Unstable Vortex Merger

Submitted by
P. Meunier and T. Leweke, CNRS/Universités Aix-Marseille

We present visualizations of the merging of two initially laminar co-rotating vortices. The vortices are generated in water, at the edges of two flat plates impulsively started from rest, and visualized using fluorescent dyes.

The upper photographs show a side view (left) and a cross-cut view (right) of the three-dimensional instability which appears when the Reynolds number (based on the circulation of one vortex) exceeds approximately 2000. This instability leads to internal deformations of the vortex cores, visible in the side view as wavy deformations of the vortex centerlines, and in the cross-cut view as a pronounced loss of symmetry. This distinct spatial structure of the perturbation is a characteristic sign of an elliptic instability, which is here observed for the first time in a co-rotating vortex pair. The visualizations also show that the perturbations of both vortices are in phase, i.e., that the instability develops in a cooperative way.

At later stages, perpendicular secondary structures are generated when fluid initially orbiting one vortex is drawn around the other vortex. This leads to a rapid breakup of the flow into small-scale motion (lower images). The two vortices still merge into a single final vortex. This merging begins earlier than in the absence of the instability and leads to a bigger and more turbulent final vortex.