Microfluidics is the study of fluid flow at very small scales (micro -- one millionth of a meter) and is prevalent in many areas of science and engineering. Typical applications include lab-on-a-chip devices, microfluidic fuel cells, and DNA separation technologies. All of these microfluidic devices rely on micron-resolution velocimetry measurements to improve microchannel design and characterize existing devices. Mature methods such as micro particle imaging velocimetry (µPIV) and micro particle tracking velocimetry (µPTV) readily characterize steady 2D flow fields, however, increasingly complex microdevices require techniques that measure unsteady or three component velocity fields in volumes.

This defense presents a method for high-speed velocimetry for unsteady flows and volumetric three component velocimetry based on spinning disk confocal microscopy and depth scanning of a microvolume. High-speed 2D unsteady velocity fields are resolved by acquiring images of particle motion using a high-speed CMOS camera. A confocal microscope spatially filters out of focus light using a rotating disk of pinholes placed in the imaging path. We show that the confocal disk improves the ability of the system to resolve unsteady µPIV measurements by improving the correlation signal to noise ratio.

We use an objective positioner to quickly scan the depth of the microvolume and collect 2D image slices, which are assembled into 3D stacked images. Super resolution µPIV interrogates these 3D images using µPIV as a predictor field for µPTV. We measure the 3D3C velocity field in a microchannel with an expanding section. This technique is appropriate for investigations such as real-time 3D tracking of cells, 3D quantitative fluorescence imaging, and the dynamics of colloidal crystal deposition.