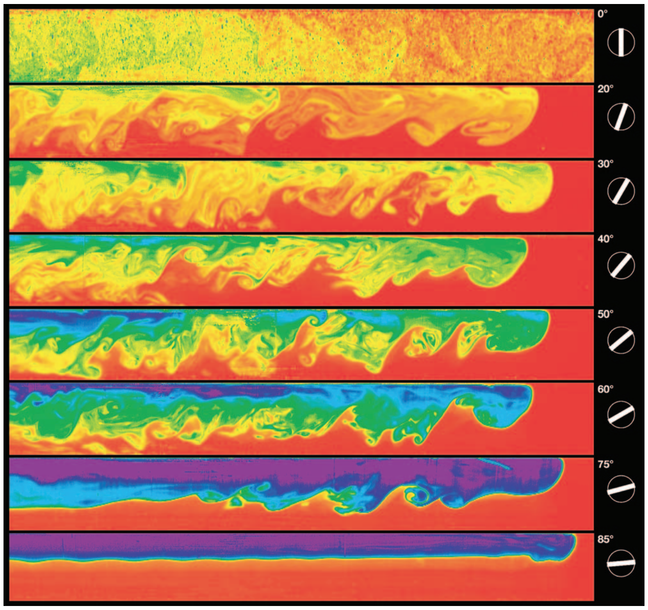

FIG. 1. The distribution of fluorescent dye in a vertical diametral plane of the tube for different tilt angles of the tube from vertical (see Fig. 3). The field of view is located between 200 and 500 mm above the gate valve (Fig. 2). Red and purple-blue shades correspond, respectively, to the pure heavy and light fluids and intermediate colors to mixtures of various compositions.

From turbulent mixing to gravity currents in tilted tubes

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The buoyancy driven motion of a lighter fluid rising spontaneously into a heavier miscible fluid in vertical or tilted tubes give rise to flows as different as diffusive turbulent mixing and counterflow without mixing (Fig. 1).

Two miscible fluids of different densities are initially in an unstable configuration, each of them occupying one half-length of a long transparent tube (d=20 mm, L=4 m). The

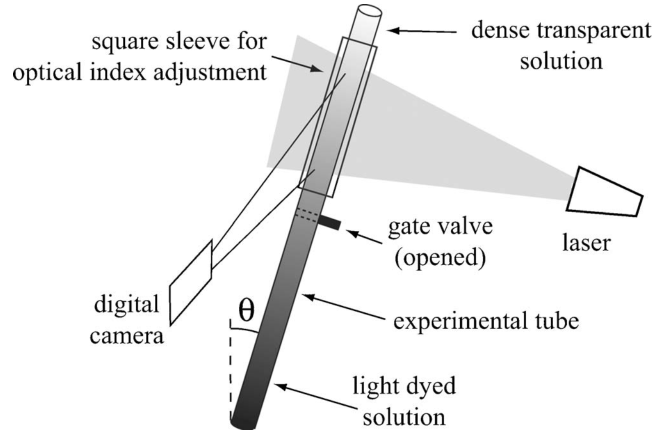

FIG. 2. Experimental setup.

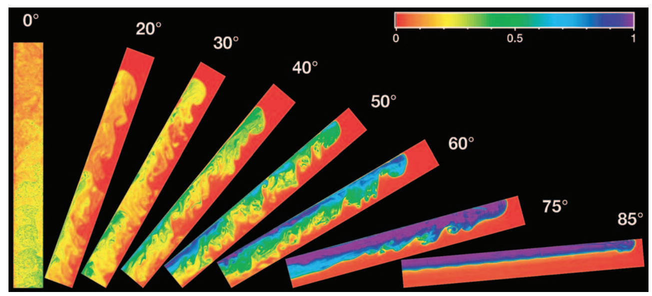

FIG. 3. The same views as Fig. 1 but displaying the actual tilt angle and the color scale indicating the local mixture composition.

lower half is filled with a solution of fluorescein in water. The upper half contains a denser transparent solution of $CaCl_2$ salt in water. The upper half of the tube is illuminated by a vertical thin plane of laser light (532 nm) containing the tube axis (Fig. 2).

The mixing pattern involves several competing effects. Buoyancy components parallel to the tube axis drive a longitudinal interpenetration of the two fluids, inducing in turn shear instabilities and transverse mixing; on the contrary, gravity perpendicular to the axis induces transverse segregation. When the tube is vertical ($\theta=0°$), turbulent mixing takes place while, close to the horizontal ($\theta=85°$), a segregated counterflow occurs. Between these extreme cases, both segregation effects and the concentration contrast at the front tip increases with θ due to less efficient transverse mixing. The front velocity dynamics is shown to be directly quantitatively related to this front density contrast.

