HISTOGRAM MONTE CARLO APPROACH TO SITE PERCOLATION ON THREE-DIMENSIONAL LATTICES

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Finite-size scaling is important in both theoretical [1, 2, 3, 4, 5] and experimental [6] studies of critical phenomena. According to the theory of finite-size scaling [1, 2, 3, 4, 5, 7], the scaled data for different values of lattice size fall on the same curve, represented by scaling function, if they are plotted as a function of the scaling variable. Thus it is important to have a good method to calculate the scaling functions and use the method to study the behavior of the scaling function under various conditions. The histogram Monte Carlo simulation method proposed by Hu is suitable for such studies [8, 9, 10, 11, 12, 13, 14, 15].

In this paper we use the data obtained from the histogram Monte Carlo simulation method in the percolation renormalization group (PRG) transformation from lattice G_1 of linear dimension L_1 to lattice G_2 of linear dimension L_2, where $L_1 > L_2$, to calculate the critical point p_c, the thermal scaling power $y_t(= 1/\nu)$ and the field scaling power y_h. After that, the scaling functions of the existence probability E_p and the percolation probability P of the site percolation model on the three-dimensional lattices, including fcc, bcc and diamond structure, with free and periodic boundary conditions are calculated. The figures listed below are some of our results for the E_p of the fcc lattice. Figure 1 is the typical calculated results of E_p, and figure 2 is the scaling function of E_p. Note that we use $y_t = 1.14, y_h = 2.52$ as Ziff [16] for the scaling function. Figure 2 shows that E_p has good scaling behavior.

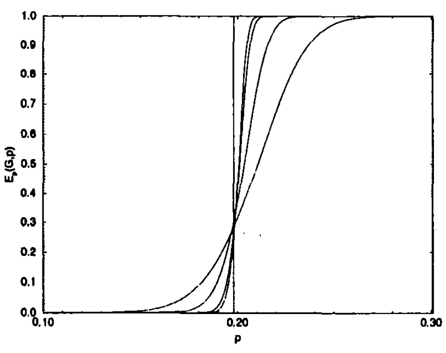

Fig.1. The calculated E_p for the fcc lattice with free boundary condition and linear dimensions L :16, 32, 64, 80 as a function of p. The vertical line intersects p axis at $p_c = 0.1992$.

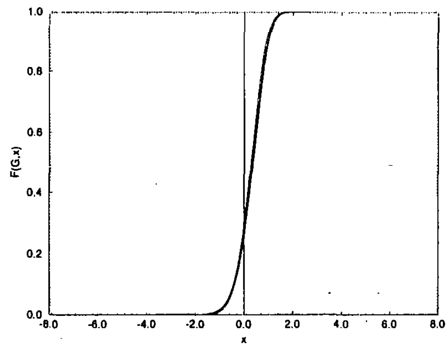

Fig.2. The calculated E_p for the fcc lattice with free boundary condition and linear dimensions L :16, 32, 64, 80 as a function of x, where $x = (p - p_c)L^{y_t}$. The function is the scaling function $F(G, x)$.

We also find that different boundary conditions give quite different scaling functions near the critical region as in the cases of the two-dimensional lattices [13]. However, they also give the consistent critical points and exponents from renormalization group calculations.

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