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THE EFFECT OF INERTIA IN MICROFLUIDIC JUNCTIONS

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Despite numerous examples of the impact of inertia on the motion of particles in microfluidics, the inertia of one phase flows in microfluidic networks is often underestimated and neglected. Usually, it is argued by the laminar character of the flow in small microfluidic channels. Herein we show that in spite of the laminarity, the inertia can play a significant role in the microfluidics. In this paper we study a junction – the common element of microfluidic structures. We show experimental evidence that even for moderate Reynolds numbers (1<Re<250) the impact of inertia on the distribution of flows in a junction is significant. Moreover, we show the crucial role of angles between channels connected by a junction.

The neglect of inertia is tempting as it radically simplifies a flow description. In the ideal non-inertial world the electric analogy[1] can be applied to the analysis and the design of even complex microfluidic structures[2][3]. This commonly applied approach utilises the fact that stationary, viscous, laminar and incompressible flow through regular pipe satisfies the linear relation between the static pressure drop and volumetric flow rate [4] (analogous to Ohm's law). If the analogy to electric circuit is satisfied, the analytical solutions prescribing fluid flow in microfluidic networks can be derived from equivalent electric circuit equations, which typically reduce to a system of linear algebraic equations[1].

Although the flow through straight regular channel remains laminar for Re<2300, the inertial effects (introducing non-linearities into equations), can appear in all non-regular elements, even for moderate Re[5]. This constitutes limitation for linear electric circuit analogy.

The results of our experiments undoubtedly show that the ratio of flows in two arms of the junction significantly depends on Re. Importantly, we show that the flow through the junction depends strongly on angles between channels This phenomenon cannot be described or explained by simple electric circuit analogy, which treats a junction as a point. The additional numerical simulations allowed us for efficient investigations of different geometrical configurations.

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