Field theoretical approach to the glass transition

Yukawa Institute for Theoretical Physics, Kyoto Univ.
Taka H. Nishino and Hisao Hayakawa

モード結合理論 (MCT) はガラス転移を説明する理論として多くの研究がなされてきたが、ガラス転移温度が実験よりかなり高くなるなどのいくつかの問題を含んでいる。これはMCTでは導出仮定においてdecoupling近似等、物理的に不透明な近似を導入していることや、そもそもMCTでは熱活性化過程を捉えれないことが要因となっていると考えられている [1]。そこで我々は系統的な近似を行うことができる場の理論に基づいて二体相関関数の発展方程式の導出を行った。

1 Introduction

There are some theories which try to understand the glass transition. Amongst them Mode-Coupling Theory (MCT) is one of remarkable approaches which is regarded as the rst-principle equations derived from Liouville or Langevin equation. MCT can capture the characteristics of the relaxation of the time correlation function in glass transition and uncover the feature of α-relaxation regime and the β-relaxation regime.

On the other hand, it is known that there are some serious failures in MCT. Indeed, the critical temperature T_c for the glass transition predicted by MCT higher than the observed glass transition point T_g. It is more serious that MCT predicts a virtual transition so-called ergodic-nonergodic transition under T_c, which has not been observed in any experiments [1].

There are some reasons that MCT makes failures. The derivation of the MCT equation includes a crude approximation, the decoupling approximation. To overcome this di culty we would have to start from the reliable basic equations using controllable approximation. The most systematic approach to describe the glass transition is the eld theoretical approach in which we can avoid adopting some uncontrollable approximations.

2 Field theoretical approach with FDR-preserving

When we calculate the Langevin equation, we should keep in mind that the equation must satisfy the Fluctuation-Dissipation Relations (FDR). On the contrary to Langevin equation with the white noise, it is known that FDR cannot be satis ed in each order of the perturbative expansion in usual approaches. Therefore, it is di cult to construct the FDR preserving eld theory [2].

Recently, Andreanov et al. [3] (ABL) have developed the FDR preserving eld theoretical approach to the glass transition by the introduction of some new variables and some relations of time reversal symmetry. Their approach makes FDR preservation in each loop possible. Furthermore, Kim and Kawasaki [4] re ne ABL and succeed in obtaining the MCT equation from the Dean-Kawasaki equation [5, 6].

Dean-Kawasaki equation, however, does not include the momentum conservation, which might be related to the defects of MCT. Indeed, Das and Mazenko [7] have suggested that the set of Langevin equations including the momentum conservation law leads to the cut o the mechanism which destructs the ergodic-nonergodic transition. We also indicate that the momentum conservation can cause some heterogeneous motion of particles when the density is enough high.

In this poster we demonstrate that we can construct a FDR-preserving eld theory starting from Das-Mazenko equation instead of Dean-Kawasaki equation. We have derived closed equations for two-point correlation functions under the systematic approximation. The emergence of the cuto mechanism will be discussed in the poster session, if possible.

References

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