Viscosity Measurements and Hydrodynamic Memory Effects Studied by Optical Trapping Interferometry

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Diffusion governed by Brownian motion is an efficient transport mechanism on short time and length scales. Even a highly organized system like a living cell relies in many cases on the random Brownian motion of its constituents to fulfill complex functions. A Brownian particle will rapidly explore a heterogeneous environment that in turn strongly alters its trajectory. Thus, detailed information about the environment can be gained by analyzing the particle's trajectory. It is well known that the non-negligible fluid's inertia leads to hydrodynamic memory effects [1] resulting in a characteristic long-time tail of $t^{-3/2}$ in the velocity correlations of the particle's motion. Here, we study the motion of a colloidal microsphere immersed in a viscous Poly-Ethylene Oxide (PEO) solution confined by a soft harmonic potential using an optical trap with a position detector providing microsecond temporal resolution. In our application the optical trap has a twofold function: it ensures that the particle remains within the detector range, and it provides a light source for the position detection.

Based on a calibration method proposed by Tolić-Nørrelykke and coworkers [2] we calculate the viscosity of the PEO solution as a function of the concentration and characterize hydrodynamic memory effects present is such solution. We find that memory is lost above the critical concentration C*, which corresponds to the point where neighboring polymer coils start to overlap and form a transient mesh where fluid dynamics is dominated by viscous terms rather than inertial ones. Above this point the mesh surrounding the Brownian particle increases its effective mass and therefore the characteristic power law of the velocity correlations vanishes.

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[1] *B. Lukić et al.*, Direct observation of nondiffusive motion of a Brownian particle // *Phys. Rev. Lett.* **95**, 160601 (2005).

[2] *S. F. Tolić-Nørrelykke et. al.*, Calibration of optical tweezers with positional detection in the back-focal-plane // *Rev. Sci. Instrum.* **77**, 103101 (2006).