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Nonlinear Dynamics and Control in Microfluidic Networks[1]
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Researchers currently use abundant external devices (e.g., pumps and computers) to achieve precise flow dynamics in microfluidic systems. Here, I show our use of network concepts and computational methods to design microfluidic systems that do not depend on external devices yet still exhibit a diverse range of flow dynamics. I present an example of a microfluidic channel described by a nonlinear pressure-flow relation and show that complex flow behavior can emerge in systems designed around this channel. By controlling the pressure at only a single terminal in such a system, I demonstrate the ability to switch the direction of fluid flow through intermediate channels not directly connected to the controlled terminal. I also show that adding (or removing) flow channels to a system can result in unexpected changes in the total mass flow rate, depending on the network structure of the system. We expect this work to both expand the applicability of microfluidics and promote scaling up of current experiments.

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