Microfluidic flows in the inertial regime exhibit a fascinating range of phenomena (inertial migration and focusing, secondary flows). These phenomena can be leveraged to enable passive control of flow as well as the localization of particles (cells, precipitates, particles) in flow, with applications to biological processing, chemical reaction control, and for creating structured materials. In particular, inertial flow deformations induced by sequences of pillars that disrupt the flow provide a simple, lego-like strategy for passive flow control. Several groups have shown the ability to passively engineer the cross-sectional shape of a fluid by placing a sequence of pillars that disrupt flow. A challenge is to efficiently identify an (near) optimal sequence of pillars that accomplish a desired flow transformation, or particle localization. This talk gives an overview of our work in the past few years focused on fast computational approaches for pillar sequence design. We utilize high throughput approaches for CFD (including immersed boundary approaches), Markov matrices, and applied machine learning to accomplish near real time design exploration.

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