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Reversible-Irreversible Transition Induced by Increased Shear Amplitude and Vortex Density

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When a periodic ac shear is applied to many-particle assemblies with disordered configuration, the particles gradually self-organize to avoid future collisions and transform into an organized configuration. For a small shear amplitude d, the particles finally settle into a reversible state where all the particles return to their initial position after each shear cycle, while they reach an irreversible state for d larger than a threshold amplitude d_c [1]. Using periodically sheared vortices in amorphous Mo_xGe_{1-x} films with random pinning, we have studied the critical behavior of the reversible-to-irreversible transition (RIT). From the time-dependent voltage generated by vortex motion, we have observed organization of vortex configuration called random organization [2,3]. The relaxation time for the system to reach the steady state, plotted against d, shows a power-law divergence at the threshold amplitude d_c, indicative of a nonequilibrium RIT. The critical exponent is in agreement with the value expected for an absorbing phase transition in the two-dimensional directed-percolation universality class [4,5]. In our previous experiments, RIT was induced by increasing d at a fixed vortex density n, that is, at a fixed magnetic field B. This situation is qualitatively equivalent or similar to the one where n (i.e., B) is increased at fixed d. However, it is not evident whether the same critical behavior of RIT is observed irrespective of the parameters (d or n [6]) used in the experiment. This is an important issue in examining the universality of RIT. We will present the data in favor of the notion.

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