NRL LASER FUSION PROGRAM

January - February 2003 **Bimonthly Highlights**

Analytical Solution to the Evolution of Rippled Shock Waves in Real Materials

Recent analytical studies at NRL have sought to gain a better understanding of the evolution of perturbations to shock waves propagating through materials with realistic equations of state. Using NRL's CALEOS database, two classes of problems were addressed: (1) isolated rippled shocks; and (2) rippled shocks launched from a moving piston with a slightly corrugated surface. For isolated shocks, it was found that at least two solution branches exist for initial disturbances localized near the front. Figure 1 shows examples of the two branches, which share the same late-time asymptotic behavior (oscillations decay in time as $t^{3/2}$), but differ in the degree of damping that the oscillations undergo at the outset. The less damped of the two solutions is denoted as "Branch #1" – a category that encompasses ideal gases. For shock strengths up to tens of megabars, the behavior in materials such as polystyrene (CH), aluminum (Al), and deuterium-tritium (DT) ice is accurately described by the more strongly damped solution known as "Branch #2." At higher pressures, though, the solutions in these three materials eventually transition to Branch #1. The threshold for this crossover is material dependent, and the physical significance of the bifurcated solution to this class of problems is presently unclear and requires further study to elucidate. As shown in Fig. 1, theoretical predictions agree well with results from purely-hydrodynamic FAST2D simulations. This new theory provides a useful series of test problems for benchmarking the performance of ICF and HEDP codes.

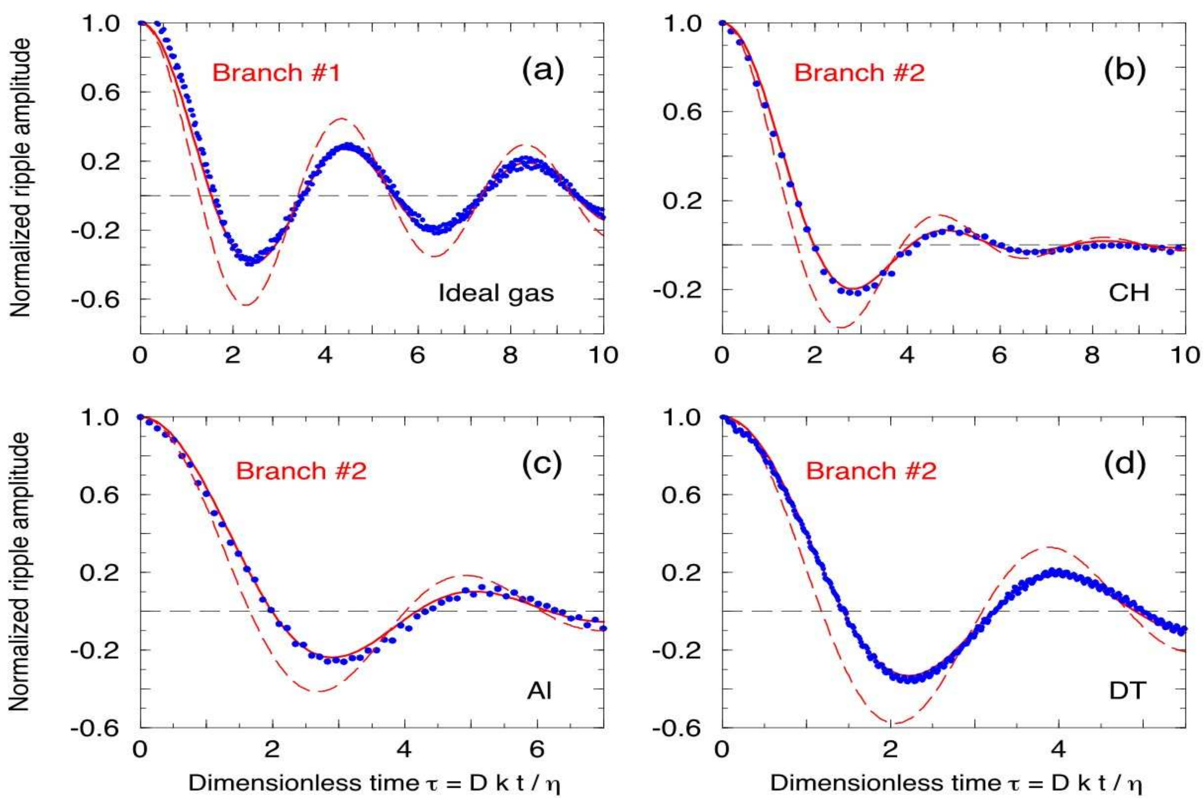

FIG. 1. Comparison of theoretical predictions (solid red lines) and FAST2D simulation results (blue dots) for the normalized ripple amplitude of a perturbed shock propagating through (a) an ideal gas with $\gamma = 5/3$, M=3; (b) polystyrene; (c) aluminum; and (d) deuterium-tritium ice. The unperturbed shock strengths in (b), (c), and (d) are 1, 5, and 0.5 Mbar, respectively. The independent variable is the dimensionless time $\tau = \boldsymbol{D\,k\,t\,/}\,\eta$, where $\boldsymbol{D}$ is the unperturbed shock speed, η is the compression ratio, and $\boldsymbol{k}$ is the wavenumber of the perturbation. The theoretical prediction for the evolution of a rippled shock driven by a corrugated piston (dashed red line) is also shown.