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3D tomography of red blood cells in micro-channels

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We propose a new confocal 3D imaging technique for fluorescent stained red blood cells (RBCs) in micro-fluidic flow[1]. Our approach allows us to recover the full 3D representation of moving RBCs under conditions prevailing in the micro-vasculature. As key feature, we employ a microfluidic channel which is tilted by a small angle with respect to the objective. This forces cells to pass the focal plane in an inclined manner and a stack of cross-sectional images is recorded for each traversing object. Image slices are then assembled to recover the volumetric representation of individual cells. In contrast to common scanning approaches, the present method relinquishes any mechanical actuation of the objective or stage and frame rates up to 600 FPS can be realized since no mechanical delay is involved. At maximum frame rate, cells up to a velocity of 1.5mm/s can be recovered. Even if our approach appears straightforward, a number of sophisticated image processing are necessary for successful 3D recovery. For instance, artifacts from the spinning disc at high frame rate must be compensated for a smooth reconstruction. Moreover, the cell velocity must be determined very precise to achieve a correct stacking of individual image slices. In a micro-channel of 25 μm $\times$ 10 μm, we were able to find two equilibrium cell shapes under certain flow condition: the "slipper" and the "croissant" shape (Fig. 1). Validating this result, we performed numerical simulations which are in good agreement withthe experimental observations.

[1] S. Quint, A. F. Christ, A. Guckenberger, S. Himbert, L. Kaestner, S. Gekle, and C. Wagner, 3D tomography of cells in micro-channels, Appl. Phys. Lett. **111**, 103701 (2017)

Figure 1: