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Simulations of a Detonation Wave in Transverse Magnetic Fields[1]

LORD COLE, ANN KARAGOZIAN, University of California, Los Angeles, JEAN-LUC CAMBIER, Air Force Research Laboratory — Numerical simulations of magneto-hydrodynamic (MHD) effects on detonation wave structures are performed, with applications to flow control and MHD power extraction in Pulse Detonation Engines (PDE) and their design variations. In contrast to prior studies of MHD interactions in PDEs,[2] the effects of the finite relaxation length scale for ionization on the stability of the detonation wave are examined. Depending on the coupling parameters, the magnetic field can quench the detonation and effectively act as a barrier to its propagation. Conversely, an applied transient magnetic field can exert a force on a pre-ionized gas and accelerate it. The dynamics are subject to non-linear effects; a propagating transverse magnetic field will initially exert a small force if the gas has a low conductivity and the magnetic Reynolds number (Re_m) is low. Nevertheless, the gas accelerated by the "piston" action of the field can pre-heat the ambient gas and increase its conductivity. As the wave progresses, Re_m increases and the magnetic field becomes increasingly effective. The dynamics of this process are examined in detail with a high-order shock-capturing method and full kinetics of combustion and ionization. The complex chemical kinetics calculations are ported onto a GPU using the CUDA language, and computational performance is compared with standard CPU-based computations.

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[2]Cambier, et al., AIAA-2008-4688

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