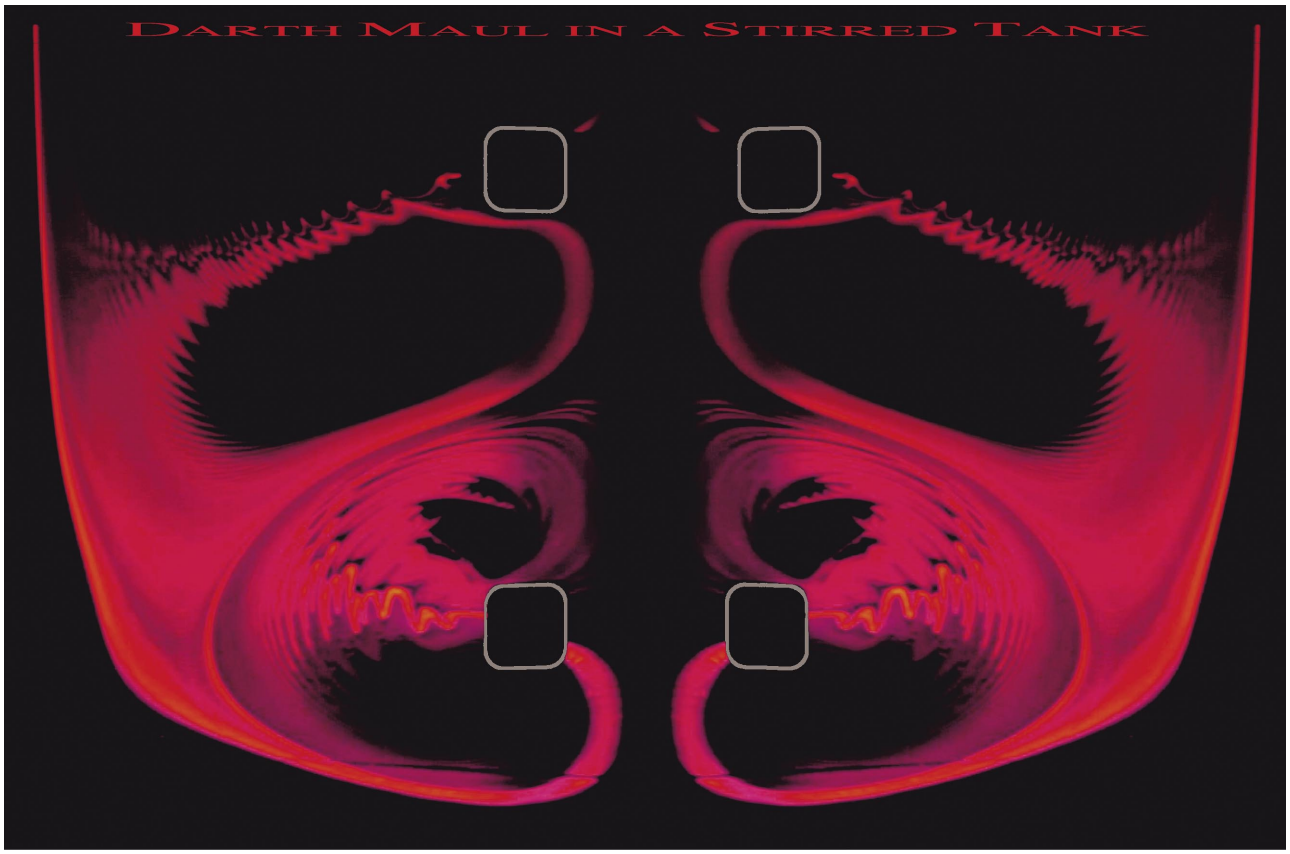

Chaotic Mixing in Viscous Fluids

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This figure shows an experiment in which fluorescent dye is injected near the center of a stirred tank of glycerine and the tank is illuminated from the side by a vertical laser sheet. The tank is stirred at Reynolds number 30 by two sets of impellers, visible as superimposed gray squares: one beneath the ''nostrils'' of the pattern, and one above its ''eyes.'' The oscillatory lobes of dye emanating from the impeller blades are hallmarks of a chaotic mixing process. The vanes of the upper impeller are uniformly spaced, producing simply periodic lobes, while the vanes of the lower impeller are unevenly spaced, producing repeated ''*m*''-shaped lobes. This figure provides graphic evidence that it is the three dimensional enfolding of fluid around the impeller vanes that leads to chaos and mixing in this common industrial mixer. Indeed, careful accounting of the energy expenditure in this system reveals that 90% of the kinetic energy present is associated with large scale recirculating, nonmixing flows (evident here as the open, black island structures), and only 10% of the kinetic energy generates measurable mixing.

Image processing notes: In this figure, the illuminating laser sheet was placed exactly in the center of the tank, and so one half of the tank was in the shadow of the central vertical impeller shaft. To produce this figure, we duplicated and inverted the right half of the original image and placed it in position on the left. The dye used is rhodamine dissolved in glycerine to neutral buoyancy; the color shown here is digitally enhanced.

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