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Critical Dynamics of Multiplicative Systems

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In this study we analyze the critical dynamics of a real scalar field in 2D near a continuos phase transition. We have computed
and solved Dynamical Renormalization Group (DRG) equations to two loops order. We have found that, different from
the case $d < 4$, characterized by a Wilson-Fisher fixed point with $z = 2 + O(\epsilon^2)$, the critical dynamics is dominated by a novel multiplicative fixed point.

The interest in critical dynamics is rapidly growing up in part due to the wide range of multidisciplinary applications deeply impacted by the use of criticality. For instance, the collective
behavior of biological systems displays critical behavior with space-time correlation functions with non-trivial scaling laws[1].

The standart approach to deal with dynamics is the Dynamical Renormalization Group[2]. We assume that the evolution of the system near the critical point is governed by a dissipative process.
Then we use the *Martin-Siggia-Rose-Janssen-DeDominicis* formalism[3] to transform the dynamical equation in to a functional generator.
On top of that, one can add two Grassmann fields $\bar{\xi}, \xi$ in the functional generator in order to increase the supersymmetric formulation for the dynamics[4,5]. This supersymmetric formalism enables the choice of a specific stochastic evolution.

In this work, we begin with the dynamical ϕ^4. We adopted the so called Generalized Stratonovich prescription parametrized by a real number $0 \leq \alpha \leq 1$ and present here the calculations for the Itô ($\alpha = 0$) prescription. % For instance, $\alpha = 0$ is the Itô prescription, $\alpha = 1/2$ is the Stratonovich while $\alpha = 1$ is the Hangii-Klimontovich or anti-Itô prescription.
We use the functional generator to compute the dynamical correlation functions. We perform a diagrammatic pertubation theory up to 2-loops and obtain the DRG equations. We fully calculated up to 2-loop corrections for the flux equations using an "Wilsonionan approach". Here we are presenting only the 1-loop corrections since the analysis for the 2-loop equations is still ongoing.
The 1-loop DRG equations has fixed points, depending essentially
on dimensionality. For $d > 4$, the Gaussian fixed point,
with $z = 2$ correctly describes the phase
transitions. However, for $d < 4$, a Wilson-Fisher fixed point[6] shows up. At this level of approximation, g is an irrelevant variable and the dynamics is driven by a usual
additive noise stochastic process recovering the results from Ref. [2]. However,
at d = 2 the dynamical behavior changes and the former Wilson-Fischer point is transfered to a relevant multiplicative fix point with $g \neq 0$. Thus creating a critical plane for the transition. We also notice, in 1-loop, the appearance of an anomalous dimension originatad from the multiplicative interaction.

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