INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.

Thesis Title: Discontinuous percolation transition: Search for new models and scaling theory

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Thesis Submitted to the Department : Physics
Date of completion of Thesis Viva-Voce Exam : 09/04/2018

Key words for description of Thesis Work : Percolation, phase transition and critical phenomena, finite-size scaling and fractals.

SHORT ABSTRACT

Percolation has long served as a model for diverse phenomena. The percolation transition is known as one of the most robust continuous geometrical phase transitions. However, in the recent past, a series of new models with abrupt percolation transitions have been observed in complex systems. Whereas, the nature of explosive percolation transitions has been the topic of intense debate for the past few years. In this thesis, a number of lattice models are developed incorporating the essential ingredients like nucleation and growth in order to realize percolation as a first-order transition in static equilibrium properties of clusters as well as in a non-equilibrium growth process. First, a new two-parameter percolation model (TPPM) with simultaneous growth of multiple clusters is developed. The model has an expand parameter space than that of original percolation model. Percolation transition is determined by the final static configurations of spanning clusters. It is found that the values of the critical exponents describing the scaling functions at the criticality in this model are that of original percolation for all values of ρ and the transitions belong to the same universality class of percolation. Secondly, the model is improved by introducing suppressed cluster growth incorporating a cluster size dependent dynamic growth probability. This dynamically varying growth probability leads to correlated growth. It is found that the values of the critical exponents describing the scaling functions at the criticality in this model are that of original percolation for $\rho \geq 0.2$. Whereas for $\rho < 0.2$, suppression of the growth of larger clusters seems to have non-trivial effect on the critical properties. The values of the critical exponents found to deviate from those of the original percolation. However, such suppression is found to be too weak to change the nature of the percolation transition. After that a nucleation and preferential growth in cluster generation is further incorporated in TPPM, the above model. Following usual spanning cluster approach of original percolation, the model is found to exhibit distinctly a first-order transition as well as a continuous percolation transition at different regimes of initial seed concentration ρ. As ρ decreases starting from the percolation threshold p_c of the original percolation, a line of continuous transition encounters a coexistence region of percolating and non-percolating large clusters. First-order transitions are found to occur. Finally a dynamical model of random cluster growth lattice filling percolation model with touch and stop rule is developed. Nucleation centers are continuously added one at a time to the empty sites and clusters are grown from these nucleation centers with a growth probability g. The model is found to exhibit second order continuous percolation transitions as original percolation for $g \leq 0.5$ whereas for $g \geq 0.8$ it exhibits first order discontinuous percolation transitions. Instead of a sharp tricritical point, a tricritical region is found to occur for $0.5 < g < 0.8$ within which the values of the critical exponents change continuously till the crossover from continuous to discontinuous transition is completed. Since the order parameter distribution is of a weak bimodal type for $g \geq 0.8$, the discontinuous transitions in this regime are weak first-order transitions.