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Critical behavior of the system of two crossing self-avoiding walks on a family of three-dimensional fractal lattices

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ABSTRACT

We study the polymer system consisting of two-polymer chains situated in a fractal container that belongs to the three-dimensional Sierpinski Gasket (3D SG) family of fractals. The two-polymer system is modeled by two interacting self-avoiding walks (SAW) immersed in a good solvent. To conceive the inter-chain interactions we apply the model of two crossing self-avoiding walks (CSAW) in which the chains can cross each other. By applying renormalization group (RG) method, we establish the relevant phase diagrams for $b = 2$ and $b = 3$ members of the 3D SG fractal family. Also, at the appropriate transition fixed points we calculate the contact critical exponents φ, associated with the number of contacts between monomers of different chains. For larger b ($2 \leqslant b \leqslant 30$) we apply Monte Carlo renormalization group (MCRG) method, and compare the obtained results for φ with phenomenological proposals for the contact critical exponent, as well as with results obtained for other similar models of two-polymer system.

1. Introduction

The self-avoiding walk (SAW) is widely accepted as a standard lattice model for a flexible linear polymer chain in various types of solvents [1]. In this model, the monomers that comprise a polymer chain are related to the steps of a random walk that must not contain self-intersections, while the surrounding solvent is represented by an underlying lattice. In a good solvent, we associate the same weight factor x with each SAW step. In spite of the fact that an isolated polymer chain is difficult to observe experimentally, numerous studies of the single-chain statistics have been upheld as a requisite step towards understanding the statistics of collection-chain systems [2]. A natural extension of a single-polymer concept is a model of two interacting linear polymers, which may help out to comprehend the critical behavior of multicomponent polymer solutions [3]. To study statistics of two-polymer system the following two models may be applied: the first is the model that consists of two mutually avoiding self-avoiding walks (ASAW), whose paths on a lattice cannot cross each other, and the second is the model of two mutually crossing self-avoiding walks (CSAW), whose paths may intersect each other. In the case of ASAW model it is assumed that two SAWs interact when they approach each other at the distance being equal to a lattice constant, and contributing the relevant energy ϵ_u. In addition to the described energy contribution ϵ_u, in the CSAW model the two SAWs interact also at each mutual crossing between them, and therefore we associate the contact energy ϵ_c with each crossing. In analogy with the problem of polymer adsorption onto a hyperplane [4], we may assume that with decreasing temperature the number of crossings M increases, so that at the critical temperature T_c it behaves according to the power law

$$M \sim N^{\varphi}, \tag{1}$$

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