Spatio-temporal correlation for 3D velocity field characterization in microfluidic devices

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The implementation of microfluidic platforms to measure flow speeds is usually accomplished in a planar geometry; however when used to simulate complex or intricate vessel patterns, a 3D treatment of the velocity field is demanded. In the present study, the velocity field is mapped at high spatial and temporal resolution by combining a spatio-temporal correlation analysis (STICS) to a single plane illumination (SPIM) setup on ad-hoc designed microchannel geometries. The PDMS channels are realized by 3D-printed molds with less than 20 microns resolution. Fluorescent microspheres are used as fluorescent samples; the velocity is kept constant by a piezo-controlled syringe. Stacks of images are acquired in a wide field mode by an EMCCD camera and analyzed by a home coded software.
A first planar "Y" shaped channel of constant cross section is employed to explore 2D flow patterns. The velocity components parallel and perpendicular to the flow direction are detected. Then a "telescopic" structure is investigated whose cross section doubles in three successive regions, generating an off-plane component of the velocity. We show here that the SPIM-STICS approach successfully quantifies the axial velocity component when the amplitude of the generalized correlation function is followed at different delay times, thereby allowing a 3D reconstruction of the velocity field in the microchannel. The limits of detection are explored and discussed.