Research Statement

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I began my mathematical career as a doctoral student in the Stanford math department working in the field of probability and stochastic processes under the supervision of A.Dembo.

Percolation, self-avoiding walks and related processes. In my thesis I used the regeneration techniques developed in [4], [1], [2], [7] and [3] to study the long-term behavior in subcritical temperatures of connected components in Bernoulli bond percolation, self-avoiding walks and related statistical mechanical models. See [9], [10], [8] and [13] for the details.

In [9] I derived the Brownian bridge asymptotics for the d-dimensional subcritical bond percolation model conditioned on the event of the origin being connected to a faraway point: We fix $\vec{\mathbf{a}}$ in $\mathbb{Z}^d$ and condition on the event that the origin and $n\vec{\mathbf{a}}$ belong to the same connected component (cluster). It was shown that an interpolation "skeleton" connecting zero to $n\vec{\mathbf{a}}$ and going through some appropriately defined points in the cluster (called "regeneration points"), if scaled $\frac{1}{n\|\vec{\mathbf{a}}\|}$ times along $\vec{\mathbf{a}}$ and $\frac{1}{\sqrt{n}}$ times in all directions orthogonal to $\vec{\mathbf{a}}$, converges weakly to Time $\times$ linearly transformed $(d-1)$-dimensional Brownian bridge as $n \to +\infty$. There the scaled interval connecting points zero and $n\vec{\mathbf{a}}$ serves as a $[0,1]$ time interval. In a subsequent step it was shown that, after scaling, the hitting area of the hyper-planes orthogonal to $\vec{\mathbf{a}}$ shrinks, implying that, for any $\epsilon > 0$ and all n large enough, all points of the scaled cluster are within an ϵ-neighborhood of the interpolation "skeleton" of the regeneration points going from the origin to $n\vec{\mathbf{a}}$.

As a VIGRE assistant professor at the UCLA math department, I have worked on problems from the theory of interacting particle systems, edge-reinforced random walks (ERRW) and random walks in random environments.

Interacting particle systems. In [11] I developed the mathematical theory of the particle systems that interact via permutations, where the transition rates are assigned not to the jumps from a site to a site, but to the permutations themselves. These permutation processes were invented by T.Liggett as a generalization of the symmetric exclusion processes, where particles interact via transpositions. I have introduced new coupling techniques to study the stationary distributions of the permutation processes in the translation invariant case. [11] naturally extends the approach developed in [18], [6], [19], [14] , [15] and [16] to the permutation processes.

Edge-reinforced multi-particle processes and random walks in random environments. In [12] I introduced the multi-particle generalization of ERRW model. There, in absence of partial exchangeability or Polya's urn representation on acyclic graphs, new techniques are needed in order to study the multi-particle model. A combinatorial trick was used to prove the recurrence of a two-point edge-reinforced process on a one-dimensional lattice. I view [12] as a continuation of the theory developed in [5] and [17].

Other research. In addition, I am now collaborating with a UCLA student, T.Gao, on a project of producing better numerical estimates for the exit probabilities in two-dimensional Lorentz lattice gas model. In a separate development, a joint project with E.Nir of the UCLA chemistry department is underway.

Plans for future research. I am currently studying the limiting behavior of edge-reinforced multi-particle processes on finite graphs. This involves finding general new approaches for exploring reinforced processes. As a result, I am led to researching questions concerning the notion of exchangeability, generalized Polya's urns, and random walks in random environments.

At the same time I continue working on problems in the theory of interacting particle systems. I am in the process of developing the theory of permutation processes, the generalized symmetric exclusion processes introduced in [11], where even in the translation invariant case, many questions have not been answered. I am currently involved in estimating the mixing time for permutation processes with properties described in [11].

I am planning to continue applying probability theory and stochastic processes in chemistry and in other fields such as genetics, ecology or finance, where probability theory plays an important role.

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