

FIG. 1. Thick film shadowgraph images.

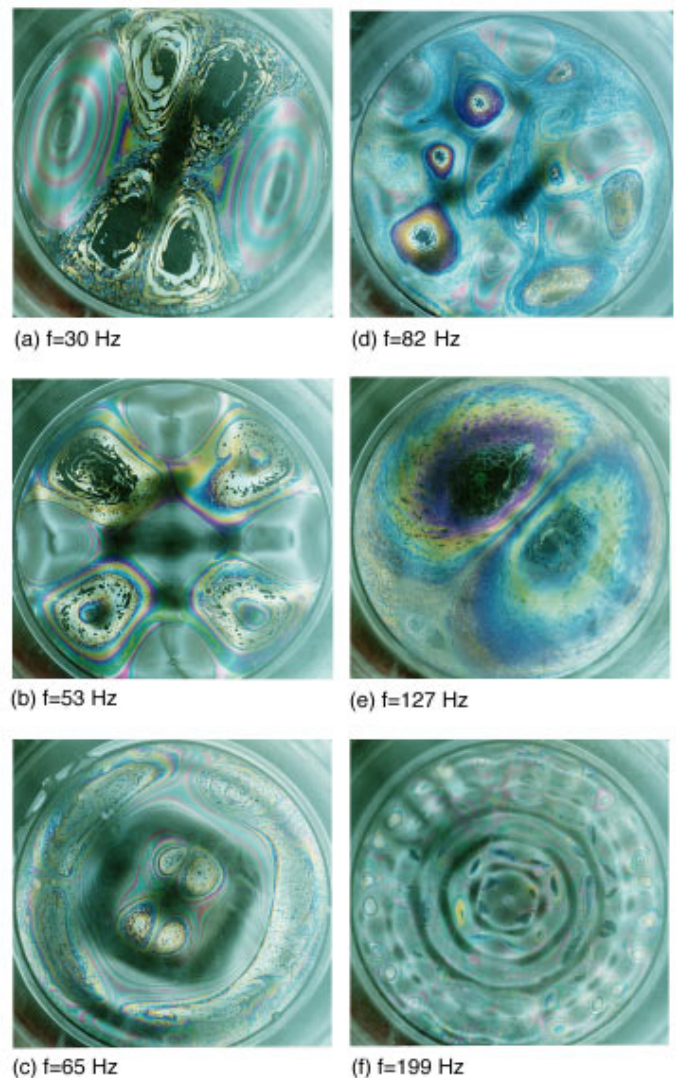


FIG. 2. Thin film interferences fringes.

THE GENERATION OF TWO-DIMENSIONAL VORTICES BY TRANSVERSE OSCILLATION OF A SOAP FILM

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Observations of the dynamics of horizontal soap films stretched over circular frames 8.0 cm in diameter and square frames 7.0 cm on a side undergoing periodic transverse oscillations at frequencies 20–200 Hz and accelerations 3–18 g are captured on 35 mm film. The composition was typically 94% tap water, 5% glycerine and 1% liquid soap. Lighting from an overhead fluorescent lamp yields shadowgraph images of the flexural mode patterns when the film is relatively

thick as in Fig. 1. As the film thins through evaporation, vortex motions are observed through colored fringe interference patterns as in Fig. 2.

Many of the mode patterns are spatially stationary. However, the pattern in 1(c) pulsed and the pattern in 1(d) oscillated chaotically as a whole in the azimuthal direction. Vortices often appear in counter-rotating pairs around the perimeter of the cells but also emerge spontaneously in the interior. As the film thins they coalesce into larger vortices and observations suggest that the total circulation of the vortex system is zero. Inevitably, “black films” of thickness $O(10 \text{ nm})$ emerge at the vortex centers as may be seen in Figs. 2(a) and 2(e). The vortices often lie between thick “bladders” of liquid as evidenced by the closely spaced fringe pattern as in Fig. 2(b) where we estimate the ratio of film thickness between the center of the “bladder” to the neighboring black films to be 1000:1.