Laminar free-surface flow around emerging obstacles : Role of the obstacle elongation.

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A rectangular obstacle placed in a boundary layer developing under a free-surface generates three swirl structures: a horseshoe vortex (HSV) in front of the obstacle, a wake downstream and lateral recirculation zones at its sides. The present work investigates, through PIV measurements, the effect of the obstacle elongation (length over width L/W) on those three structures and on their interactions.

Horizontal velocity fields in the near-bottom region show that increasing the obstacle elongation (L/W) leads to: (i) a longitudinal extension of the HSV, due to the modification of the adverse pressure gradient generated by the obstacle, (ii) an expansion of the lateral recirculation zone, whose size stabilizes for $L/W > 4$, and (iii) a modification of the wake lateral extension, in regards to the flow deflection provoked by the lateral recirculation zones.

Spectra and oscillation direction maps (figure 1) obtained from velocity fields indicate that each structure has a proper frequency. The oscillation associated to the wake is dominant in terms of energy and is strong enough to travel upstream, impacting, for sufficiently short obstacles, both the lateral recirculation zones and the HSV.

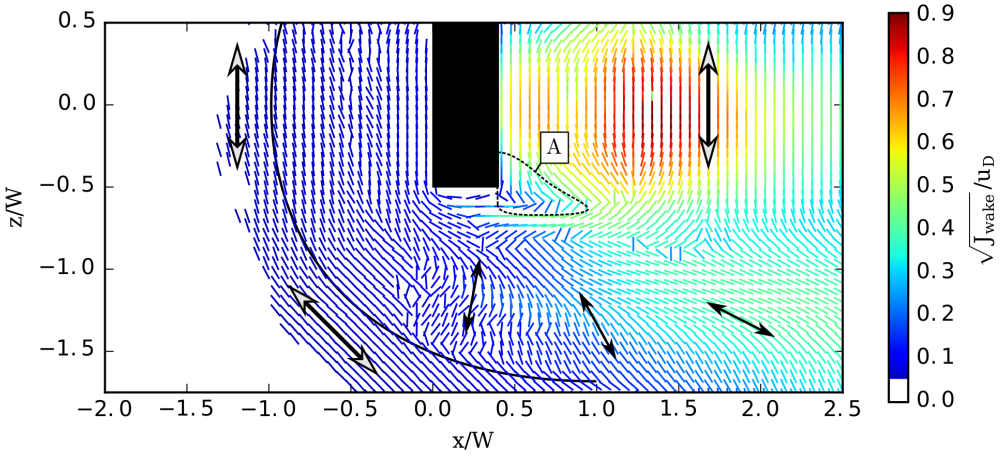

Figure 1: Map of the main oscillation directions (rods) and oscillation amplitudes (colors) in the horizontal plane for $L/W = 0.4$ and for the frequencies associated to the HSV : $f_{hsv} = 0.025Hz$. Marker A : zone of influence of the lateral recirculation. Black line : boundary layer separation line (delimiting the HSV). White-headed arrows indicate the circular oscillation due to the wake. Black-headed arrows indicate the oscillation perturbations due to the HSV. It is to be noted that the color code differs for (a) and (b).