膨張無限系の分子動力学シミュレーション

近角真平
筑波大学物理学系（日本学術振興会特別研究員）
日本原子力研究所　先端基礎研究センター　極限ハドロングループ

千葉敏
日本原子力研究所　先端基礎研究センター　極限ハドロングループ

岩本昭
筑波大学物理学系
日本原子力研究所　物質科学研研究グループ

The purpose of this study is to investigate the fragmentation mechanism in expanding matter. The fragmentation is subject to the instability of the system. As long as the system is in thermal equilibrium, its instability can be studied by several models based on thermal physics. However, thermal physics cannot be used for expanding matter due to its non-equilibrium e®ects which can only be treated numerically.

The expanding matter model [1, 2] is a useful framework to study how the expanding motion a®ects the instability of the system. The model is based on molecular dynamics modi¯ed by imposing an extended periodic boundary condition. Under this condition, the dynamics of expanding matter can be simulated free from the surface e®ect which makes it di±cult to understand the essential point in fragmentation process.

In [3], the expanding matter model with quantum molecular dynamics (QMD) was introduced to study the fragmentation in heavy ion reactions. The expanding matter model has two control parameters: initial temperature T_{ini} and the expanding velocity h. In [3], in particular, the fragment mass distribution is discussed as a function of these two parameters. In this study, we concentrate on the instability of expanding matter by using the Lennard-Jones (LJ) potential [4]. In principle, the instability can be evaluated from time evolution of the temperature and the pressure. However, in our previous work, the meaning of the temperature is not clear due to the presence of the momentum dependent potentials. This is why the LJ potential is used in the present study. In addition, we can calculate the exact liquid-gas coexistence curve for the LJ system.

The coexistent curve speci¯es the border of the instability in thermalized system. However, the instability region in expanding matter is a®ected by its expanding motion. In the framework of the expanding matter model, the expanding velocity can be controlled by only one parameter (h). When h is very small, the time evolution of the system is regarded as quasi-static process. In this study, it is found that the temperature of the expanding matter stays constant during the time evolution in the quasi-static process just after the system enters into the coexistence region. This indicates that the system undergoes the ¯rst order phase transition, which is consistent with the expectation of thermal physics. On the other hand, in the case of more rapid expanding matter, the instability region is di®erent from the coexistence region in such a way that the fragmentation occurs at smaller density.

To investigate the fragment mass distribution as a function of T_{ini} and h is another purpose of the present study. Though we use the LJ potential, the obtained fragment mass distribution is very similar to the result from QMD expanding matter. This means that there is a universal mechanism in the fragmentation occurred in expanding matter independent of the kinds of interactions we use.

[1] S. Toxvaerd, Physical Review E 58, 704 (1998).
[2] W. T. Ashurst and B. L. Holian, Physical Review E 59, 6742 (1999).
[3] S. Chikazumi, T. Maruyama, S. Chiba, K. Niita, and A. Iwamoto, Physical Review C 63, 024602 (2001).
[4] S. Chikazumi and A. Iwamoto, Physical Review C 65, 067601 (2002).