Coarsening and percolation in a disordered ferromagnet

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We study numerically the phase-ordering kinetics of a two-dimensional ferromagnetic Ising model quenched from above to below the critical temperature. Upon computing usual quantities used to assess percolation properties, such as the pair connectedness function, the wrapping probabilities, or the winding angle, we show that these quantities attain the exact behaviour of random percolation theory after a characteristic time t_p. This shows that a critical percolation spanning cluster forms during the coarsening kinetics at t_p.

This fact comes as a surprise, since percolation is a paradigm of a non-interacting problem, whereas coarsening embodies exactly the opposite. The time t_p when the percolative spanning cluster form is shown to increases algebraically with the system size. After that time, the percolation structure is rendered more and more compact by the ensuing coarsening process and the spreading of ferromagnetic correlations. In order to assess the generality of this phenomenon we also study the effects of quenched disorder. Specifically we consider the two-dimensional ferromagnetic Ising model in the presence of random bonds or random external fields. Our results show that the phenomenon whereby the percolative structure is formed att_p and later dismantled are largely independent on the presence of quenched disorder, pointing towards a general character. This can be interpreted within a dynamical scaling framework where the typical domains size plays the role of a rescaling length. This approach holds true both in the case of clean or disordered systems, despite the fact that the rescaling length grows much slower in the latter. Our results not only opens the way to further studies on more general disordered systems (for instance, randomly diluted models where a more complex scaling structure has been recently observed), but also prompts the attention on a possible generalisation of analytical theories where the properties of phase-ordering are traced back to percolation effects, originally developed for clean systems, to the disordered cases.

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