Behaviour of a vortex in a time-periodic shear flow

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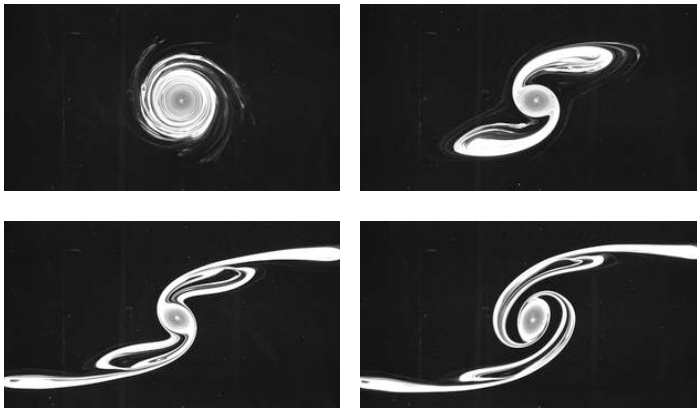
In order to investigate the behaviour of vortices in a two-dimensional turbulent background flow, the generic situation of a single monopolar vortex in a time-periodic shear flow has been studied, both experimentally and numerically. Although the situation of a vortex in a constant adverse or cooperative shear flow has been analysed to some extent in previous studies [1, 2], the unsteady ambient flow introduces time-dependence in the vortex stripping process, which complicates the evolution significantly.
The laboratory experiments were performed in a rectangular fluid tank mounted on a rotating table. A harmonic modulation of the rotation speed of the turntable results in a time-periodic shear flow in the central part of the container. The behaviour of a barotropic vortex generated in that region has been monitored by dye visualization and quantitatively by particle tracking techniques. In particular the dye visualization revealed the complicated nature of the time dependent vortex stripping: filaments of dye that is removed from the vortex are observed to show repeated stretching and folding during the time-dependent perturbation. The advection properties of this time-dependent vortex flow were studied numerically on the basis of a point vortex in a modulated shear flow, by releasing large numbers of tracer particles and by using the contour kinematics method [3].
For the case of small-amplitude shear modulation, the Melnikov theorem was applied to quantify the erosion of the vortex.



Dye visualization a vortex in a periodic shear flow.

[1] B. Legras & D.G. Dritschel – Vortex stripping and the generation of high vorticity gradients in two-dimensional flows. *Appl. Sci. Res.* **51**, 445-455 (1993).
[2] R.R. Trieling, A.H. Linssen & G.J.F. van Heijst – Monopolar vortices in an irrotational annular shear flow. *J. Fluid Mech.* **360**, 273-294 (1998).
[3] V.V. Meleshko & G.J.F. van Heijst – Interacting two-dimensional vortex structures: point vortices, contour kinematics and stirring properties. *Chaos, Solitons & Fractals* **4**, 977-1010 (1994).