Analysis of weak and strong transverse-wave structures in gaseous detonations by large-scale simulation

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Direct numerical simulation of the governing thermo- and hydrodynamic equations provides a viable tool for improving the understanding of formation and development of transient triple point Mach reflection structures intrinsic to the propagation of gaseous detonation waves. Large-scale parallel numerical simulations in two and three space dimensions have been carried out for detailed hydrogen-oxygen chemistry that exhibit all experimentally observed types of reflection patterns. It is found that triple point shock polar analysis for a thermally perfect but non-reactive gas mixture is applicable to this problem class thereby enabling a reliable classification of the observed structures solely based on the triple point Mach number and the relative pressure difference across the transverse wave. While the Mach reflection pattern of a single triple point can switch between “weak” and “strong” type (aka transitional and double Mach reflection), particularly under varying flow conditions, computational evidence strongly suggests that triple points in the single Mach reflection regime always disappear.

Beside discussing and demonstrating the developed computational technique for carrying out accurate shock polar analysis for oscillating and evolving triple points, the components of the parallel detonation solver and recent scalability improvements of the underlying structured adaptive mesh refinement system will be sketched.