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Optical Manipulation and Chaotic Mixing in Micro-droplets: Theory and Experiment VIVEK SHARMA, Center for Nonlinear Science and School of Physics; School of Polymer, Textile and Fiber Engineering, MOHAN SRINIVASARAO, School of Polymer, Fiber and Textile Engineering; School of Chemistry and Biochemistry, ROMAN GRIGORIEV, MICHAEL SCHATZ, Center for Nonlinear Science and School of Physics, Georgia Institute of Technology, Atlanta, GA — We use laser-induced thermocapillary forces for precise, non-contact transport, merger and mixing of microdroplets suspended in liquid substrates. The thermal gradients drive flow both inside and outside the droplet. We present a general theoretical framework, to calculate the basic flows and their symmetries and for understanding how complete three-dimensional mixing via chaotic advection requires destruction of all the flow invariants. We present experimental results that test this general theoretical framework, by probing the interior of droplet using fluorescence microscopy and laser light sheet illumination. Our visualization method allows clear discrimination between the cases of complete vs incomplete mixing, as predicted by the theoretical model. The results of this work are expected to apply quite generally to mixing at the microscale in a wide variety of settings, regardless of the specific implementation details for the microfluidic system.

Vivek Sharma
Center for Nonlinear Science and School of Physics;
School of Polymer, Textile and Fiber Engineering

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