MAR10-2009-008158

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Avalanche dynamics of imbibition fronts

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The spatio-temporal dynamics of interfaces driven through random media has become a subject of central importance in non-equilibrium statistical mechanics in last years. A wide variety of slowly driven physical systems - vortex lines in superconductors, dislocation lines in defective crystalline solids, fracture fronts in heterogeneous materials, magnetic domain walls in disordered ferromagnets or wetting contact lines on rough substrates - exhibit a self-affine morphology and burst-like correlated motion, that arise from the interplay between competing interactions. In this context, we address here the problem of forced-flow imbibition in a disordered medium where a fluid (oil) that preferentially wets the medium displaces a resident fluid (air) at a constant flow rate. Using a high resolution fast camera, we follow the propagation of the fluid-air interface invading a disordered Hele-Shaw cell. Measuring the local waiting time fluctuations along the front during its propagation, we show that the imbibition fronts display an intermittent behavior signature of an avalanche-like dynamics. First, we will discuss the Non-Gaussian fluctuations of the global (spatialy averaged) velocity V (t) of the interface. Then, we will focus on the various scaling behavior of the local avalanches defined as spatial clusters of large local velocity. Our experimental results underline the critical behavior of the imbibition dynamics, suggesting the existence of a critical depinning transition for this process at V=0.