CRKSPH - A Conservative Reproducing Kernel Smoothed Particle Hydrodynamics Scheme

N. Frontiere[†], **C. Raskin**[‡] **and M. Owen**[‡]

[†] Argonne National Laboratory (nfrontiere@gmail.com)
[‡] WPD Division, Lawrence Livermore National Laboratory (raskin1@llnl.gov, owen8@llnl.gov)

Keywords: shock hydrodynamics; Lagrangian methods; reproducing kernels; artificial viscosity.

ABSTRACT

Suitable modifications to the SPH interpolation scheme first suggested by [1] allow for the exact reproduction of constant, linear, or higher order fields, and these modifications are commonly referred to as reproducing kernel methods (RPKM). However, efforts in this realm have run into difficulties maintaining conservation of momentum when the kernel functions are no longer symmetric. We demonstrate a version of smoothed particle hydrodynamics that employs a first-order consistent smoothing function that exactly reproduces linear fields, building on RPKMs, while also maintaining momentum conservation. This scheme confers all of the benefits of traditional particle methods, such as Galilean invariance and natural conservation of momentum, while also eliminating some of their shortcomings, such as overly aggressive artificial viscosity and their inability to reproduce linear fields. We employ a simple fix to the momentum equation first derived for moving least-squares SPH methods [2] to our reproducing kernels that restores conservation. We also show how the reproducing kernel method's more accurate approximation of the velocity gradient allows for a much more conservative form of artificial viscosity, which hitherto fore has been a barrier to particle codes being employed for problems featuring fluid instabilities such as the Kelvin-Helmholtz instability.

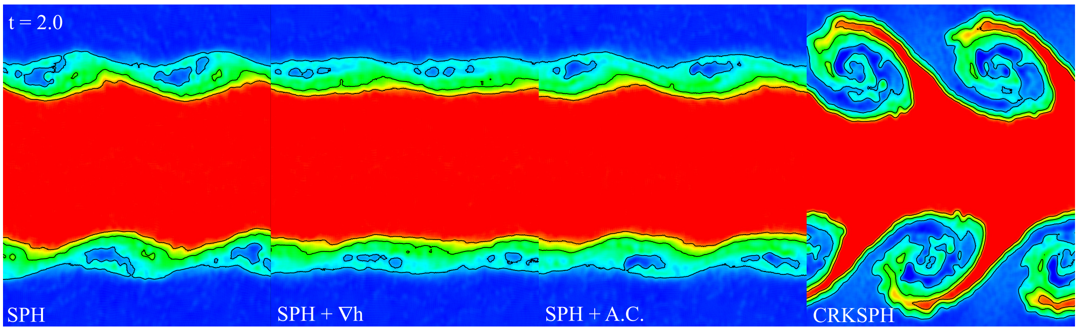

Figure 1: Snapshots at $t = 2.0 \approx 5\tau_{\mathrm{KH}}$ of the growth of a Kelvin-Helmholtz instability in density for (from left-to-right) traditional SPH, SPH with "grad-h" corrections, SPH with artificial conduction, and CRKSPH.

References

[1] Liu, W. K., Jun, S., and Zhang, Y. F., "Reproducing kernel particle methods", *International Journal for Numerical Methods in Fluids*, 20(8-9), pp. 1081-1106, 1995.

[2] Dilts, G. A., "Moving-least-squares-particle hydrodynamics?i. consistency and stability", *International Journal for Numerical Methods in Engineering*, 44(8), pp. 1115-1155, 1999.