Non-equilibrium dynamics of semiflexible polymers in solution

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Experimental studies of individual DNA molecules in steady shear flow by fluorescence microscopy have provided a wealth of information on single polymer dynamics [1,2]. In particular, these experiments reveal remarkably large conformational changes due to tumbling motion; i.e., a polymer stretches and recoils in the coarse of time. Since shear flows are omnipresent in biological systems and technical applications, e.g., microfluidics, the understanding of the dynamics of semiflexible polymerssuch as DNAis of great practical interest. The microscopic conformational properties affect the macroscopic rheological behavior of the polymer solution, and hence a detailed theoretical description of the microscopic dynamics is desirable. The dynamic behavior of a macromolecule in shear flow is governed by various parameters; aside from the shear rate, the finite chain extensibility is of major importance.

In this contribution, the significance of hydrodynamic interactions on the dynamics of dsDNA molecules in solution will be discussed based on an analytical model for semiflexible polymers. As will be shown, the end-point dynamics of dsDNA molecules can quantitatively be described by this approach, thereby resolving the discussion on the relevantes of hydrodynamic interactions in dsDNA dynamics [3]. In addition, the dynamics of semiflexible polymers under the influence of shear flow is studied analytically. Power laws are derived for various conformational and dynamical quantities which are in agreement with experimental findings. In particular, the tumbling motion is analyzed and expressions are provided for the probability distributions of the orientation angles and the tumbling time. The calculations explain the similarities in the behavior of flexible and semiflexible polymers as well as free-draining and non-draining systems.

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[3] E. P. Petrov, T. Ohrt, R. G. Winkler, P. Schwille, Phys. Rev. Lett. 97, 258101 (2006)