

A stable free-surface-detection method for consistent high-order MPS method

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Abstract

The high-order schemes in MPS method can enhance accuracy but easily suffer from numerical instability at free surfaces. In this study, a new free-surface-detection method based on the stability analysis is proposed to solve this problem. Numerical examples demonstrated that the new method detected fewer free-surface particles but enhanced the stability.

Keywords: Particle method, MPS, Free surface, Stability, Accuracy

1. Introduction

The high-order schemes in particle methods can greatly suppress pressure fluctuations [1], improve boundary accuracy [2,3], and enhance reliability. The high-order particle method has great potential but suffers from instability easily at free surfaces. This paper aims to develop a novel free-surface-detection approach to suppress the instability.

2. Numerical methods

The high-order schemes presented in our previous study [3] are employed here. After careful investigation, it is found that the instability is closely related with the free-surface-detection method. Namely, when an internal particle is subjected to seriously biased neighbor support, the biased error will accumulate rapidly, triggering instability. After this internal particle is detected as a free-surface particle, the boundary condition imposition at free surfaces can break the error-accumulation loop and suppress the instability. The coefficients of discretization models can effectively measure the bias of neighbor supports. Therefore, the model coefficients are used to detect the required free surface particles.

3. Simulations and discussion

Four typical test cases were performed to contrast the stability between the existing and proposed approaches. It was found that the proposed approach detected fewer free-surface particles but produced more stable simulations than the existing ones. Meanwhile, the simulated results were in good agreement with the benchmark results in literatures.

4. Conclusion

A new free-surface-detection approach based on stability analysis is proposed for the high-order MPS method. The biased neighbor support is the main reason for error accumulation and instability. The proposed approach can detect fewer free-surface particles but produce more stable results than the existing approach. Based on the new technology, the high-order schemes can greatly enhance the accuracy and stability of particle methods.

5. Acknowledgements

This research was partially supported by the MEXT Quantum Leap Flagship Program (MEXT Q-LEAP) under Grant No. JPMXS0118067246 and JSPS KAKENHI under Grant No. 19K15478.

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