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A meshfree method for nonlinear deformation problems

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Introduction

Mesh-based methods like FEM require remeshing to handle mesh distortion under large deformation. We present a truly meshfree method based on the Stabilized Collocation Method and Reproducing Kernel approximation. It avoids remeshing, ensures stability via subdomian integration, and remains accurate and efficient even beyond the deformation limits of FEM and HFEM.

Methods

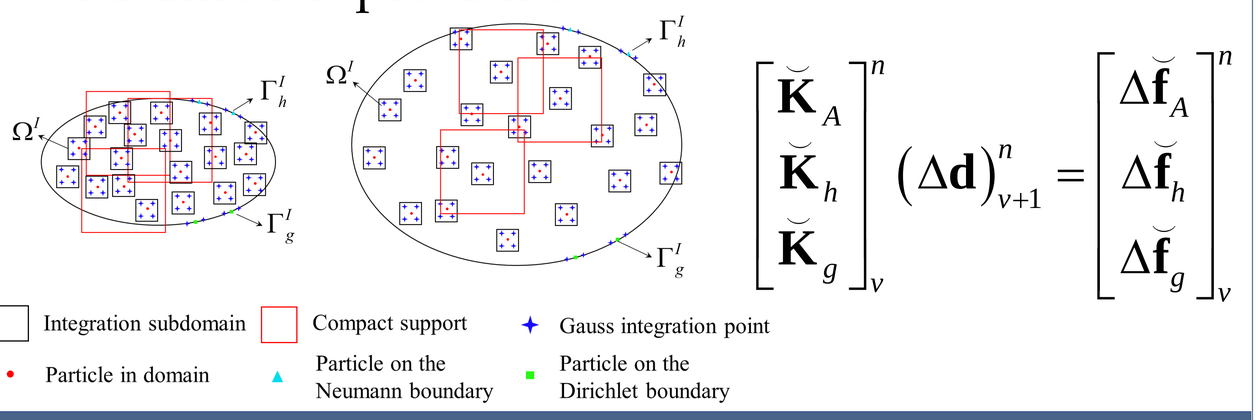
➢Reproducing kernel (RK) approximation

$$u(\mathbf{X}) \approx u^{\lambda}(\mathbf{X}) = \sum_{I=1}^{N} \psi_I(\mathbf{X}) d^I$$

➢Reproducing kernel shape function

$$\psi_I(\mathbf{X}) = \boldsymbol{\Xi}^{\mathrm{T}}(\mathbf{X}-\mathbf{X}_I)\boldsymbol{\Lambda}^{-1}(\mathbf{X})\boldsymbol{\Xi}(\mathbf{0})\ell_\rho(\mathbf{X}-\mathbf{X}_I)$$

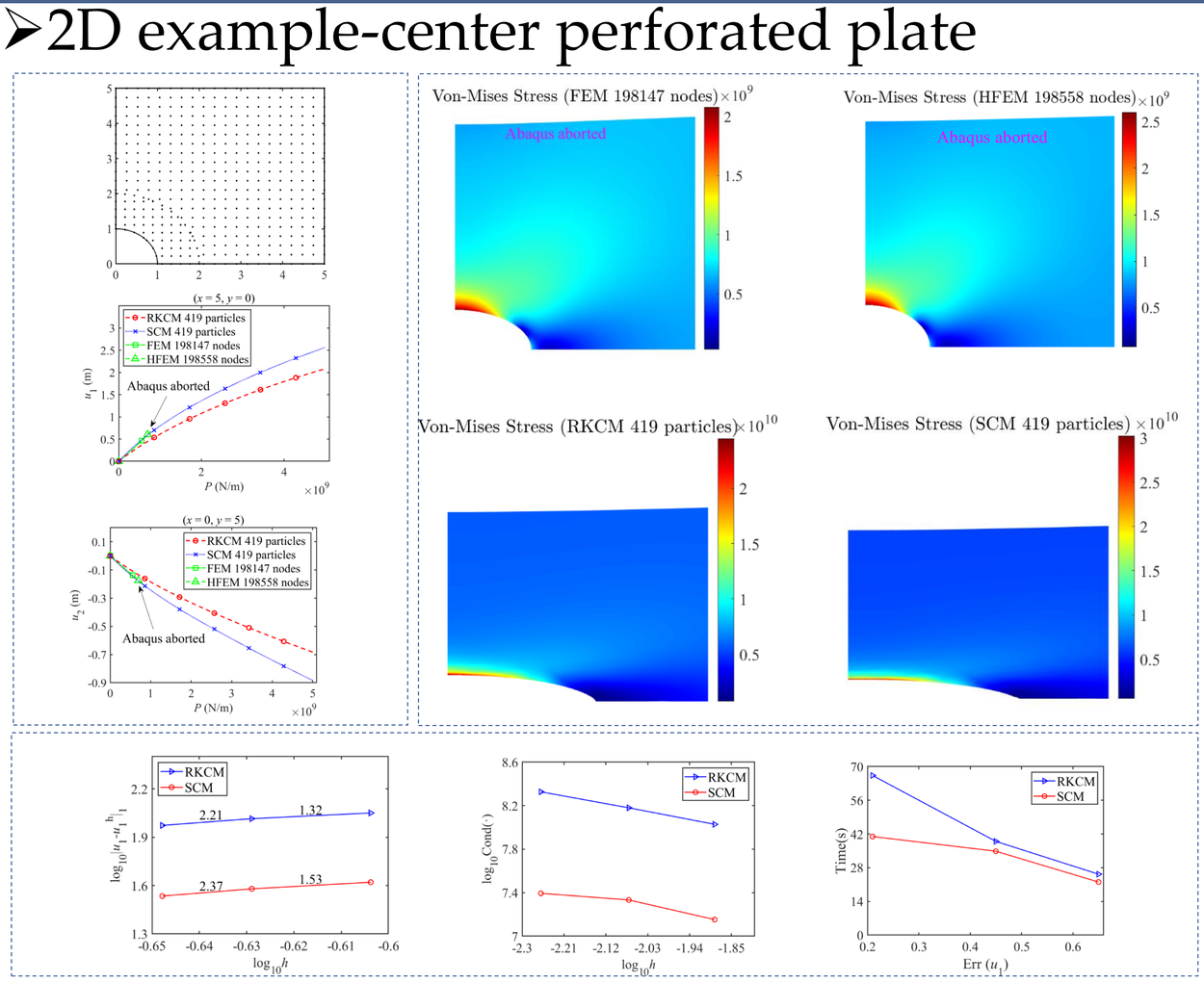
➢Stabilized collocation Method (SCM) for finite deformation problems



$$\begin{bmatrix} \breve{\mathbf{K}}_A \\ \breve{\mathbf{K}}_h \\ \breve{\mathbf{K}}_g \end{bmatrix}^n (\Delta\mathbf{d})_{v+1}^n = \begin{bmatrix} \Delta\breve{\mathbf{f}}_A \\ \Delta\breve{\mathbf{f}}_h \\ \Delta\breve{\mathbf{f}}_g \end{bmatrix}^n$$

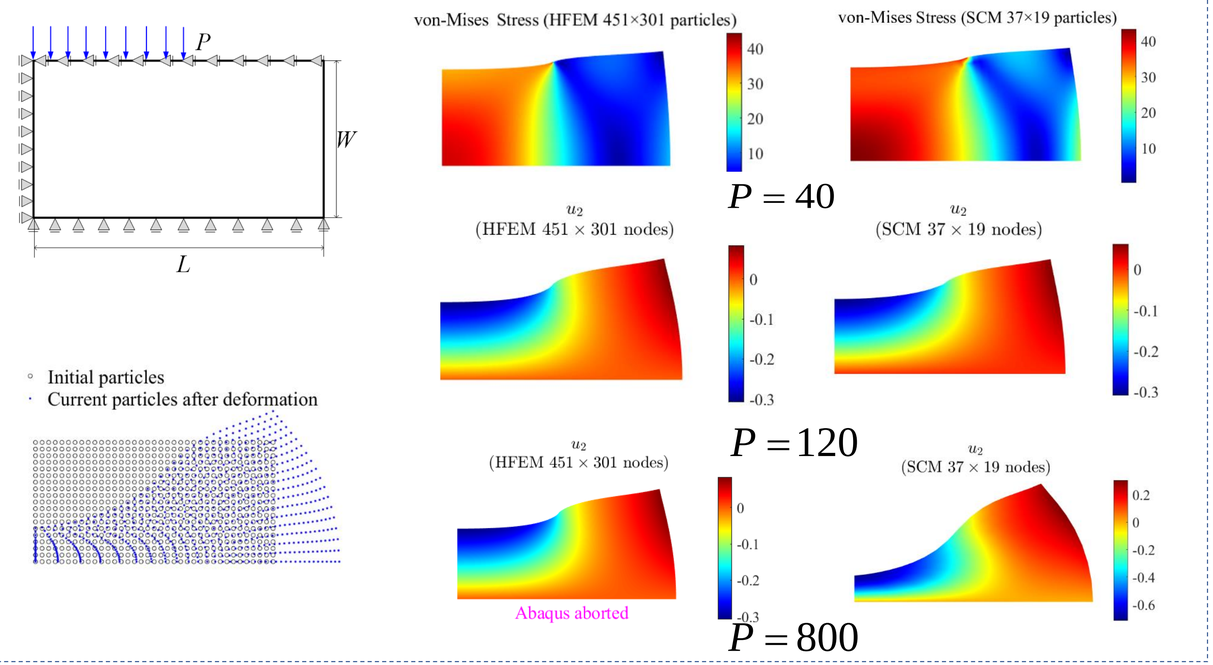
Numerical examples

➢2D example-center perforated plate

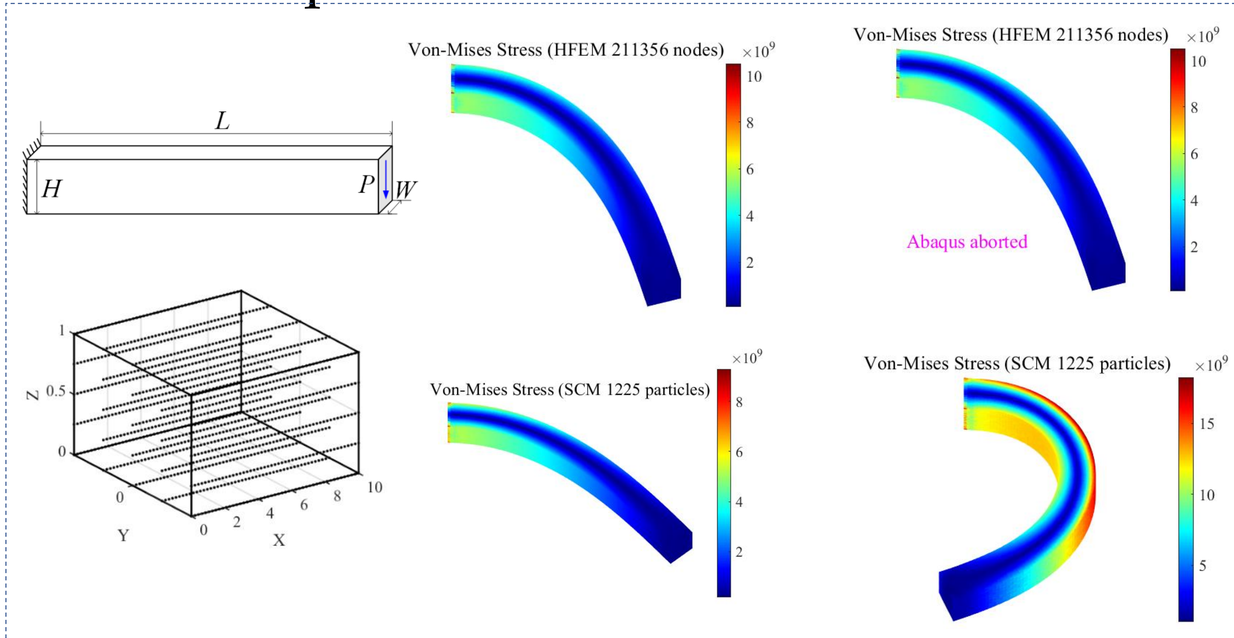


➢2D example-punch test

Possion's ratios $\tilde{\nu} = 0.4999$



➢3D example



Conclusions

- A nonlinear scheme based on SCM is presented for the finite deformation analysis.
- No domain remeshing is required during the entire large deformation solution.
- SCM can obtain accurate subdomain integration, which raises accuracy and stability.
- Eliminating the need for remeshing can notably promote the solution efficiency.
- SCM can handle very large deformation problems beyond the limit of FEM solutions.