Mutual synchronization of coupled oscillators of a thermoacoustic system

Samadhan A. Pawar, Akshay Seshadri, Vishnu R. Unni and R. I. Sujith
Department of Aerospace Engineering, Indian Institute of Technology Madras, Chennai.

Thermoacoustic instability is an important problem of the real combustion systems. Such instabilities arise mainly due to the positive feedback between the coupled processes viz. an acoustic field in the duct and the heat release rate fluctuations from the flame of a combustor. Here, we study the synchronization features of these coupled non-identical oscillators present in a bluff-body-stabilized turbulent flame combustor. We show that the onset of thermoacoustic instability is a phenomenon of mutual synchronization of these coupled oscillators. We demonstrate that the stable operation of the combustor corresponds to desynchronized aperiodic oscillations, which transitions to the unstable operation of phase synchronized (PS) periodic oscillations, upon an increase in the mean velocity of the flow. In between these states, we observe a state of intermittently phase synchronization (IPS), wherein the two oscillators are synchronized during the periodic epochs and desynchronized during the aperiodic epochs of their oscillations. Such transition of a thermoacoustic system culminates in a state of generalized synchronization (GS) after the state of PS. We notice a significant increase in the linear correlation between the pressure and heat release rate oscillations during the transition from PS to GS state. Our analysis shows that the time taken by vortices, shed from the inlet step, to reach the bluff-body play a dominant role in determining the dynamical behaviour of the thermoacoustic system.