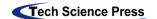
DOI: 10.32604/icces.2023.010004



#### **PROCEEDINGS**

# **GPU-Accelerated Numerical Modeling of Hypervelocity Impacts on CFRP Using SPH**

Yao Lu<sup>1</sup>, Jianyu Chen<sup>2</sup>, Dianlei Feng<sup>3,\*</sup> and Moubin Liu<sup>1,\*</sup>

<sup>1</sup>College of Engineering, Peking University, Beijing, 100871, China

<sup>2</sup>School of Mechanical Engineering, Nanjing University of Science and Technology, Nanjing, 210094, China

<sup>3</sup>College of Civil Engineering, Tongji University, Shanghai, 200092, China

\*Corresponding Author: Dianlei Feng; Moubin Liu. Email: dianleifeng@tongji.edu.cn; mbliu@pku.edu.cn

#### **ABSTRACT**

CFRPs (carbon fiber reinforced plastics), as a kind of fiber-reinforced plastic, present various advantages over traditional materials regarding the specific strength, stiffness, and corrosion resistance. For this reason, CFRPs are widely used in the space industry, like satellites and space stations, which are easily subjected to the HVIs (hypervelocity impacts) threatened by space debris. In order to mitigate the damage of HVIs and protect the spatial structures, it is necessary to predict the HVI process on CFRPs. Smoothed particle hydrodynamics (SPH) method, as a mesh-free particle-based method, has been widely applied for modeling HVI problems due to its special advantages when modeling problems with large deformations [1]. Also, SPH is attractive for parallel computing, benefiting from its particle-based nature [2]. Considering such advantages, we present a GPU-accelerated HVI model for composite CFRPs structures based on the SPH method in this talk. Firstly, a metallic penetration problem is studied as a test example to validate the numerical model. The simulation results agreed well with the published data, and nearly 350 times of speedup (GPU vs CPU) has been achieved. Then, the process of a bullet penetrating a CFRP laminate has been investigated and the corresponding physical behaviors, such as the orthotropic property, shock response, and delamination have been well captured as well. Finally, the HVI problem of the Whipple bumper shield, one of the typical shields for spatial structures, has been investigated considering the secondary debris cloud and the damage effects. Our studies have shown that the GPU-accelerated SPH model allows us to investigate three-dimensional HVI problems with complex composite structures accurately and efficiently.

### **KEYWORDS**

Space debris; hypervelocity impact (HVI); carbon fiber reinforced plastics (CFRPs); smoothed particle hydrodynamics (SPH); GPU parallelization

**Acknowledgement:** Dianlei Feng wants to thank the Fundamental Research Funds for the Central Universities in China for the financial support. This work is also supported by the Natural Science Foundation of Jiangsu province of China (No. BK20210319) and by the opening project (No. KFJJ22-12M) of the State Key Laboratory of Explosion Science and Technology at the Beijing Institute of Technology.

**Funding Statement:** The authors received no specific funding for this study.

**Conflicts of Interest:** The authors declare that they have no conflicts of interest to report regarding the present study.



## References

- 1. Zhang, Z. L., et al. (2019). Predicting the damage on a target plate produced by hypervelocity impact using a decoupled finite particle method. *Engineering Analysis with Boundary Elements*, 98, 110-125.
- 2. Chen, J. Y., et al. (2020). GPU-accelerated smoothed particle hydrodynamics modeling of jet formation and penetration capability of shaped charges. *Journal of Fluids and Structures*, 99, 103171.