Hybrid Lattice Particle Modeling (HLPM) of Dynamic Fragmentation of Solids

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Motivations

Mechanical behavior of a solid material is controlled by its microstructure.

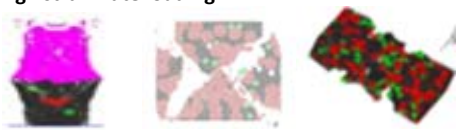
Complex macroscopic behaviors, such as fracture and failure, arise from microstructure interactions. Thus, if the microstructure and the microstructural interactions within a numerical model could be correctly and accurately replicated, then that model should precisely reproduce the macroscopic behaviors. However, current computing power limits the size of the atomic ensemble to numbers of atoms that are too small to be useful for most engineering-scale systems. Hybrid Lattice Particle Modeling (HLPM) is developed to directly mimic microstructural features and can be executed in reasonable times on standard computers.

Model Introduction

HLPM is a dynamic simulation that uses small discrete solid physical particle (or quasi-molecular particles) as a representation of a given fluid or solid. Different particle interaction schemes and mesh structures can be adopted.

Applications of HLPM

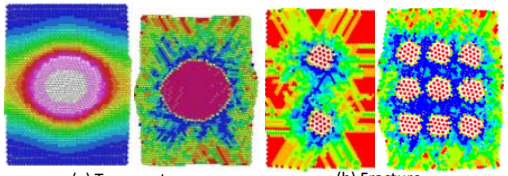
- **High strain rate loading:**



(a) High speed collision (b) High strain rate compression (c)High strain rate tension

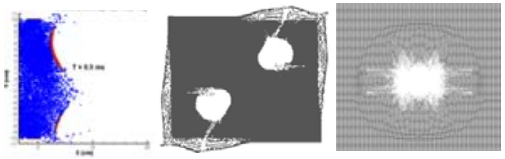
- **Thermally induced fracture:**

Mixture of calcite and pyrite subject to a microwave

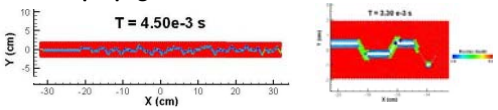


(a) Temperature (b) Fracture

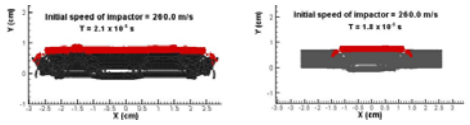
- **Blasting:**



- **Crack propagation:**



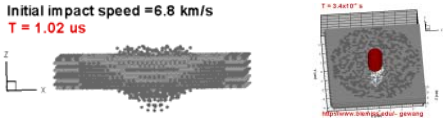
- **Spallation of plate impact:**



- **Wave propagation:**

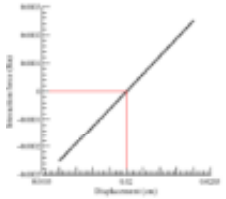
- **3-D puncture:**

Initial impact speed =6.8 km/s
T = 1.02 us

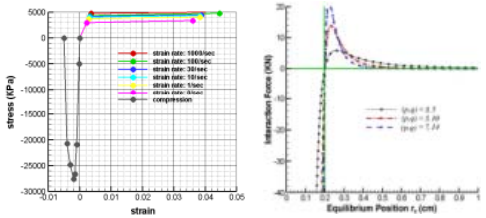


Interactions of HLPM

- **Linear:**

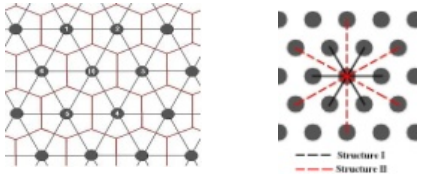


- **Non Linear**

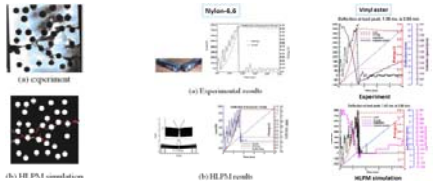


(a) Polynomial (b) Lennard–Jones

- **Meshing structures**



Validations of HLPM



(a) Epoxy in tension (b) Indentation of polymeric materials

Acknowledgement

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Selective publications

Hybrid lattice particle modeling: theoretical considerations for a 2-D elastic spring network for dynamic fracture simulations, *Computational Materials Science* , **44**, 1126-1134, 2009.