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Role of Structural Asymmetry in Controlling Drop Spacing in Microfluidic Ladder Networks WILLIAM WANG, JEEVAN MADDALA, SIVA VANAPALLI, RAGHUNATHAN RENGASAMY, Texas Tech University — Manipulation of drop spacing is crucial to many processes in microfluidic devices including drop coalescence, detection and storage. Microfluidic ladder networks —where two droplet-carrying parallel channels are connected by narrow bypass channels through which the motion of drops is forbidden—have been proposed as a means to control relative separation between pairs of drops. Prior studies in microfluidic ladder networks with vertical bypasses, which possess fore-aft structural symmetry, have revealed that pairs of drops can only undergo reduction in drop spacing at the ladder exit. We investigate the dynamics of drops in microfluidic ladder networks with both vertical and slanted bypasses. Our analytical results indicate that unlike symmetric ladder networks, structural asymmetry introduced by a single slanted bypass can be used to modulate the relative spacing between drops, enabling them to contract, synchronize, expand or even flip at the ladder exit. Our experiments confirm all the behaviors predicted by theory. Numerical analysis further shows that ladders containing several identical bypasses can only linearly transform the input drop spacing. Finally, we find that ladders with specific combinations of vertical and slanted bypasses can generate non-linear transformation of input drop spacing, despite the absence of drop decision-making events at the bypass junctions.

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