

A new formalism for the statistical dynamics of planar spin systems

KAMLESH KUMARI and DEEPAK KUMAR*

* Department of Physics, University of Roorkee, Roorkee 247 667, India

*School of Physical Sciences, Jawaharlal Nehru University, New Delhi 110067, India

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Abstract. The relaxational dynamics of a classical planar Heisenberg spin system is studied using the Fokker-Planck equation. A new approach is introduced in which we attempt to directly calculate the eigenvalues of the Fokker-Planck operator. In this connection a number space representation is introduced, which enables us to visualize the eigenvalue structure of the Fokker-Planck operator. The mean field approximation is derived and a systematic method to improve the mean field approximation is presented.

Keywords. Relaxational dynamics; planar Heisenberg model; Fokker-Planck equation; mean field approximation; critical slowing-down.

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1. Introduction

The dynamical critical behaviour of the macroscopic systems is a well studied subject. Starting with the pioneering work of Van Hove (1954) and Landau and Khalatnikov (1954), the subject has now reached a mature stage, in which the advanced theoretical techniques like renormalization group have been brought to bear upon the problem (Hohenberg and Halperin 1977; Enz 1979). However, most of the recent theoretical developments have been confined to basically two kinds of models. The first kind are the so-called 'kinetic Ising models' while the second kind are a variety of field theoretic models, known more familiarly as time-dependent Landau-Ginzburg models. Though these models bring out very fascinating and germane physics, both these classes of models are either somewhat idealized abstractions of the physical systems they intend to describe, or are semi-microscopic approximations of the microscopic equations of motion (Kawasaki 1970). For example, in the kinetic Ising models the dynamics is described in terms of a master equation for the joint probability distribution of spins, as the spins as such have no dynamics of their own (Glauber 1963). While in Landau-Ginzburg models (Ma 1976) the order parameter field and the other relevant fields are allowed to assume values over an infinite range, and the basic nonlinearities of the problem, viz interaction between fields and restrictions on their range are simplified by taking them to be the simplest polynomials.

Given the complexity involved in the study of the dynamics of macroscopic systems it is not surprising that so much attention has been given to these models, which are

*To whom all correspondence should be addressed