Efficient Monte Carlo Simulations of the Random-Cluster Model using a Dynamic Connectivity Algorithm

Eren M. Elci and Martin Weigel - Applied Mathematics Research Centre, Coventry University, Coventry, CV1 5FB, England

The simulation of spin models close to points of continuous phase transitions is heavily impeded by the occurrence of critical slowing down.
A number of cluster algorithms usually based on the Fortuin-Kasteleyn representation of the Potts model and suitable generalizations for continuous-spin models has been used to increase simulation efficiency. The first algorithm making use of this representation, suggested by Sweeny in 1983, has not found widespread adoption due to problems in its efficient implementation. It has been shown recently, however, that it is indeed more efficient in reducing critical slowing down that the more well-known variants due to Swendsen/Wang and Wolff. Here, we discuss an efficient implementation of Sweeny's approach using recent algorithmic advances in dynamic connectivity algorithms, and show how these can be used for efficient simulations in the random-cluster model. An extension of this approach, which is also efficient for first order phase transitions, is the combination of the random cluster model and multicanonical simulations. In this framework, we directly sample the combined geometrical bond- and cluster-number density of states of the model. By construction, this approach does not suffer from any (hyper-)critical slowing down.