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## **SPG and Peridynamics for Material Failure Analysis**

**Instructors:** Youcai Wu (Ph.D.) – SPG, Bo Ren (Ph.D.) – Peridynamics

**2 Days - \$400, Students \$200 w/student ID**

Includes on-site continental breakfasts, lunches, breaks, class notes, class dinner

Includes 30-day demonstration license

**Prerequisite:** Students should be familiar with LS-PrePost, understand the basic LS-DYNA keywords and be able to run an LS-DYNA simulation

**Objective:** This two-day intermediate level class is intended for attendees who are using the LS-DYNA code for their advanced dynamic material failure analyses in solids and composites. It is of particular interest to LS-DYNA users in the automotive, aerospace and defense industries for modeling various material failure scenarios in design, manufacturing and safety of vehicle, aircraft and weapon systems.

### **Description:**

The smoothed particle Galerkin (SPG) method is a new Lagrangian particle method for simulating the severe plastic deformation and material rupture taken place in ductile material failure. The Peridynamics method is another compelling method for brittle fracture analysis in isotropic materials as well as certain composites such as CFRP. These two numerical methods share a common feature in modeling the 3D material failure using a bond-based failure mechanism. Since the material erosion technique is no more necessary, the simulation of the material failure processes becomes very effective and stable.

In this class, attendees will learn the basic principles behind each numerical method, theoretical and practical considerations in creating the computer model for material failure simulation, research breakthroughs and numerical advantages in these two methods. The class will also offer attendees an in-class workshop and help them interpret numerical results to assure the physics has been properly restored.

## Contents:

- 1. Overview of LS-DYNA failure analysis**
  - 1.1. Advanced FEM/EFG
    - 1.1.1. FEM, adaptive FEM/EFG
    - 1.1.2. Continuum damage mechanics and element erosion technique
  - 1.2. Meshfree and particle methods
    - 1.2.1. Meshfree methods: general features and applicability in failure analysis
- 2. LS-DYNA SPG method for ductile and semi-brittle failure analysis**
  - 2.1. Theoretical and numerical aspects
    - 2.1.1. Motivation, fundamentals, keywords
    - 2.1.2. Examples of SPG in non-failure analysis
      - 2.1.2.1. Elastic wave propagation & Taylor impact
    - 2.1.3. Workshop I: Taylor impact (FEM vs SPG)
  - 2.2. Industrial applications I: low speed deformations
    - 2.2.1. SPG bond failure mechanism
    - 2.2.2. Input deck for SPG failure analysis
      - 2.2.2.1. Control cards, SPG parameter cards, contact cards, material cards
    - 2.2.3. Applications of SPG in destructive manufacturing analysis
      - 2.2.3.1. Metal cutting, machining, riveting, friction drilling, FDS
      - 2.2.3.2. Convergence study and sensitivity study to SPG parameters
    - 2.2.4. Workshop II: rod tension
  - 2.3. Industrial applications II: high strain rate deformations
    - 2.3.1. SPG bond failure mechanism
    - 2.3.2. LS-DYNA keywords for SPG analysis of high strain rate deformations
      - 2.3.2.1. Control cards, SPG parameter cards, contact cards, material cards
      - 2.3.2.2. SPG self-contact algorithm to prevent material fusion and self-penetration
    - 2.3.3. Numerical simulations of high strain rate deformations
      - 2.3.3.1. Penetration and perforation of metal and concrete targets
      - 2.3.3.2. Convergence study and sensitivity study to SPG parameters
    - 2.3.4. Workshop III: perforation of steel plate
- 3. Peridynamics for brittle failure analysis: isotropic materials**
  - 3.1. Peridynamic theory and implementation in LS-DYNA
  - 3.2. LS-DYNA keywords for peridynamic analysis
  - 3.3. Numerical results of peridynamic analysis
    - 3.3.1. Static: plate bending, Kalthoff-Winkler problem, 3-point bending of cement beam
    - 3.3.2. Dynamic: windshield impact
- 4. Peridynamics for brittle failure analysis: laminate composite**
  - 4.1. Peridynamic laminate model
    - 4.1.1. Determination of the micro modulus and critical stretch
  - 4.2. LS-DYNA keywords for peridynamic laminate model
  - 4.3. Numerical results of peridynamic laminate analysis
    - 4.3.1. Compression and 3-point bending of laminate
    - 4.3.2. Drilling of laminate
  - 4.4. Workshop IV: brittle failure analysis by peridynamics