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Investigation of detonation propagation through an array of random discrete energy sources using the reactive Burgers' analog

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For a homogeneous reactive medium such as a combustible gaseous mixture, the detonation wave is nearly always observed to propagate at a velocity predicted by the Chapman-Jouguet (CJ) condition. Although the CJ condition was originally formulated for a wave propagating in homogeneous media at constant velocity, it has been posited that this condition may also determine the average detonation velocity in heterogeneous media. This work aims to test the applicability of the CJ condition to heterogeneous media on the one-dimensional reactive Burgers equation, a tractable analog to the reactive Euler equations, with the reaction governed by an Arrhenius rate law. In this study, heterogeneity is modeled using discrete energy sources, of random energy content, randomly distributed throughout space such that the total energy release is equivalent to that of a homogeneous medium with constant energy density. The equations are solved using a second-order finite volume approach with an exact Riemann solver. The evolution of the discrete detonation is tracked over a long duration and its average propagation velocity is computed. In all cases, the average detonation velocity was found to be in agreement with the velocity predicted by the CJ condition for the equivalent homogeneous system.

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