X-ray Photon Correlation Spectroscopy in Microfluidic System

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We present a new experimental method that combines X-ray photon Correlation Spectroscopy (XPCS) and microfluidics and allows the direct measurement of the mesoscale dynamics of various soft matter systems (e.g. colloids, polymers, biological molecules like proteins, RNA, etc.) under flow. XPCS is an ideal way to perform direct measurements on the underlying slow (10^{-3}-10^{3} s) mesoscale (~100-5000Å) dynamics in a large class of hard- and soft- condensed matter systems. Microfabricated fluid mixers are being used nowadays to study micro-scale flow regimes both with the purpose to achieve new functionality or as an experimental tool. Our aim is to develop an experimental method that combines microfluidics and XPCS in order to measure the intrinsic mesoscale dynamics taking place in the fluid. Such a setup reduces the risk of beam damage and also allows time-resolved studies of various processes taking place in mixing flowcells. In the experiments reported here, we have used colloidal suspensions of hard-sphere systems and studied their Brownian dynamics while flown through in-house made flowcells.

Our experimental results agree with theoretical predictions, and show that in the low-shear limit and for a transverse scattering geometry (scattering vector q perpendicular to the flow) the diffusive dynamics of the PMMA particles is decoupled from the flow-induced convective response. In such a case, the homodyne intensity fluctuation correlation times measured by XPCS scale with q^{-2} as expected for a suspension of non-interacting Brownian particles, and are independent of the flow rate. However, this result does not hold for more general geometries. The correlation times measured in a homodyne-XPCS experiment depend on the Brownian diffusion time, on the shear rate and also on the exact scattering geometry. Here we show theoretical predictions and experimental results for XPCS measurements performed in a longitudinal geometry (scattering vector q perpendicular to the flow).