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Recent numerical calculations of two-dimensional jets induced by breaking-wave impact: a comment

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Comment

In the work of Cooker & Peregrine (1991) computational results were reported for a wave breaking against a vertical wall. In the absence of the wall the wave overturns as a plunging breaker, with particle accelerations which are at most $4g$, at points under the curved arch of the wave. Initially the wave is long, with small initial slope, but as time proceeds the wave steepens, until at a certain instant the water surface first achieves a tangent which is vertical. This breaking point enables us to place judiciously a vertical wall against which the wave can break. (This was achieved by computing a fluid domain which is symmetric about $x = 0$.) By shifting the initial position of the wave, relative to the wall, impacts of greater or less violence can be computed.

At least two different types of impact are identifiable. The first type (type I) occurs if a wave overturns before it reaches the wall, then it can capture a pocket of air against the wall. However, the computations must be halted when the horizontally moving jet strikes the wall (see Zhang *et al.* 1996).

The second type of impact (type II) occurs if the wave has insufficient time to overturn before meeting the wall, then there forms a narrow region of fluid, adjacent to the wall, which ascends as a vertical jet (see figure 1). The jet is generally launched upward with a large initial acceleration. An indication of the violence of the jet is the maximum computed acceleration, which sometimes exceeds $10\,000g$. The most violent jets are thinnest and of greatest tip velocity.

In accordance with the observations of Longuet-Higgins & Oguz (this volume) on axisymmetric collapse of bubbles, it was found that the most violent jet coincides with the borderline between type-I and type-II wave impact. In this case the vertical jet ‘flips through’ between the wall and the shoulder of the horizontally advancing wave.

The computations conducted do not contain any numerical smoothing and the same violent flow occurs despite changes in discretization of the free surface, or changes in convergence criteria within the numerical algorithm.

It is interesting to note for flip-through-type motion that: (a) the initial width of the vertical jet is not zero and is typically two to three orders of magnitude smaller than the still water depth; (b) the accelerations are three to four orders of magnitude greater than g; and (c) the vertical velocity of the jet ascent is 10 or 20 times the wave celerity. For the borderline case, between wave overturning and vertical jet formation, it is an open question as to how to predict the width, speed and acceleration of the

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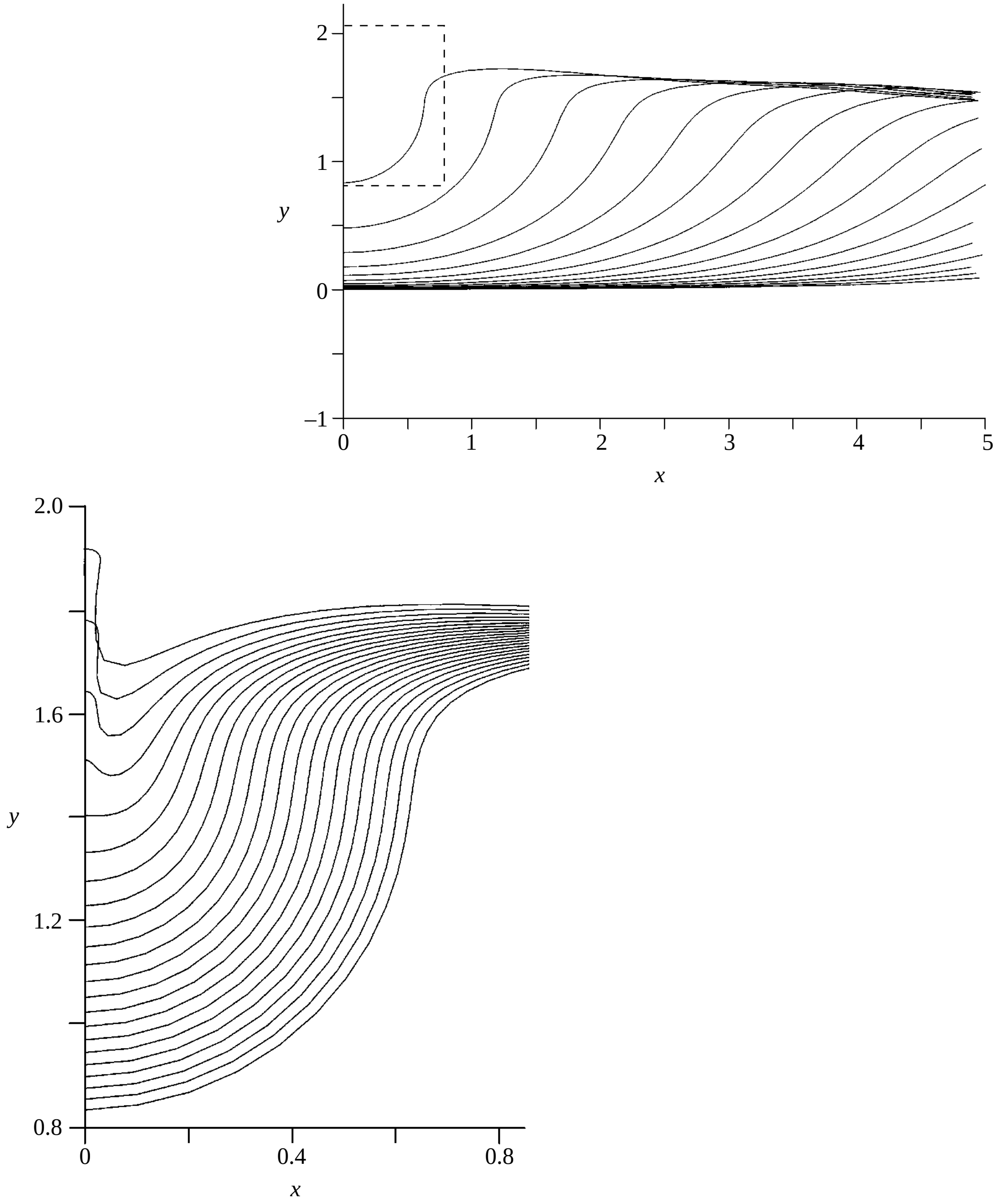

Figure 1. (*a*) Free-surface profiles of a wave of initial height 1.5, on a still-water depth $h = 1$, approaching a vertical wall at $x = 0$. Times shown are $t = 0, [0.25], 4\sqrt{h/g}$. The later motion, in the dashed box, is shown in detail in (*b*). (*b*) Detail of free-surface motion following that shown in (*a*). A vertical jet forms and flips-through between the wall and the horizontally advancing shoulder of the wave. Times shown are $t = 4.00, [0.01], 4.21\sqrt{h/g}$.

jet (or spray root) which occurs, from gross measures of the fluid mass which is undergoing impact. Cooker & Peregrine (1995) show how to model some important features of violent flow using the idea of pressure impulse. To some extent these simplified calculations show that the free surface velocity after impact is sensitive only to the flow before impact near the waterline.

New computations are being undertaken.

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