

# Validation of a Two-Phase Lattice Boltzmann Method with Local Mesh Refinement for Gas Entrainment Simulation in Fast Reactors

\*Yos Sitompul<sup>1</sup>, Kenta Sugihara<sup>1</sup>, Seiya Watanabe<sup>2</sup>, and Yasuhiro Idomura<sup>1</sup>

<sup>1</sup>Japan Atomic Research Agency, <sup>2</sup>Kyushu University

This study addresses gas entrainment (GE) simulation in fast reactor using a two-phase Lattice Boltzmann Method (LBM) with Local Mesh Refinement (LMR). The approach enhances simulation accuracy and reduces computational time. It demonstrates LBM-LMR's potential for efficient and reliable analysis of complex flow phenomena in reactor systems.

**Keywords:** validation, two-phase LBM, local mesh refinement, gas entrainment, fast reactors

## 1. Introduction

Argon cover GE prevention is crucial for safe sodium-cooled fast reactor operation. At JAEA, we simulated a benchmark GE experiment using a two-phase LBM, accurately predicting velocity profiles and GE depths with a uniform grid [1]. To improve efficiency, LMR is being developed. This study focuses on validating, optimizing, and evaluating the LBM-LMR approach.

## 2. Two-phase LBM-LMR Validation

We implemented a two-phase LBM for gas-liquid interface simulation and validated it with Moriya et al.'s experiment [2] (Fig. 1). It accurately reproduced flow profiles and GE depths using a grid spacing  $\Delta x < 0.625$  mm. Efficiency was improved with multi-GPU and LMR algorithms using an octree-based data structure and Morton curve domain decomposition [3]. A multi-time-step approach and rescaling of distribution functions were employed to enhance accuracy and efficiency. Using two-phase LBM-LMR with three refinement levels, we could reduce computational cells by 50% and achieved a  $1.5\times$  speedup, solving the problem in about 20 hours, and obtained good agreement of the vortex center location, velocity profiles, and GE depths with the uniform grid calculation.

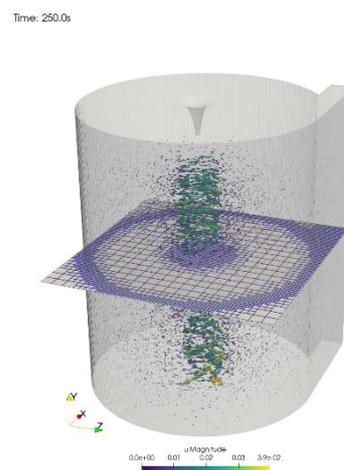


Fig. 1. LBM-LMR calculation of Moriya et al.'s experiment.

## 3. Conclusion

We developed a two-phase LBM-LMR method for simulating gas entrainment in fast reactors. It achieves accurate results and reduces computational costs.

**Acknowledgements:** We express our gratitude for the following support: Part of this research was supported by the JHPCN Exploratory Project (EX24308). Part of the calculations were performed using the Japan Atomic Energy Agency's supercomputer "HPE SGI8600."

## References

- [1] Y. Sitompul, K. Sugihara, N. Onodera, and Y. Idomura, *EPJ Web of Conferences*, Vol. 302, 2024, pp. 05004
- [2] S. Moriya, *Denryoku Chuo Kenkyusho Hokoku*, 1998.
- [3] S. Watanabe, and T. Aoki. *Computer Physics Communications*, Vol. 264, 2021, pp. 107871.