

Continuous and first-order polymer adsorption on hierarchical fractal walls

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Abstract. Polymer adsorption on fractally rough walls of varying dimensionality is studied by renormalization group methods on hierarchical lattices. Exact results are obtained for deterministic walls. The adsorption transition is found continuous for low dimension d_w of the adsorbing wall and the corresponding crossover exponent ϕ monotonically increases with d_w , eventually overcoming previously conjectured bounds. For d_w exceeding a threshold value d_w^* , ϕ becomes one and the transition changes to first order. $d_w^* > d_{saw}$, the fractal dimension of the polymer in the bulk. An accurate numerical approach to the same problem with random walls gives evidence of the same scenario.

1. Introduction

The adsorption on an attracting impenetrable wall is perhaps the most elementary transition involving a single interacting polymer in solution [1]. High dilution in a good solvent is the realistic condition for which this problem can be directly relevant. The fundamental character and the obvious relation with more complex applications, like colloid stabilization or surface protection [2], have resulted in a great deal of attention being directed towards polymer adsorption in recent years, and much information is presently available on this problem. It is now well understood that this transition can be interpreted as a surface critical phenomenon [1, 3]: at the adsorption temperature, T_a , the conformational statistics of the polymer shows a multicritical behaviour with peculiar geometric features and with crossovers to the high- T desorbed and the low- T adsorbed regimes. For a chain with N monomers at T_a the average number of adsorbed monomers, $\langle M \rangle$, scales as $\langle M \rangle \propto N^\phi$, where ϕ ($0 < \phi < 1$) is the crossover exponent. In the high- and low- T regimes, $\langle M \rangle \propto N^0$ and $\langle M \rangle \propto N$, respectively. ϕ is known exactly in 2D for a polymer in both good [4] and theta [5] solvents, and in 3D in a theta solvent, in which case logarithmic corrections are present [6]. Further exact results have been obtained for models defined on fractal lattices, like Sierpinski gaskets [7–9], which are now recognized as an important context in which to test theoretical ideas concerning polymer statistics.

Most explicit results obtained so far on polymer adsorption refer to cases in which the wall is smooth and flat. In this paper we address the adsorption transition on a fractal substrate. This problem has applicative interest. Indeed, in many processes involving polymers, highly corrugated, irregular walls may be present. In addition, there are interesting theoretical implications. A polymer in a good solvent is known to possess a self-similar stochastic

a decay of this potential right at the threshold for discontinuous tunnelling [12]. Our results show that fractal wall roughness also leaves room for a continuous polymer adsorption when $d_w > d_{saw}$.

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