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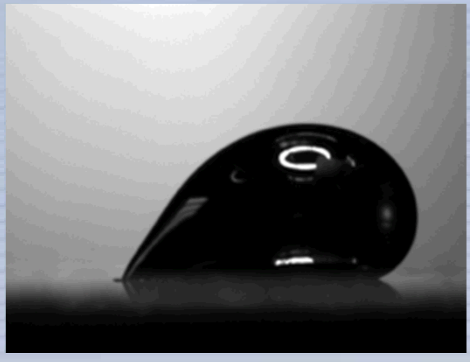
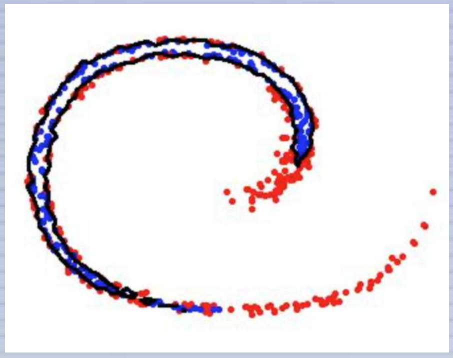
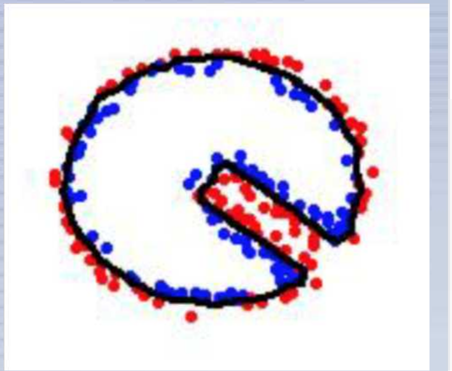

An Interpolative Particle Level Set Method

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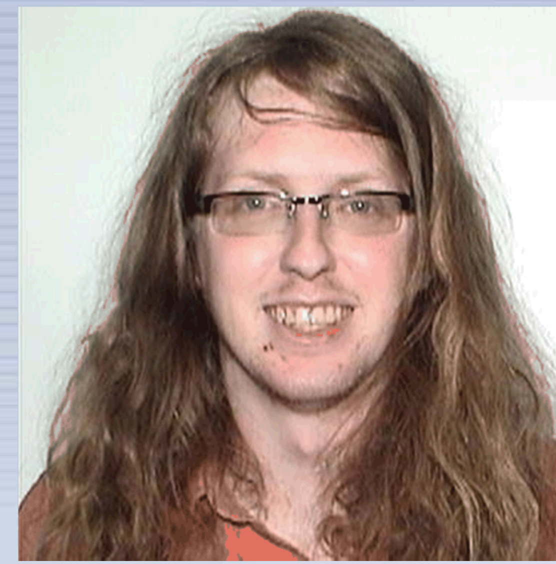
Acknowledgements

Karla Morris

Jeremy Templeton

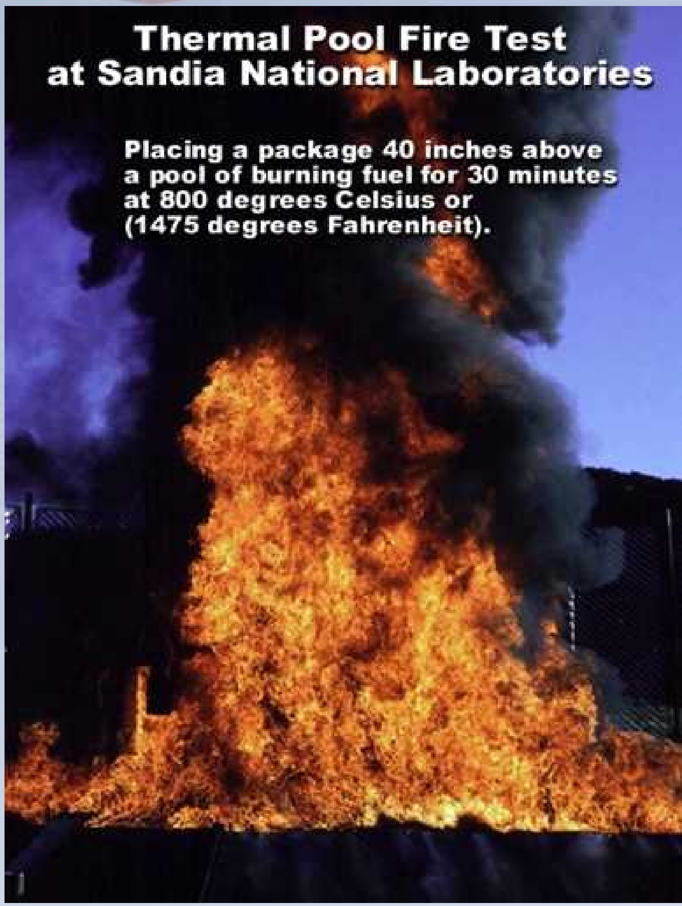


David Poliakoff

Funding: Sandia LDRD Program

Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Interfacial methods are needed for melting metal simulations



Fire scenario simulations

Heated metal droplet on incline, courtesey of C. Brooks (Sandia National Laboratories, 2012)

Interface Method Choices

- **Interface capturing (VOF, Level Set)**
  - ✓ Natural merging and pinch-off
  - ✓ Normal vector and curvature calculations
  - X Mass conservation problems
  - X Limited by grid size
- **Interface tracking (Lagrangian particle methods)**
  - ✓ Conservative by design
  - ✓ Excellent at resolving fine scale
  - ✓ Can handle topological changes
  - X No connectivity/difficult to define normal vector/curvature
  - X Needs reseeding

Particle-Level Set Method

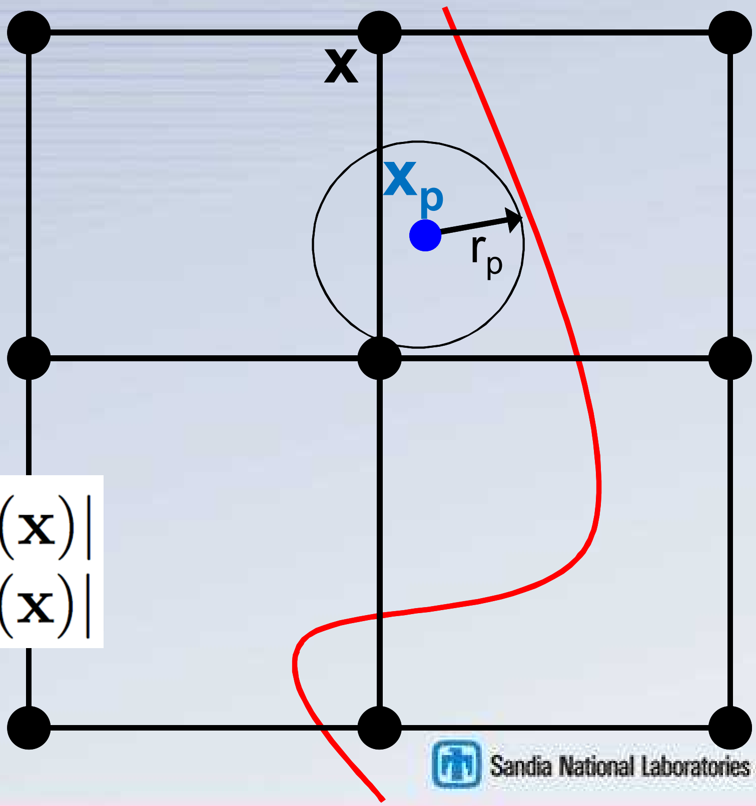
- Particles are placed near the interface and initialized with a sign and distance from the interface
- This information is used to update the level set field

$$\phi_p(\mathbf{x}) = s_p(r_p \pm |\mathbf{x} - \mathbf{x}_p|)$$

$$\phi^+(\mathbf{x}) = \max_{p \in E^+}(\phi_p, \phi)$$

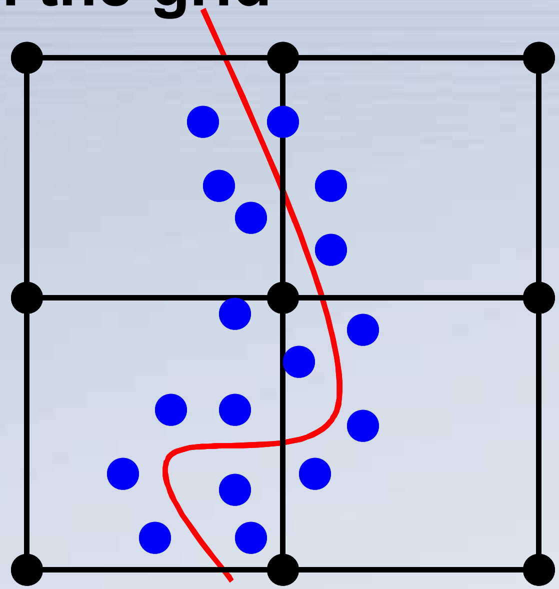
$$\phi^-(\mathbf{x}) = \min_{p \in E^-}(\phi_p, \phi).$$

$$\phi(\mathbf{x}) = \begin{cases} \phi^+(\mathbf{x}) & \text{if} \quad |\phi^+(\mathbf{x})| \leq |\phi^-(\mathbf{x})| \\ \phi^-(\mathbf{x}) & \text{if} \quad |\phi^+(\mathbf{x})| > |\phi^-(\mathbf{x})| \end{cases}$$

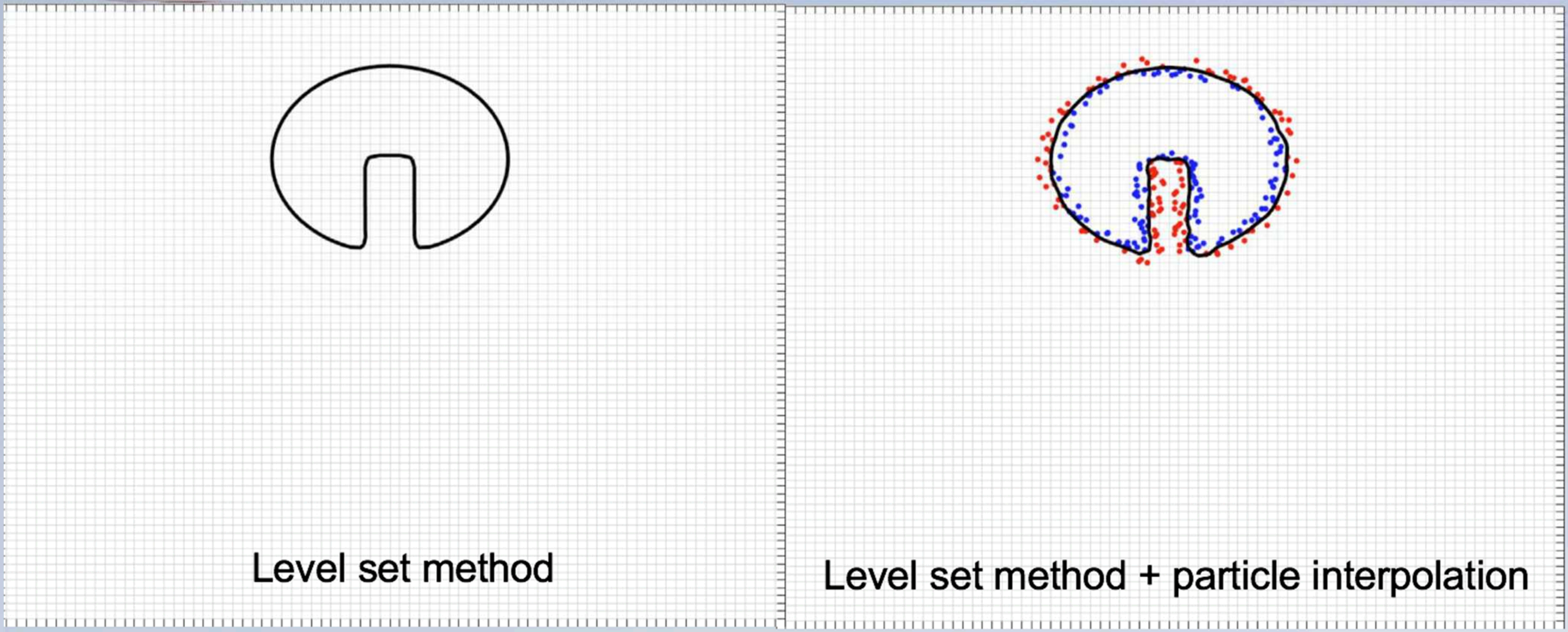


Interpolative Level Set Method

- Instead of using a min/max function to reset the level set field and only using escaped particles, we treat the particles as a refinement around the interface and use bilinear interpolation to update the 'coarse' level set field on the grid

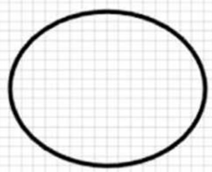


Rotating Zalesak's disk test

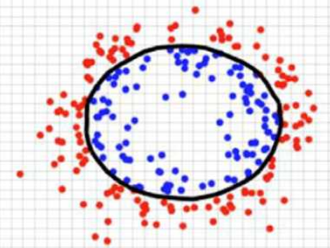


- Comparing numerical diffusion between traditional level set method and our particle interpolation correction procedure
  - Numerical diffusion is diminished

Particle level set method reduces the numerical diffusion of the level set method



Level set method

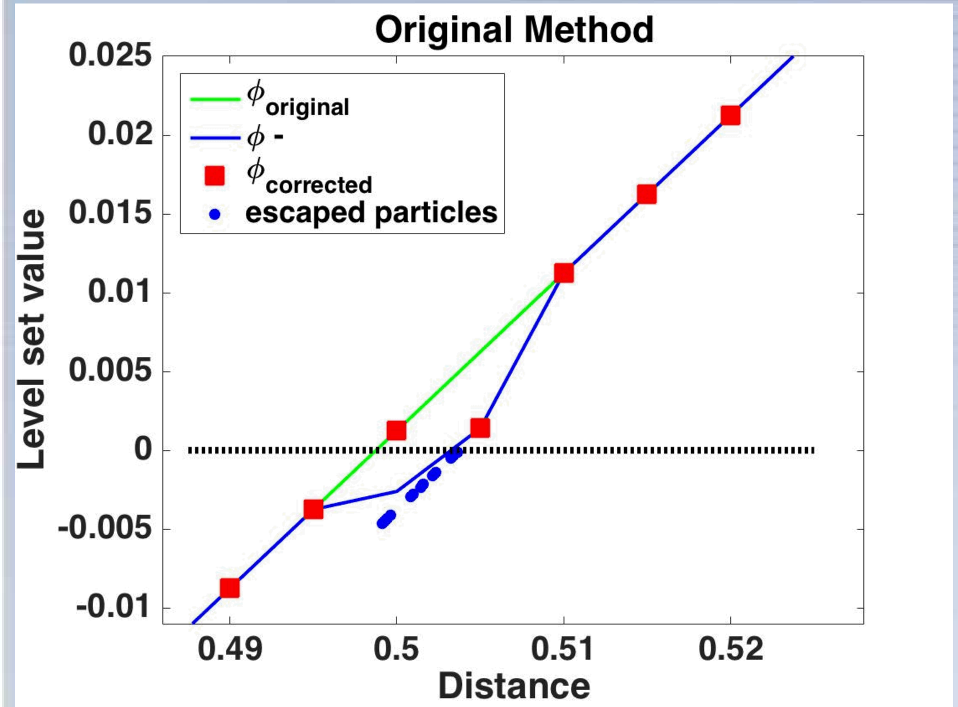


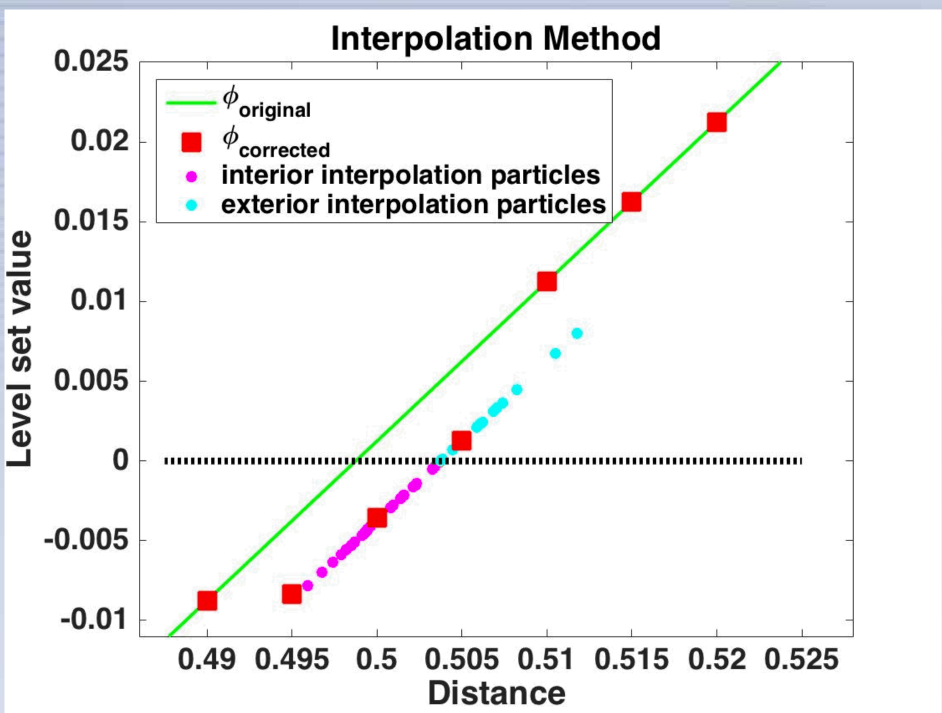
Level set method + interpolative particle correction

- PLS beats traditional level set method when tested on a single vortex problem
  - Limits numerical diffusion
  - Resolves thin filaments below the mesh scale

Particle Level Set Method Comparison

Particle Level Set (PLS) Method[1] versus Interpolative PLS[2]





[1] Enright, Fedkiw, Ferziger, Mitchell, "A hybrid particle level set method for improved interface capturing," J. Comp. Phys. (2002).

[2] Erickson, Morris, Poliakoff, Templeton, "An interpolative particle level set method," in preparation.

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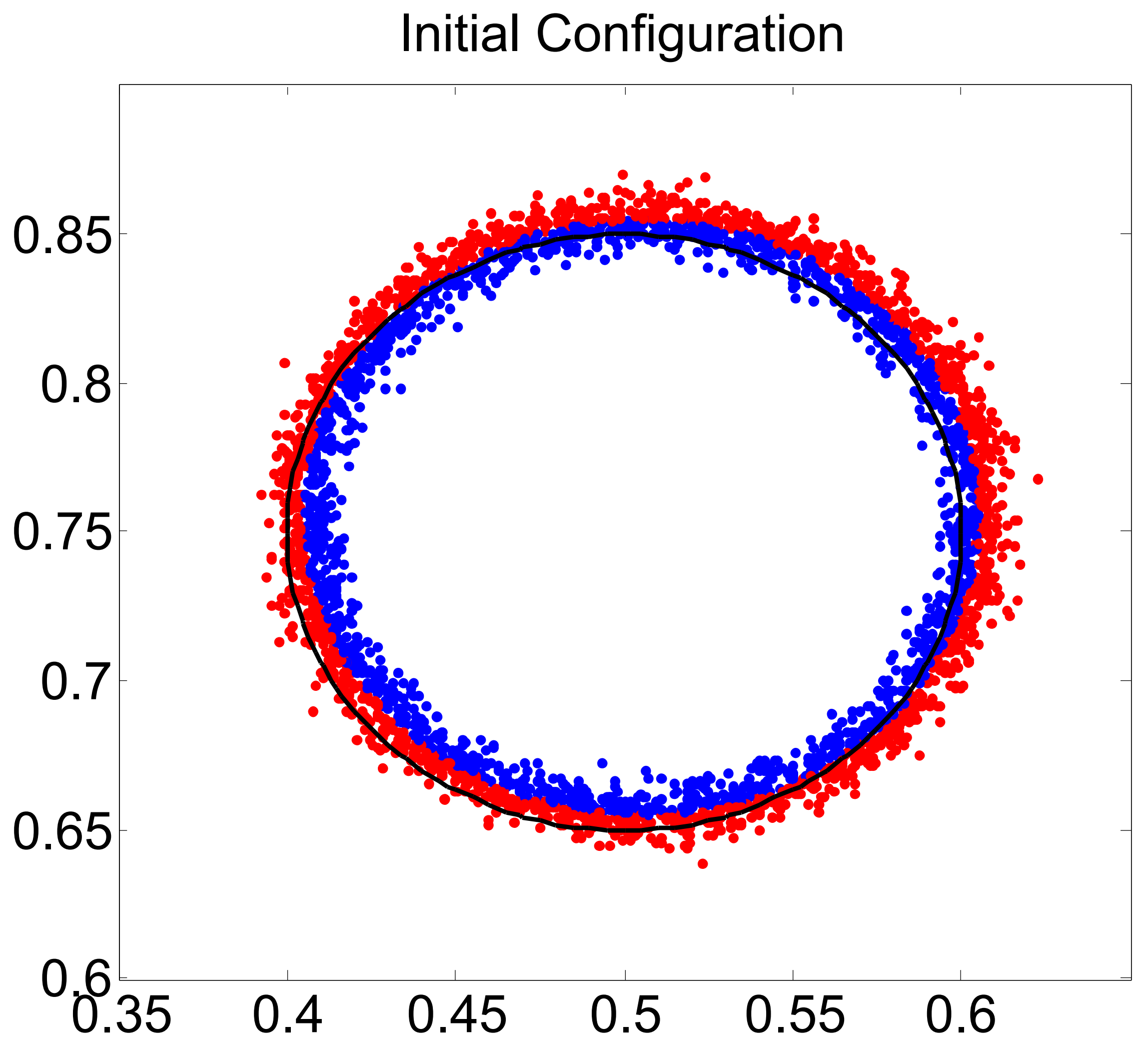
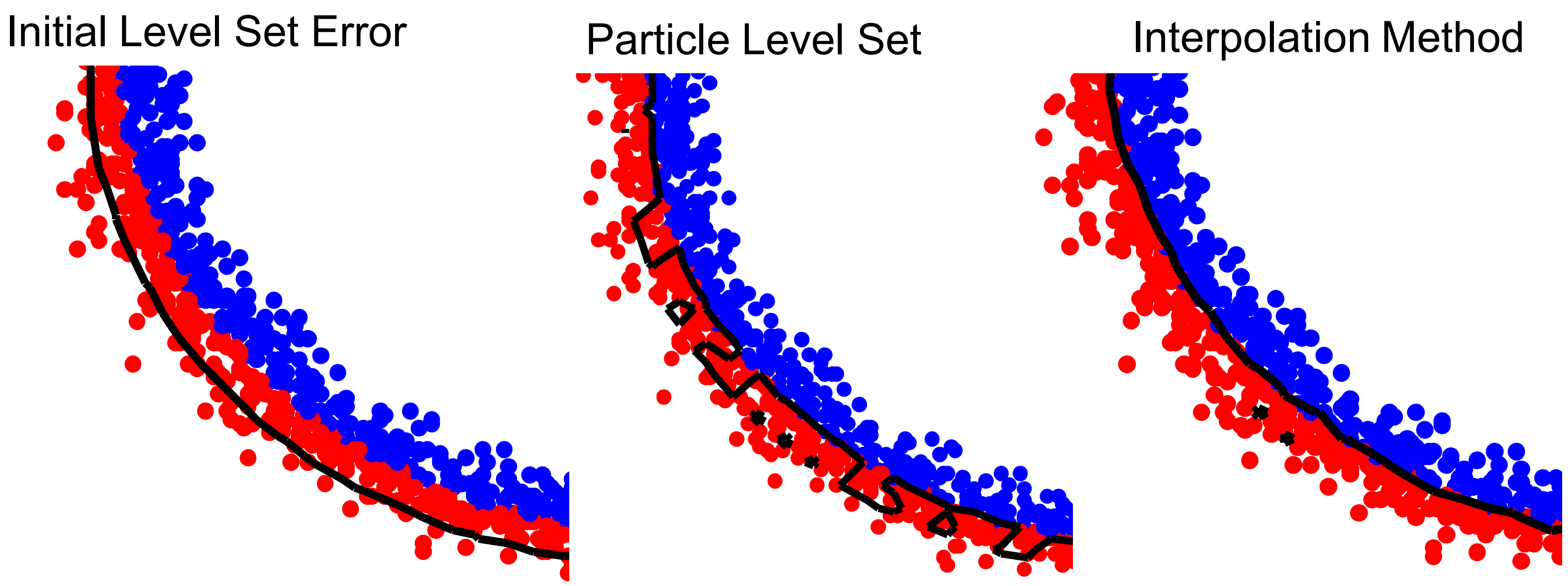
Shifted circle test



Interpolation improves PLS correction for 2D circle test



Conclusions and Future Work

- **Under certain conditions, interpolative PLS method can out-perform original PLS**
- **Developing particle level set method that can handle topological changes for melting metal applications**

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- S. Hieber, P. Koumoutsakos, A Lagrangian particle level set method, Journal of Computational Physics 210 (2005) 342–367.
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