the shear flow. Reflection continues to occur when sufficiently strong adverse currents are imposed on ‘gentle’ deep-water waves though now affected by vorticity. For increasingly positive values of vorticity, the induced shear flow reduces the speed of right-going progressive waves introducing significant changes to the free-surface profile until waves are completely blocked by the underlying current. A plunging breaker is formed at the blocking point when ‘steep’ deep-water waves interact with strong adverse currents. Conversely negative vorticities augment the speed of right-going progressive waves with wave breaking being detected for strong opposing currents. The time of breaking is sensitive to the vorticity’s sign and magnitude with wave breaking occurring later for negative values of vorticity. Stopping velocities according to nonlinear wave theory proved to be sufficient to cause wave blocking and breaking.