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Summary: In this paper we analyze metastability and nucleation in the context of the Kawasaki dynamics for the two-dimensional Ising lattice gas at very low temperature. Let $\Lambda \subset \mathbb{Z}^2$ be a finite box. Particles perform simple exclusion on $\Lambda$, but when they occupy neighboring sites they feel a binding energy $-U_1 < 0$ in the horizontal direction and $-U_2 < 0$ in the vertical one. Thus the Kawasaki dynamics is conservative inside the volume $\Lambda$. Along each bond touching the boundary of $\Lambda$ from the outside to the inside, particles are created with rate $\rho = e^{-\Delta \beta}$, while along each bond from the inside to the outside, particles are annihilated with rate 1, where $\beta > 0$ is the inverse temperature and $\Delta > 0$ is an activity parameter. Thus, the boundary of $\Lambda$ plays the role of an infinite gas reservoir with density $\rho$. We consider the parameter regime $U_1 > 2U_2$ also known as the strongly anisotropic regime. We take $\Delta \in (U_1, U_1 + U_2)$, so that the empty (respectively full) configuration is a metastable (respectively stable) configuration. We consider the asymptotic regime corresponding to finite volume in the limit as $\beta \to \infty$. We investigate how the transition from empty to full takes place with particular attention to the critical configurations that asymptotically have to be crossed with probability 1. The derivation of some geometrical properties of the saddles allows us to identify the full geometry of the minimal gates and their boundaries for the nucleation in the strongly anisotropic case. We observe very different behaviors for this case with respect to the isotropic ($U_1 = U_2$) and weakly anisotropic ($U_1 < 2U_2$) ones. Moreover, we derive mixing time, spectral gap and sharp estimates for the asymptotic transition time for the strongly anisotropic case.

MSC:
60J10 Markov chains (discrete-time Markov processes on discrete state spaces)
60K35 Interacting random processes; statistical mechanics type models; percolation theory
82C20 Dynamic lattice systems (kinetic Ising, etc.) and systems on graphs in time-dependent statistical mechanics
82C22 Interacting particle systems in time-dependent statistical mechanics
82C26 Dynamic and nonequilibrium phase transitions (general) in statistical mechanics

Keywords:
lattice gas; Kawasaki dynamics; metastability; critical droplet; large deviations; pathwise approach; potential theory

Full Text: DOI

References:


