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Entropic forces generated by grafted semi-flexible polymers

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I. INTRODUCTION

The force exerted by a fluctuating semi-flexible polymer on a rigid obstacle and the probability to find a gap of given size between the wall and the polymer's tip are quantities of immediate interest for recent theories of force generation by action or microtubule polymerization [1,2]. Force generation of this type is thought to play a prominent role in cell motility. The fluctuating sections of filament are typically very short compared to their persistence length $\ell_p=\kappa/k_BT$ where κ is the polymers bending modulus. This allows the use of approximations which make the problem solvable up to quadrature for the general case.

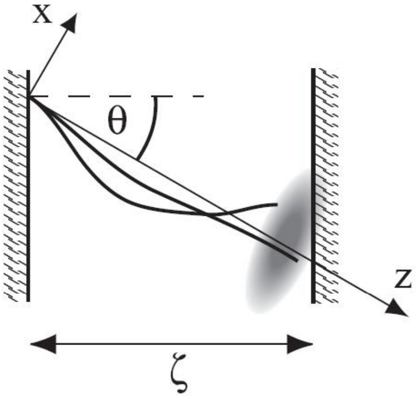

FIG. 1: A smooth hard wall constraints the fluctuations of a grafted semi-flexible polymer with a contour length L resulting in an average force between wall and graft. Two possible configurations of the polymer are indicated. The shaded area is a symbolic representation of the distribution of the loci of the polymer's end in the absence of the wall.

II. RESULTS

We compute the average force exerted by a fluctuating grafted semi-flexible polymer upon a rigid smooth wall as well as the corresponding free energy in 2d and 3d. Both quantities are thought to be of interest for understanding the physics of actin-polymerization driven cell motility.

As Fig. (3) shows force in 2d has a peak which means that somewhere the entropic force goes beyond mechanical one. We think this peak is just a geometrical effect due to restricting the polymer to fluctuate in 2d which entropic forces are stronger than 3d.

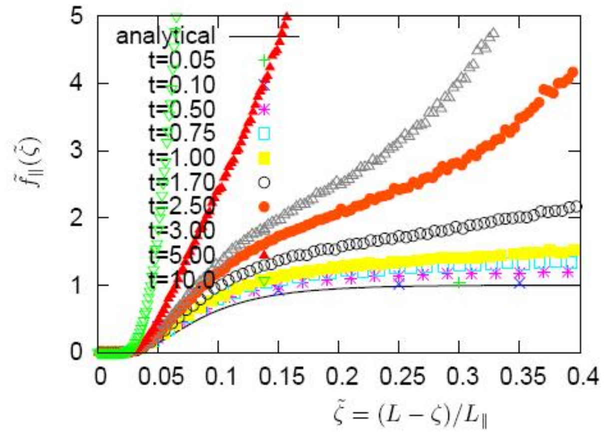

FIG. 2: Universal scaling function $\tilde{f}_{\|}(\tilde{\zeta})$ for the force exerted on a wall at a distance ζ from the grafted end in 3d at θ=0. The scaling variable $\tilde{\zeta}=(L-\zeta)/L_{\|}$ measures the smallest allowed stored length (L−ζ) in units of $L_{\|}$ where $L_{\|}=Lt$ and t=L/ $\square_p$.

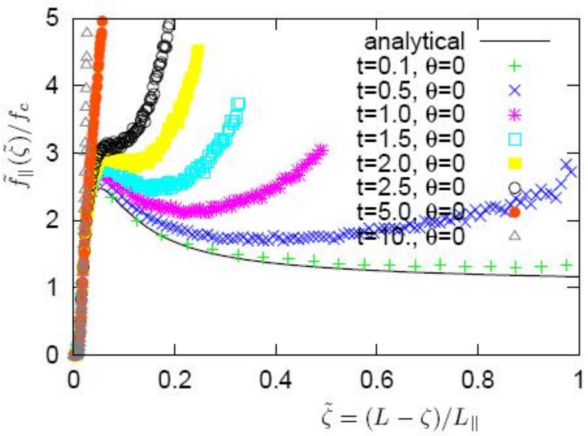

FIG. 3: Average force between grafted polymer at θ=0 and rigid wall for different values of t=L/$\square_p$ in 2d where $L_{\|}=2Lt$.

Depending on the angle between the constraining wall and the direction of the graft, two asymptotic regimes with different dependence of the force on the position of the wall can be discerned. The angle determining the position of the crossover varies as the square root of the ratio of the polymer's length to its persistence length. For angles larger than the critical angle, previous expressions are qualitatively valid but for smaller angles different behavior is found.

III. REFRENCES

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