Analysis of flame dynamics in a periodic porous medium with the Flame Transfer Function approach

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Due to their unique energy conversion mechanisms, Porous Media Burners (PMB) hold a promising potential for advancements in the field of combustion system design. While the steady behavior of PMB has been studied extensively both experimentally and numerically, the response to transient perturbations in the operating conditions has only been partially analyzed [1]. This work aims at studying the impact of velocity perturbations on flame dynamics in the framework of a simplified porous burner with periodic structure operating under laminar conditions, using pore-resolved numerical simulations. The description of the flame response is characterized by means of the Flame Transfer Function (FTF) approach [2, 3], and the flame is subjected to both tonal and broadband perturbations. An example FTF analysis for a broadband perturbation of the inlet velocity is shown in Fig. 1. Local fields of the FTF gain and phase are reconstructed using the Discrete Fourier Transform (DFT) for a given frequency of interest. Ultimately, the main goal and novelty of this work has been to apply the global and local FTF analysis of a flame immersed in a porous medium, and to explore the effect of intrinsic properties of the porous medium, such as its porosity and tortuosity, on the flame response.

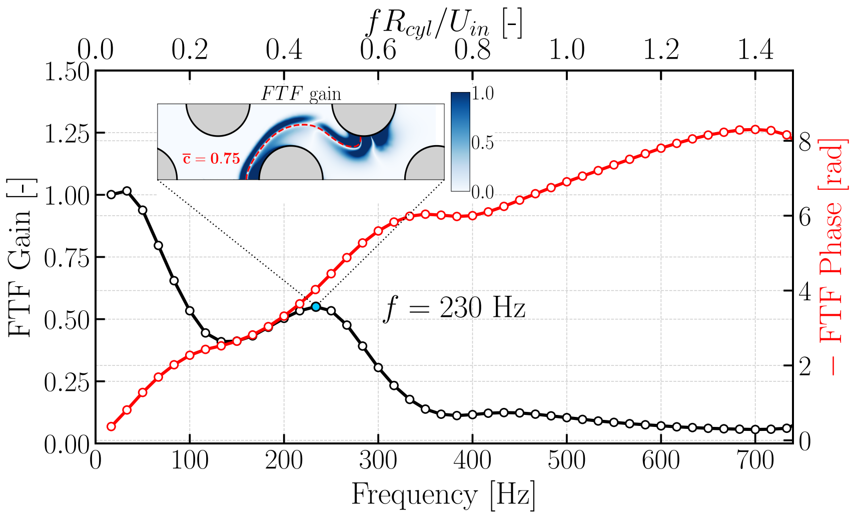

Figure 1: Numerical FTF gain and phase versus frequency for a broadband perturbation of inlet velocity. Local FTF gain $|FTF|$ is shown for $f = 230$ Hz, with $\bar{c}$ as the time-averaged iso-level of progress variable based on H_2O mass fraction.

References

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