THE UNIVERSITY OF CHICAGO

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DISSERTATION PRESENTATION AND DEFENSE

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Two Problems in Percolation Theory

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ABSTRACT

This thesis deals with two problems in percolation theory.

In the first part, we consider accessibility percolation on hypercubes, i.e., we place i.i.d. uniform [0, 1] random variables on vertices of a hypercube, and study whether there is a path connecting two vertices such that the values of these random variables increase along the path. We establish a sharp phase transition depending on the difference of the values at the two endpoints, and determine the critical window of the phase transition. Our result completely resolves a conjecture of Berestycki, Brunet and Shi (2014).

Our work on accessibility percolation is motivated by the NK fitness model in biological evolution. We also establish the asymptotics for the global maximum of the NK fitness model, by proving that the maximum is asymptotically equivalent to the case when $K = N$ if and only if $K \to \infty$ as $N \to \infty$.

In the second part, we initiate the study on chemical distances of percolation clusters for level sets of two-dimensional discrete Gaussian free fields as well as loop clusters generated by two-dimensional critical random walk loop soups. We show that in both cases the chemical distance between two macroscopic annuli away from the boundary is of dimension 1 with positive probability. Our proof method is based on an interesting combination of a theorem of Makarov, isomorphism theory and an entropic repulsion estimate for Gaussian free fields in the presence of a hard wall.

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