Enhancing Digital Holographic Microscopic PIV by exploiting the contrast inversion property of weak scattering tracer particles

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ABSTRACT

Digital holographic microscopic particle image velocimetry (DHM-PIV) provides 3 component 3-dimensional (3C-3D) flow velocity information which is the most comprehensive way to investigate a wide range of fluid phenomenon in both micro and macro fluidics. DHM-PIV offers 3D flow measurement with high spatio-temporal resolution, minimal optical setup and easy calibration compared to other 3D PIV techniques such as tomographic PIV, defocusing PIV, etc. Despite these advantages, some of the major limitations of DHM-PIV are the extended depth-of-focus (DOF) problem and the virtual image effect which causes artefacts in the reconstruction volume and puts a limitation on tracer concentration, which in turn limits the achievable velocity spatial resolution. In this study, we present a simple, model-free but robust particle extraction method to overcome these limitations. The capability of the proposed method is demonstrated through its application to laminar micro-channel flow, where 3C-3D velocity fields are measured within sampling volume of 1.8 mm × 1.5 mm × 50 μm with 44.8 μm × 44.8 μm × 5.6 μm velocity spatial resolution in streamwise, spanwise and wall-normal directions, respectively. The results show that the bias error and the uncertainty of the ensembled mean velocity are 1.6% and 4% of maximum streamwise velocity when compared to the analytical plane Poiseuille solution.