Reactive High Speed Multi-Fluid Flows

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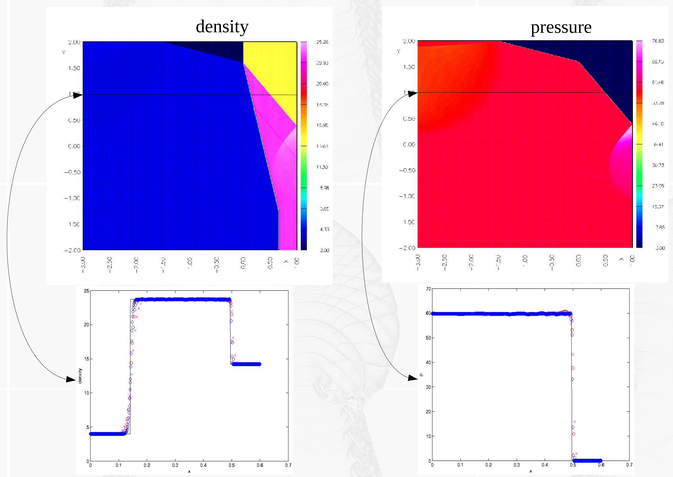
Previous work focused on the development of a shock capturing scheme for multi-fluid flows in the context of a conservative Godunov method. This new approach inherited the conservative properties of Godunov's method except in a small region around a material contact. In this region, however, the scheme was shown to converge to the weak solution upon grid refinement. Furthermore, the scheme lacks the oscillations known to occur in purely conservative codes. Here we investigate the practical implications of using such an approach. We demonstrate convergence of the scheme in two dimensions for a flow in which we have obtained an exact solution. Using an extension of the scheme to reactive flow, calculations are presented in which a high explosive is confined by some inert material. This work concentrates on "corner turning" problems with both strong and weak confinement.

Shock Polar Comparison

In 2-D we arrive at an analytic solution to the non-reactive equations by using the oblique shock jump conditions. The solution is the intersection of the shock polars

$$\frac{P_2}{P_1} = 1 + \frac{2\gamma\left(\frac{S^2\cos^2(\phi)}{a_1^2} - 1\right)}{\gamma+1}$$

$$\tan(\theta) = \frac{2\sin(\phi)\left(S^2\cos^2(\phi) - a_1^2\right)}{\cos(phi)\left(S^2\left(\gamma+1-2\cos^2(\phi)\right) + 2a_1^2\right)}$$



full 2-D solution followed by solutions along line y=1 with increasing grid resolution.

convergence in density

h	E_ρ	r_ρ
.05	$8.231071456711e-01$	
.025	$4.652779013680e-01$	0.8230
.0125	$2.668360698864e-01$	0.8021
.00625	$1.553819866403e-01$	0.7801
.003125	$9.099901439825e-02$	0.7719
.0015625	$5.414216492448e-02$	0.7491

convergence in pressure

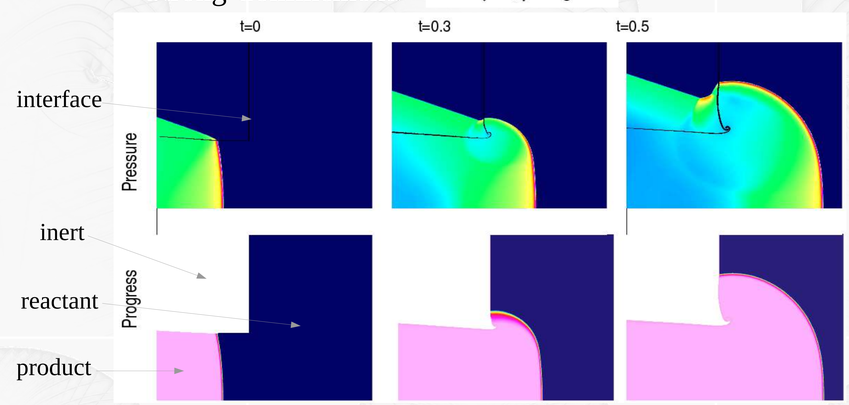
h	E_P	r_P
.05	$2.146445514332e+00$	
.025	$1.065371464067e+00$	1.0106
.0125	$5.379764676896e-01$	0.9857
.00625	$2.696416463840e-01$	0.9965
.003125	$1.347965157045e-01$	1.0003
.0015625	$6.777663957352e-02$	0.9919

Stable RXN Rate

Rate: $R=k(1-\lambda)^{1/2}\rho^n$, n=2 (stable)

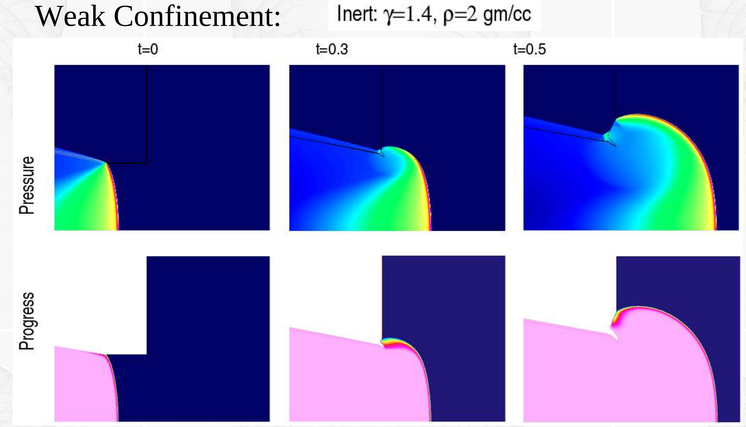
He: γ=3, ρ=2 gm/cc

Strong Confinement: Inert: γ=7, ρ=9 gm/cc



black line indicates material interface

Weak Confinement: Inert: γ=1.4, ρ=2 gm/cc



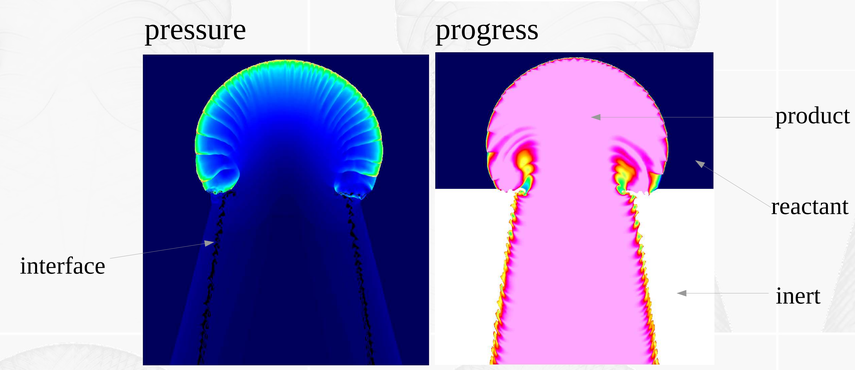
black line indicates material interface

Unstable RXN Rate

Rate: $R=k(1-\lambda)^{1/2}\rho^n$, n=3 (unstable)

He: γ=3, ρ=2 gm/cc

Weak Confinement: Inert: γ=1.4, ρ=1 gm/cc



black line indicates material interface

Summary and Future Work

Our continued study of this method indicates that solutions do indeed lack the spurious oscillations found upon application of the straight forward Godunov method. Not only have we proven convergence, but we have demonstrated convergence rates just as one would expect for a single component flow. Also the extension of the method to reactive flows compares well to results from the ghost fluid method. Our current aim is towards a reactive two component JWL EOS. Preliminary results are promising and a more detailed examination is under way.

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