Abstract Submitted
for the DFD12 Meeting of
The American Physical Society

Nonlinear dynamics in a microfluidic loop device: Chaos and Fractals JEEVAN MADDALA, RAGHUNATHAN RENGASWAMY, Texas Tech University — Discrete decision making and resistive interactions between droplets in a microfluidic loop device induces fascinating nonlinear dynamics such as multistability and period doubling. Droplets entering the device at fixed time intervals can exit at different periods or chaotically. One of the periodic behaviors that is observed in a loop is the three-period behavior; this is consistent with the notion that three period behavior implies chaos. Switching between these different dynamical regimes is achieved by changing the inlet droplet feeding frequency. Chaotic behavior is observed between islands of periodic behavior. We show through simulations and experimental observations that the transitions between periods are indeed chaotic. Network model is used to study the dynamic behavior for different inlet feeding frequencies resulting in the development of a bifurcation map. The bifurcation map shows that the three period dynamics is preceded by chaos. A Lyapunov exponent is used to further validate these results. The exit droplet spacing shows several fascinating patterns when the model is simulated for a large number of droplets in the chaotic regime. One such chaotic regime produces a fractal that has a boundary of cardioid. The correlation dimension for a fractal pattern produced by this particular loop system is calculated to be 0.7.

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Date submitted: 07 Aug 2012 Electronic form version 1.4