



Combustion waves in periodically inhomogeneous media

Maryush Soroka^{1*}, Aslan Kasimov¹

*Lead presenter: maryush.soroka@skoltech.ru

¹ Skolkovo Institute of Science and Technology, Moscow

The problem of propagation of a one-dimensional combustion wave in a periodically inhomogeneous medium is considered. The problem is motivated by the phenomenon of regularization of detonation wave velocity oscillations discovered in recent studies on detonation in inhomogeneous mixtures [1]. It is known that both detonation waves [1], and slow combustion waves [2], propagating in homogeneous media have complex nonlinear dynamics. In this case, the wave velocity can oscillate regularly or chaotically depending on the mixture parameters (for example, activation energy). The question of the influence of periodic external conditions on such oscillations is of scientific and practical interest.

In this work, we study the phenomenon of regularization of the dynamics of a combustion wave as it moves in a periodically inhomogeneous medium. A model system of reaction-diffusion equations for dimensionless temperature T and fuel concentration C with Arrhenius kinetics of energy release is studied:

$$\begin{aligned}\frac{\partial T}{\partial t} &= \frac{\partial^2 T}{\partial x^2} + Ce^{-\frac{\beta(1-T)}{T}} - qT, \\ \frac{\partial C}{\partial t} &= \frac{1}{Le} \frac{\partial^2 C}{\partial x^2} - Ce^{-\frac{\beta(1-T)}{T}}.\end{aligned}\tag{1}$$

We investigate how spatial heterogeneity in the initial concentration of the fuel, $C(x, 0)$, as well as in the heat loss coefficient, $q = q(x)$, affects wave dynamics. Specifically, we consider cases where the initial concentration follows the profile $C(x, 0) = C_0 + \epsilon \sin(kx)$, or the heat loss coefficient varies as $q(x) = q_0 + \epsilon \sin(kx)$, with ϵ and k representing the amplitude and wave number of the perturbations, respectively. The influence of these parameters on combustion wave dynamics is analysed by numerically solving the system of equations (1) for different values of k , and determining the corresponding wave velocity for each case.

The analysis performed allowed us to detect the phenomena of regularization and mode locking of oscillations and the existence of synchronization regions at certain values of the wave number. The nature of the oscillations is seen to depend significantly on k .

References

- [1] A. R. Kasimov and A. Yu. Goldin. “Resonance and mode locking in gaseous detonation propagation in a periodically nonuniform medium”. In: *Shock Waves* 31.8 (Nov. 2021), pp. 841–849. ISSN: 1432-2153.
- [2] R. O. Weber et al. “Combustion Waves for Gases ($Le = 1$) and Solids ($Le \rightarrow \infty$)”. In: *Proceedings: Mathematical, Physical and Engineering Sciences* 453.1960 (1997), pp. 1105–1118. ISSN: 13645021. (Visited on 12/26/2023).