The comparison of Favre average procedure for the gaseous detonation from Eulerian and Lagrangian point of view

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The statistical approach for the detonation is very useful to analyze the results due to the fact that detonation waves have unsteady multidimensional structures. In the Favre average procedures proposed by Radulescu et al. (J. Fluid Mech. 2007) and Sow et al. (J. Fluid Mech. 2014), instantaneous 1D profiles were extracted from straight lines parallel to the propagation direction. However, the gaseous particle trajectories are not straight, as shown by Sow et al. (Proc. Combust. Inst. 2021). Therefore, the average procedure for the gaseous detonation from the Eulerian point of view needs to be assessed from the comparison with that from the Lagrangian point of view.

Two-dimensional numerical simulations with particle tracking method were then conducted. The massless particles are tracked to obtain the time and the distance along the trajectory from the leading shock passage. The mixtures were 70% Ar diluted stoichiometric H_2-O_2 mixture ($2H_2$-O_2-7Ar) and stoichiometric H_2-O_2 mixture ($2\ H_2$-O_2) in ambient conditions.

The dispersion of the particles downstream of the leading shock is promoted by jets, transverse waves, vortex motion and boundary layer, showing anisotropy. The surprising result is that the dispersion is more important in the direction parallel to the detonation propagation than in its transverse direction. Although slight differences among the mean profiles could be observed near the front from the Eulerian and Lagrangian averaging processes, the distribution of the chemical species was almost the same regardless of the instability of the mixtures tested. This means that the Favre average 1D procedure from the Eulerian point of view gives the mean structure of the gaseous detonation with a reasonable accuracy.