Numerical stability of level-set DSD with discontinuous velocities

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The Detonation Shock Dynamics (DSD) model can be used to predict detonation wave propagation in an explosive. The detonation wave evolves with a local velocity that is a function of the local wave curvature, in the direction normal to the wave surface. The level-set method is suitable for the purpose of DSD predictions as it has been shown to be practical and versatile in a range of scenarios. The level-set field is a function of time and space that defines the position of the detonation wave. The field evolves over time according to the Hamilton-Jacobi equation, where the time derivative of the field is proportional to its spatial derivative, with proportionality factor equal to the local detonation velocity.

The DSD model assumes the curvature varies relatively slowly compared with the width of the reaction zone following passage of the detonation wave. This condition cannot always be satisfied, leading to potential inaccuracy and instability in the numerical solution. A discontinuity in local detonation velocity, such as across a material interface comprised of two different explosives, results in a disparity in level-set field evolution speed. This work discusses the impact of these disparities on the numerical solution in the framework of a staggered grid modified-Euler scheme and demonstrates the types of instability that can arise. Suggestions are then made to help improve the numerical stability with trial solutions presented and discussed.