ABSTRACT

Title of thesis: DROPLET DYNAMICS IN MICROFLUIDIC JUNCTIONS

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The dynamics of droplets in confined microfluidic geometries is a problem of fundamental interest as such flow conditions occur in multiphase flows in porous media, biological systems, microfluidics and material science applications. In this thesis, we investigate computationally the dynamics of naturally buoyant droplets, with constant surface tension, in cross-junctions and T-junctions constructed from square microfluidic channels. A three-dimensional fully-implicit interfacial spectral boundary element method is employed to compute the interfacial dynamics of the droplets in the junctions and investigate the problem physics for a wide range of flow rates, viscosity ratios and droplet sizes.

Our investigation reveals that as the flow rate or the droplet size increases, the droplets show a rich deformation behavior as they move inside the microfluidic devices. In the cross-junction, after obtaining a bullet-like shape before the flow intersection, the droplet become very slender inside the junction (to accommodate the intersecting flows), then it obtains an inverse-bullet shape as it exits the junction which reverts to a more pointed bullet-like shape far downstream. In the T-junction, the droplet obtains a skewed-bullet shape and a highly deformed slipper shape after entering the flows intersection. The viscosity ratio also has strong effects on the droplet deformation especially for high-viscosity droplets which do not have the time to accommodate the much slower deformation rate during their channel motion. Our results are in agreement with experimental findings, and provide physical insight on the confined droplet deformation.