

**Lawrence Livermore National Laboratory Project Work Statement
May 2003**

In the mixing of fuel with oxidants in SCRAMJET engine, the fuel jets are under impulsive acceleration by shock waves. The fuel mixing efficiency are enhanced by the stretching of the fuel-oxidants interface and the breakup of fuels into finer droplets. Inertial Confinement Fusion Program (ICF) uses high energy pulse source such as X-ray and laser to illuminate the target sphere in order to achieve auto fusion ignition on the National Ignition Facility. It is crucial to achieve a uniform compression of the target sphere as possible for maximum efficiency as the impulsively accelerated non-uniform sphere surface by a shock wave causes a non-uniform pressure profile over the sphere.

The source of this phenomenon known as Richtmyer-Meshkov Instability is related to the well-known fluid instability studied theoretically by Richtmyer and experimentally by Meshkov. The Richtmyer-Meshkov Instability (RMI) results from an impulsively accelerated interface of materials with different densities under perturbation. The baroclinic production of vorticity due to the cross product of the gradients of the pressure and the density generates spikes and bubbles as the shock interacted with the perturbed interface. It is important that the results of the Direct Numerical Simulation (DNS) be carefully analyzed quantitatively. As opposed to the Fourier analysis which required the resolution of all scales existed in the flow field, the Wavelet analysis through its local basis provides a quick and efficient mean to resolve only those large scale coherent structures and localized small scale turbulence eddies that deems important to a particular problem.

The students will learn the basic of the shock capturing numerical scheme for solving partial difference equations with discontinuous solution and wavelet such as the Harten's or Daubechies type wavelet that will be used to analyze the data from the simulations; and large scale parallel computing using Message Passing Interface (MPI) in the first few weeks. They will be asked to run the parallel shock capturing solver for a given perturbation of the interface, write a wavelet analysis program to analyze the energy cascade of the Richtmyer-Meshkov instability from the data with increasing resolutions, Mach number and others available options. The analysis program should be written in either Matlab or Fortran 90 language. The wavelet data analysis and tools will be the main tasks of the project that the students are supposed to be completed at the end of the program.

References:

For WENO:

G. S. Jiang and C.-W. Shu, Efficient Implementation of Weighted ENO Schemes, J. Comput. Phys, v126, 1996, pp202-228

For wavelets:

Article by Strang in SIAM Review 31 (1989) 613-627