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Theory of weakly nonlinear multidimensional detonations LUIZ FARIA, KAUST, MIT, ASLAN KASIMOV, KAUST, RODOLFO ROSALES, MIT

— We derive an asymptotic model for the dynamics of weakly nonlinear multi-dimensional detonations from the compressible reactive Navier-Stokes equations. It is assumed that activation energy is large, heat release is small, evolution is slow, and $\gamma - 1$ is small. The resultant model in 2D in dimensionless form is given by

$$\begin{aligned} u_t + uu_x + v_y &= -\frac{1}{2}T_x + \mu u_{xx} \\ v_x &= u_y \\ \lambda_x &= -k(1-\lambda)e^{\theta T} - d\lambda_{xx} \\ \kappa T_x + T &= u + q\lambda + qd\lambda_x. \end{aligned}$$

where u, v is the velocity field, T is the temperature, and $\lambda \in [0,1]$ is the reaction progress variable, q heat release, and μ, κ, d are coefficients of viscosity, heat conduction, and diffusion, respectively. This system is a generalization of the models of small disturbance unsteady transonic flow, weakly nonlinear acoustics (Zabolotskaya-Khokhlov (ZK) equation), and water waves (dispersionless Kadomtsev-Petviashvili (KP) equation). The model predicts regular and irregular multi-dimensional patterns, and in 1D exhibits transition from steady and stable traveling waves to oscillatory traveling waves through a Hopf bifurcation as θ is increased. Period-doubling bifurcations leading to chaos are also observed.

Aslan Kasimov
KAUST

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