

Inflection Point as a Manifestation of Tricritical Point on the Dynamic Phase Boundary in Ising Meanfield Dynamics

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Abstract. We studied the dynamical phase transition in kinetic Ising ferromagnets driven by oscillating magnetic field in meanfield approximation. The meanfield differential equation was solved by sixth order Runge-Kutta-Felberg method. We calculated the transition temperature as a function of amplitude and frequency of oscillating field. This was plotted against field amplitude taking frequency as a parameter. As frequency increases the phase boundary is observed to become inflated. The phase boundary shows an inflection point which separates the nature of the transition. On the dynamic phase boundary a tricritical point (TCP) was found, which separates the nature (continuous/discontinuous) of the dynamic transition across the phase boundary. The inflection point is identified as the TCP and hence a simpler method of determining the position of TCP was found. TCP was observed to shift towards high field for higher frequency. As frequency decreases the dynamic phase boundary is observed to shrink. In the zero frequency limit this boundary shows a tendency to merge to the temperature variation of the coercive field.

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1 Introduction

The ferromagnetic system, in the presence of a time varying external magnetic field, remaining far from statistical equilibrium, became an interesting object of research over the

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last two decades [1]. One interesting nonequilibrium response is the dynamic phase transition. This dynamic phase transition is widely studied in model ferromagnetic system in the presence of oscillating magnetic field, see, e.g., [1–3]. Tome and Oliveira [4] first observed a prototype of nonequilibrium dynamic transition in the numerical solution of meanfield equation of motion for the classical Ising ferromagnet in the presence of a magnetic field varying sinusoidally in time. The time averaged (over the complete cycle of the oscillating magnetic field) magnetization plays the role of the dynamic order parameter. They [4] found that this dynamic ordering depends on the amplitude of the oscillating magnetic field and the temperature of the system. Systems get dynamically ordered for small values of the temperature and the amplitude of the field. They [4] have drawn a phase boundary (separating the ordered and disordered phase) in the temperature field amplitude plane. More interestingly, they have also reported [4] a tricritical point on the phase boundary, which separates the nature (continuous/discontinuous) of the dynamic transition across the phase boundary. This tricritical point was found just by checking the nature of the transition at all points across the phase boundary. The point where the nature of transition changes was marked as the tricritical point. No other significance of this tricritical point was reported. The frequency dependence of this phase boundary was not reported earlier for the dynamic transition in Ising meanfield dynamics.

In this paper, we studied numerically the dynamic transition in Ising meanfield dynamics. Here, we confined our attention to study the frequency dependence of the dynamic phase boundary. We studied the tricritical behavior and found a method of finding the position the tricritical point on the dynamic phase boundary. The frequency dependence of the position of the tricritical point was studied here. We also studied the static (zero frequency) limit of dynamic phase boundary.

The paper is organized as follows. In the next section the model and the method of numerical solution is discussed. Section 3 contains the numerical results and the paper end with summary of the work in Section 4.

2 Model and numerical solution

The time (t) variation of average magnetization m of Ising ferromagnet in the presence of a time varying field, in meanfield approximation, is given as [4]

$$\tau \frac{dm}{dt} = -m + \tanh\left(\frac{m+h(t)}{T}\right), \quad (2.1)$$

where $h(t)$ is the externally applied sinusoidally oscillating magnetic field ($h(t) = h_0 \sin(\omega t)$) and T is the temperature measured in units of the Boltzmann constant (K_B). This equation describes the nonequilibrium behavior of instantaneous value of magnetization $m(t)$ of Ising ferromagnet in meanfield approximation.

We have solved this equation by sixth order Runge-Kutta-Felberg (RKF) [5] method to get the instantaneous value of magnetization $m(t)$ at any finite temperature T , h_0 and