Single-walled carbon nanotubes as ideal model semiflexible filaments

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Abstract: Understanding the dynamics of single-walled carbon nanotube (SWNTs) motion is crucial for establishing potential applications of nanotube architectures for material and biological sciences. Here we present analysis of the bending dynamics and the confined rotational diffusion coefficient of individual SWNTs in water at thermal equilibrium. SWNTs in aqueous suspension are visualized directly by visible as well as near-infrared fluorescence microscopy.

The visible imaging is based on simple tagging of the SWNTs with a biocompatible fluorescent marker. We measure the confined rotational diffusion coefficient and find it in reasonable agreement with predictions based on confined diffusion of dilute Brownian rods. We determine the critical concentration at which SWNTs in suspensions start interacting. Intrinsic SWNT near-infrared emission is used to visualize bending motions of semiconducting carbon nanotubes and deduce their diameter. The variance of the curvature fluctuations induced by Brownian motion is analyzed to obtain the persistence length (or bending rigidity); we find that the persistence length ranges between ~20 and ~100 micrometers and that it scales with the cube of the SWNT diameter, as expected for a hollow pipe. Additionally, the relaxation times of the slowest bending modes are measured through the autocorrelation of the SWNT shape. The measured relaxation times agree excellently with those predicted for a semiflexible chain. These findings indicate that SWNTs are ideal model semiflexible filaments.