Cover Photo

Visualization of Two-dimensional Flows by a Liquid (Soap) Film Tunnel

Gharib, M. * and Beizaie, M. *

** Graduate Aeronautical Laboratories, California Institute of Technology, 1200 East California Boulevard, Pasadena, CA 91125, USA*

e-mail: mory@caltech.edu

This image represents a two-dimensional jet produced in a soap film tunnel (Gharib and Derango, Physica D, Vol.37 pp.406-416, 1989). The small variation of the film thickness results in interference patterns, thus, providing an excellent means for flow visualization. The figure shows a laminar jet (Re number = 25), but the jet fluid has a lower surface tension than the ambient fluid, which results in a large growth rate for the jet.

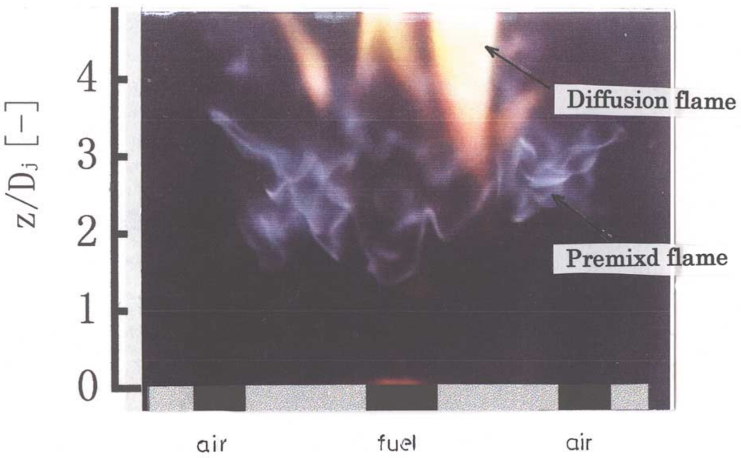
Journal of Visualization, Vol. 5, No. 2 (2002) 115

Lift-Off of Non-premixed Flames on a Bluff-Body Burner

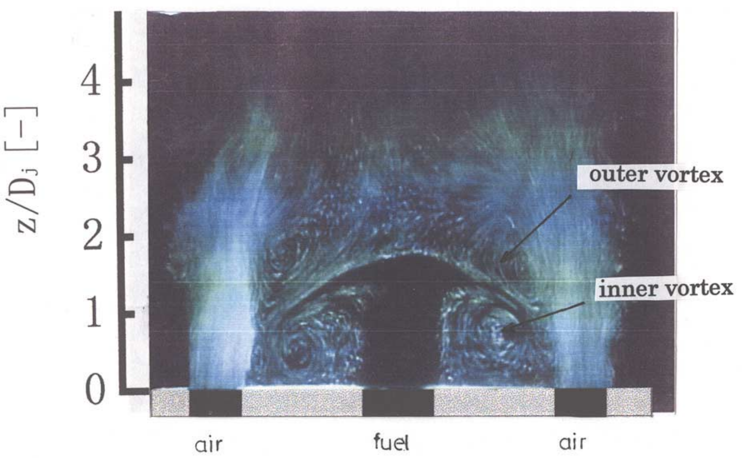
***Nishimura, T.*[1] *, Morio, K.*[1] *and Kawahara, H.*[2]**

1) *Department of Mechanical Engineering, Yamaguchi University, 2-16-1 Tokiwadai, Ube, Yamaguchi 755-8611, Japan*

2) *Shipping Technology Department, Oshima National College of Maritime Technology, Oshima 742-2193, Japan*



Lift-off flame behavior



Flow structure

Non-premixed propane and air flame stabilized by a bluff-body burner in which a central fuel jet issues into a surrounding annular air flow is often used industrially. A direct photograph of lifted flames on a bluff-body burner and the corresponding streak pattern visualized by particle tracers are shown under the conditions of the fuel velocity u_f = 0.637 m/s and the air velocity u_a = 2.69 m/s. The base of lifted flame consists of a circular ring-shaped premixed flame, i.e., separated, broken flamelets. The flamelet structure is not clear but is suggestive of a triple flame. This is because in the approaching flow field a mixture fraction gradient exists. There is also a diffusion flame in the central region above the premixed flame. The two flames violently oscillate due to the unsteady vortical motion behind the bluff-body, but never blow out. It should be noted that this phenomenon occurs at a low central fuel velocity and that the structure of the lifted flame is quite different from that for pure jet diffusion flame. This is due to a recirculation zone behind the bluff-body. This zone is established as a result of the expansion and entrainment of the annular air flow. A pair of counter-rotating vortex rings is observed in this zone, and inner and outer vortices are generated by the central fuel jet and the annular air flow, respectively. The base of lifted flame is found to be located in the edge of the outer vortex, where enhanced fluid mixing occurs because of the unsteady vortical motion.

Journal of Visualization, Vol. 5, No. 2 (2002) 116

Development of Thermally-oscillating Flow and Acoustic Streaming in the Liquid by Ultrasonic Vibrations

Oh, Y. K. [1] ***and Park, S. H.*** [1]

1) *School of Mechanical Engineering, Chosun University, Seosuk-dong, Dong-gu, Gwangju 501-759, Korea*

Under a constant heat flux (q" = 9905.1 $kcal/h \cdot m^2$) boundary condition, the melting of solid paraffin was conducted in a melting cavity as shown in Fig. 1. The melting cavity filled with paraffin was positioned inside the tank which was filled with water. The water in the tank was used in order to protect ultrasonic vibrators from electric overload, a phenomenon that could have happened if ultrasonic vibrations had been applied directly to the solid paraffin in the beginning of the melting. The melting process in the melting cavity with a heated vertical wall was presented under two experimental conditions: natural melting (i.e., without ultrasonic vibrations) and melting with ultrasonic vibrations.

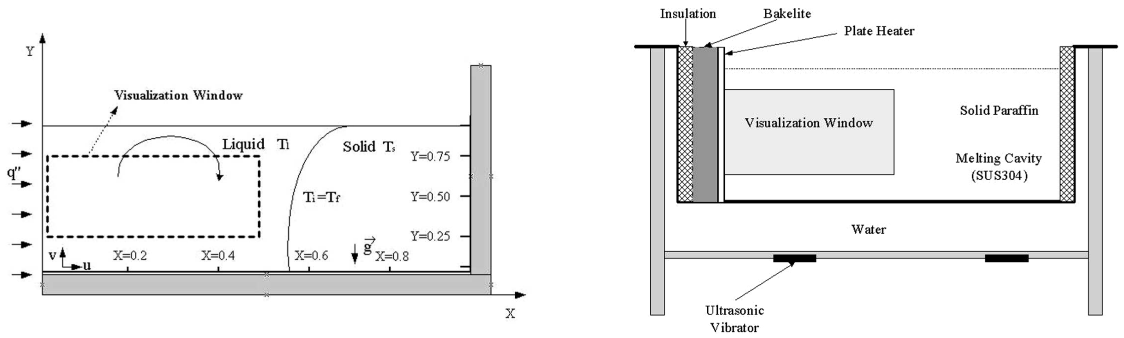
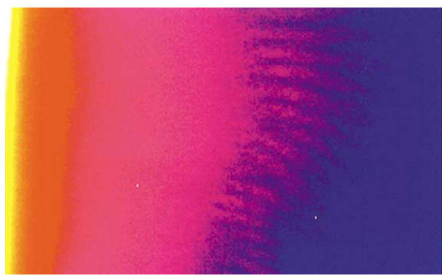
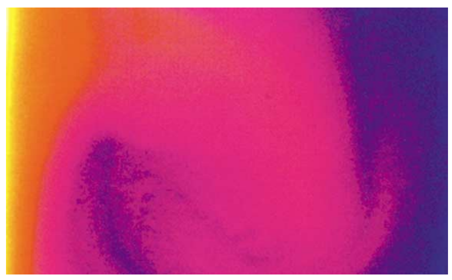


Fig. 1. Two-dimensional model for a melting procedure and schematic diagram of a melting cavity

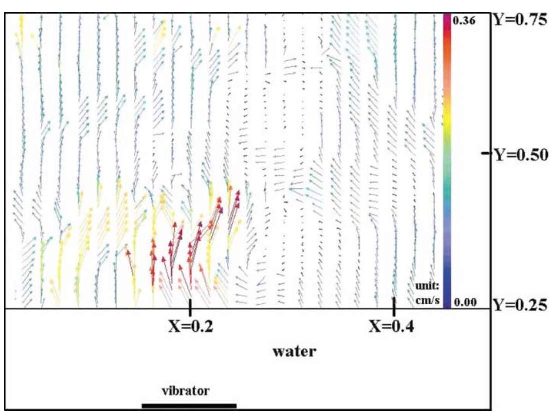
Figures 2(a) and 2(b) show two flow fields captured by an infrared thermal camera: one without the ultrasonic vibrations and the other with ultrasonic vibrations. The induced upward flow caused by an acoustic streaming was also measured using the PIV for the case of the ultrasonic vibration (see Fig. 2(c)). These fluid dynamics phenomena by ultrasonic vibrations could acclerate the heat transfer rate in the liquid.



(a) Melting without ultrasonic vibrations



(b) Melting with ultrasonic vibrations



(c) Two-dimensional velocity profiles induced by acoustic streaming of ultrasonic vibrations

Fig. 2. Thermally oscillating flow and acoustic streaming by ultrasonic vibrations observed at visualization window

Journal of Visualization, Vol. 5, No. 2 (2002) 117

Experimental Study on Flowfield around Hypersonic Space Plane Utilizing the Electric Discharge Method

Nishio, M.[1], *Sezaki, S.*[1] *and Nakamura, H.*[1]

1) *Department. of Mechanical Engineering, Fukuyama University, Fukuyama 729-0292, Japan*
e-mail: m.nishio@fume.fukuyama-u.ac.jp

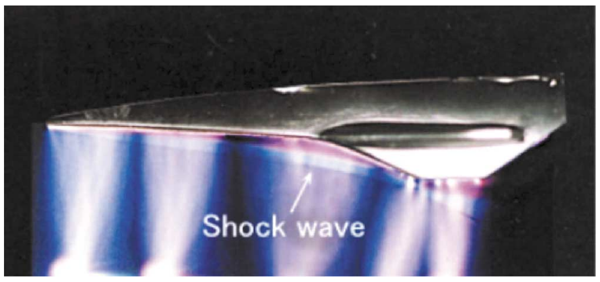


Fig. 1. Lateral shock shape
(Angle of attack is 0˚)

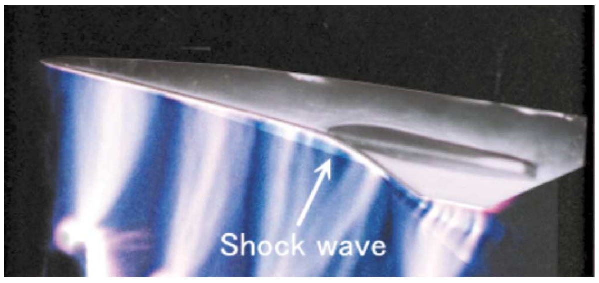


Fig. 2. Lateral shock shape
(Angle of attack is 10˚)

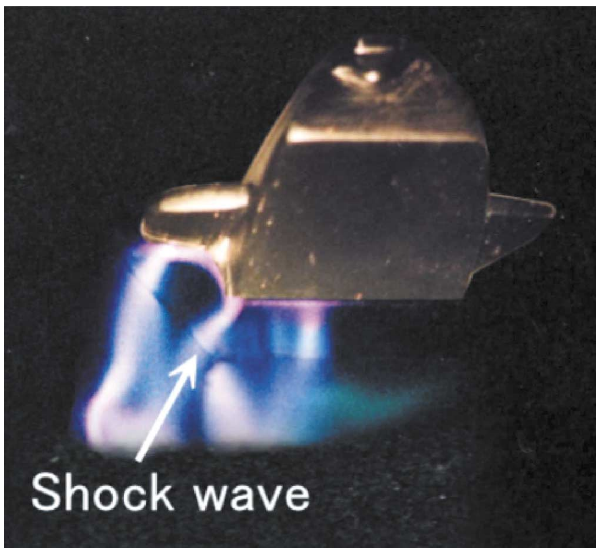


Fig. 3. Back view of shock shape around space plane
(Angle of attack is 0˚)

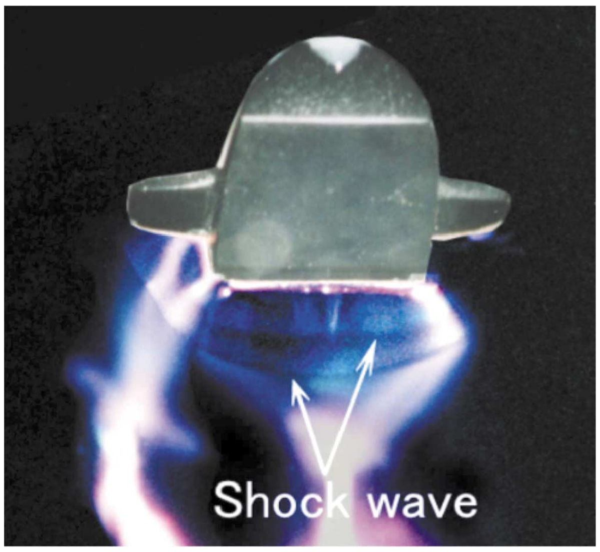


Fig. 4. Back view of shock shape around space plane
(Angle of attack is 10˚)

Figures 1-4 show the flowfield around a space plane traveling at the speed of Mach 10. The visualization of the flowfield was carried out utilizing the electric discharge method. The lateral and cross-sectional shock shapes around the space plane were demonstrated. The experiments were carried out under the condition that the model angles of attack were 0° and 10°.

First, we visualized lateral shock shapes under the model of the space plane. The results are shown in Figs. 1 and 2. Next, we visualized cross-sectional shock shapes under the model. The results are shown in Figs. 3 and 4. These photographs were observed by using the mirror from back of the model.

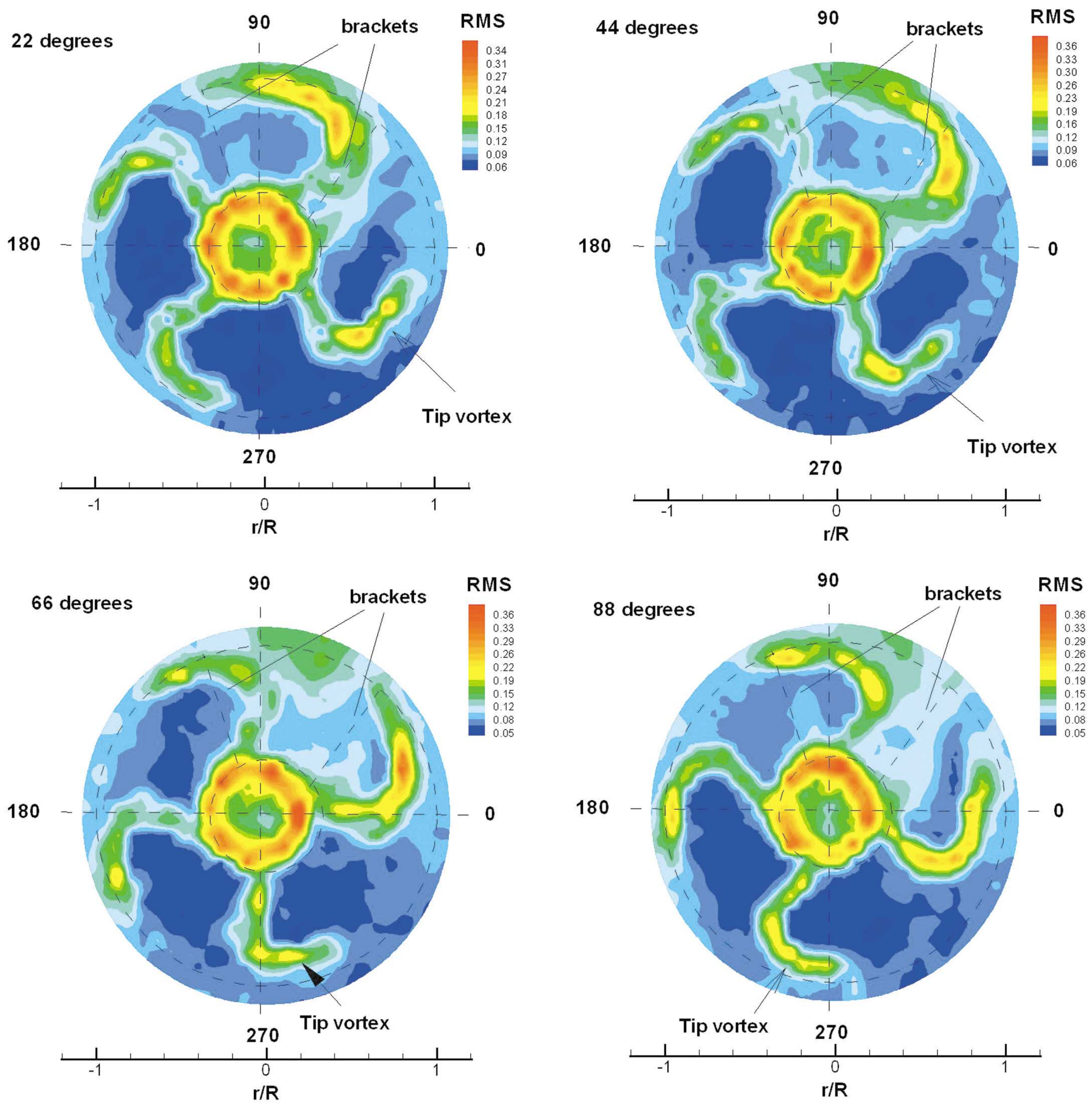
Journal of Visualization, Vol. 5, No. 2 (2002) 118

Rms Axial Velocity in the Wake of a Marine Propeller

Felli, M.[1]***, Di Felice, F.***[1] ***and Romano, G. P.***[2]

1) *INSEAN, Via di Vallerano 139, 00128 Roma, Italy*

2) *Department of Mechanics and Aeronautics, University of Roma, "La Sapienza", Via Eudossiana 18, 00184 Roma, Italy*



Three-dimensional measurements of the velocity field downstream of a marine propeller were performed at the circulation channel at INSEAN by means of a submerged LDA system. The free-stream velocity was 2.3 m/s corresponding to a Reynolds number (based on the propeller radius R = 0.183 m) equal to about 420000. The propeller has four blades and works at about 10 rounds/s. In the figure, the *rms* axial velocity (in m/s) measured at four angular positions (22°, 44°, 66° and 88°) at 0.2 R is given; these plots are derived by time histories of the velocity at each point by using a slotting technique. The position and motion of the four tip vortices and of the brackets are clearly pointed out. Further details on the experiments and on the measurements are in the Proceedings of the 9th International Symposium on Flow Visualization (Edinburgh, August 2000).

Journal of Visualization, Vol. 5, No. 2 (2002) 119

Hairpin-Shape Vortices in the Round Jet

Suto, H.[1], Matsubara, K.[2] and Kobayashi, M.[2]
1) *Graduate School of Science and Technology, Niigata University, Ikarashi 2-no-cho 8050, Niigata 950-2181, Japan*
2) *Department of Mechanical and Production Engineering, Niigata University, Ikarashi 2-no-cho 8050, Niigata 950-2181, Japan*

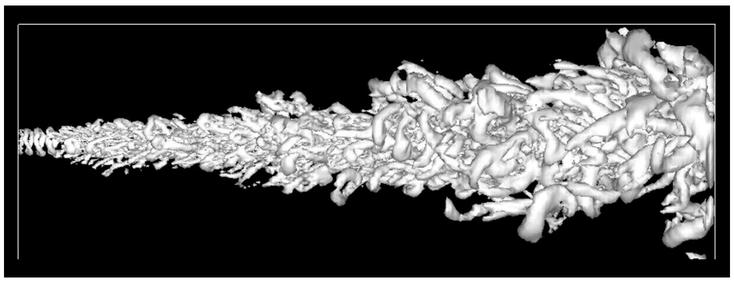


Fig. 1. Iso-surface of Laplacian for pressure

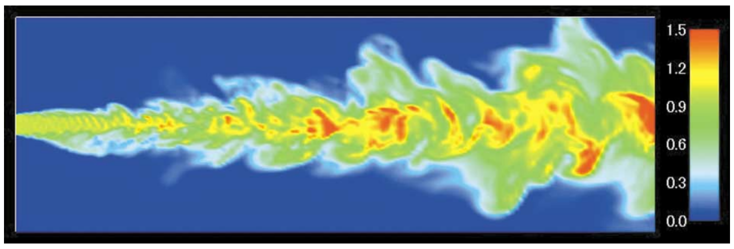


Fig. 2. Contour of temperature normalized by mean center value

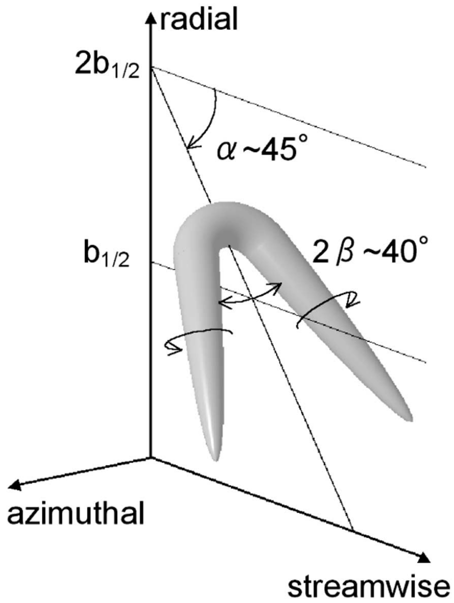


Fig. 3. Hairpin-shape vortex

Direct numerical simulation was performed for non-isothermal air jet at the Reynolds number equal to 1200. Simulated is a cylindrical domain extending 30 nozzle diameter. In the developed stage of the jet away from the nozzle exit, careful observer should notice existence of orderly structures, i.e., hairpin-shape vortex (Fig. 1) and wavy pattern of temperature variation (Fig. 2). One to one correspondence between vortical structure and temperature variation indicates that hairpin-shape vortex is a key to control the scalar mixing. From the PDF analysis of three orthogonal vorticity components, it was suggested that hairpin-shape vortices are inclined to lie in the flow field as suggested in Fig. 3.

Journal of Visualization, Vol. 5, No. 2 (2002) 120

Vortex Arrays Past a Sloping Strip Uniformly Moving in a Homogeneous or Linearly Stratified Fluid

***Chashechkin, Y. D.*[1] *and Mitkin, V.V.*[1]**

1) *Laboratory of Fluid Mechanics, Institute for Problems in Mechanics of the RAS, Moscow 117526, prospect Vernadskogo 101/1, Russia*

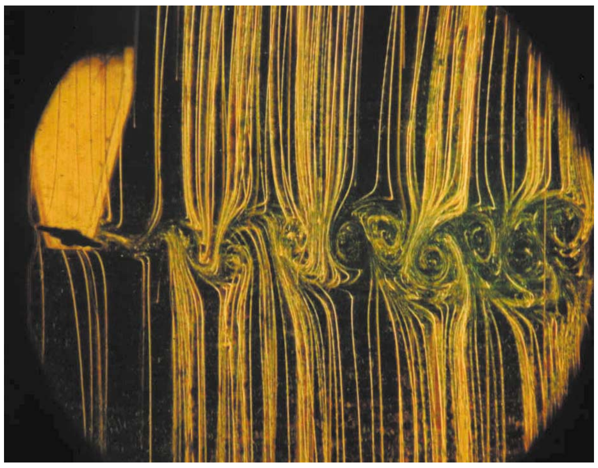


Fig. 1. Homogeneous fluid.
Strip is sloped under the angle α = 15° to horizontal and is towed with velocity U = 3.33 cm/s. Vertical markers are wakes past free descending sugar crystals.

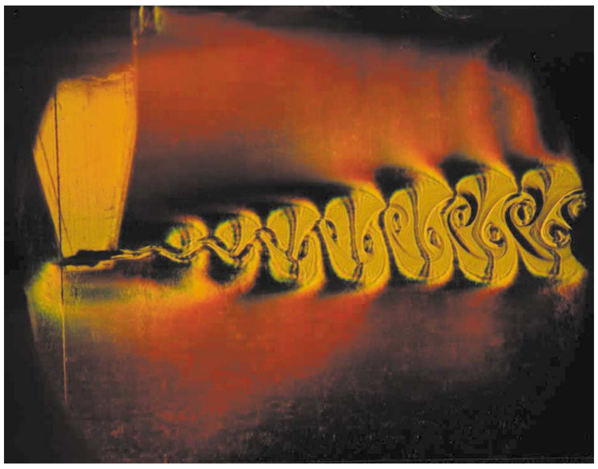


Fig. 2. Weakly stratified brine. Buoyancy period T_b = 17.5 s.
Strip is sloped under the angle α = 6° to horizontal and is towed with velocity U = 4.21 cm/s. The asymmetric laminar vortex array is formed from a wavy near wake.

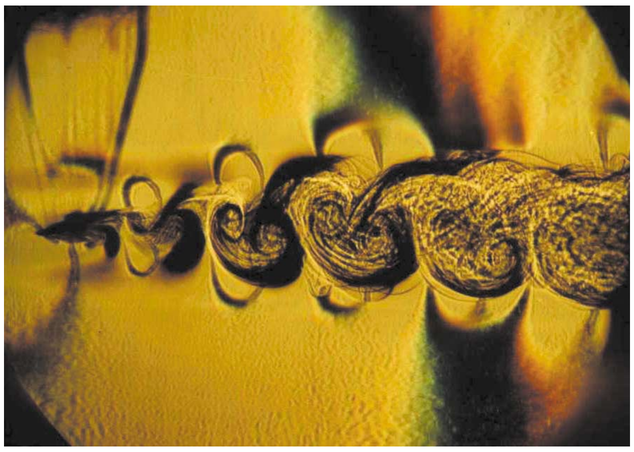


Fig. 3. Strongly stratified fluid, T_b = 7.5 s.
Strip is sloped under the angle α = 16° to horizontal and is towed with velocity U = 4.21 cm/s. Strong anisotropy of turbulent vortex array is observed. Light and dark strips across the image visualize attached internal waves. Boundaries between light and dark areas near and past the strip are crests and troughs of attached internal waves.

Length of the strip along the ray of view is 39 cm, its width is 2.5 cm and thickness is 0.1 cm. A carriage uniformly moving above the tank tows the strip fixed by two thin transparent vertical supports (knives). Visualization has been performed by Schlieren instrument IAB-458 using Maksoutov's method. Illuminating slit is vertical and Schlieren effect is produced by the vertical thread (diameter 0.16 mm) in the focus.

Reference

Chashechkin Y.D., Schlieren Visualization of a Stratified Flow around a Cylinder, Journal of Visualization, 1999, 1-4, 345-354.