MAR16-2015-001700

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Spinodals with Disorder: from Avalanches in Random Magnets to Glassy Dynamics

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We revisit the phenomenon of spinodals in the presence of quenched disorder and develop a complete theory for it. We focus on the spinodal of an Ising model in a quenched random field (RFIM), which has many applications in many areas from materials to social science. By working at zero temperature in the quasi-statically driven RFIM, thermal fluctuations are eliminated and one can give a rigorous content to the notion of spinodal. We show that the spinodal transition is due to the depinning and the subsequent expansion of rare droplets. We work out the critical behavior, which, in any finite dimension, is very different from the mean-field one: the characteristic length diverges exponentially and the thermodynamic quantities display very mild non-analyticities much like in a Griffith phenomenon. Thanks to the recently established connection between the spinodal of the RFIM and glassy dynamics, our results allow us to conclusively assess the physical content and the status of the dynamical transition predicted by the mean-field theory of glass-forming liquids.