Reactive front propagation in turbulence

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The relation between the propagation velocity of a thin flame and the turbulence intensity of the ambient flow is largely debated in the literature, giving rise to various parametrisations (e.g. [1-5]). According to Damköhler's analysis [1], based on the Huygens propagation model, a flame front propagates with a constant normal velocity even when wrinkled by turbulence. However, experiments using exothermic combustion reactions deviate from this model. The analysis of these experiments is complicated by the intermingling of turbulent and thermal effects, limiting potential improvement of the flame propagation parameterisation.

To test and improve Damköhler's original theory, an autocatalytic chemical reaction is extensively studied experimentally and numerically. Analogous to a combustion reaction, it produces a thin reactive front separating the reactants from the products in an aqueous medium. Accordingly, it allows to quantify the specific influence of turbulence on the speed and shape of the front in the absence of thermal effects.

In our experimental set-up, turbulence is generated by a system of oscillating grids allowing to establish a homogeneous and isotropic turbulence in a closed water tank. Coupled measurements of PIV and LIF allow to follow, simultaneously, the velocity field and the propagation of the front.

Our experimental approach is complemented by numerical simulations solving the propagation of a reaction front in various imposed flows, using the Dedalus solver [6].

In this poster, the characterizations of the grid turbulence as well as the laminar propagation of the chemical reaction are discussed. First results of the reactive front's turbulent propagation are analyzed together with systematic numerical studies on a progressively complexified flow in 2D and 3D domains.

Références

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