ICM 1998, Berlin, Aug. 18–27

Abstracts of Plenary and Invited Lectures

Section:

11. Mathematical Physics

1991 MS Classification: 82B43, 82B26, 60K35, 05C80
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Birth of the Infinite Cluster: Finite-Size Scaling in Percolation

Percolation is the simplest and most widely studied model of a random medium. Among the numerous applications of percolation are calculations of the distribution of oil in a porous medium, determination of the behavior of the diffusion coefficient in a turbulent plasma, and the question of intractability in the satisfiability problem in theoretical computer science. A fundamental feature of the percolation model is that it undergoes a critical phase transition from a disordered phase to a phase with long-range order and hence transport. Technically, the transition occurs only in an infinite system. Beyond the transition point, the ordered phase is characterized by the presence of an infinite cluster. The critical regime has been studied extensively by both analytical and numerical methods. This work is a detailed study of the phase transition in percolation, in particular of the question of finite-size scaling: Namely, how does the critical transition behavior emerge from the behavior of large, finite systems? Our results rigorously locate the proper window in which to do critical computation and establish features of the phase transition. This work is a finite-dimensional analogue of classic work on the critical regime of the random graph model of Erdös and Rényi. No prior knowledge of percolation or phase transitions is assumed in this talk. (This is joint work with C. Borgs, H. Kesten and J. Spencer.)