TIFR Centre for Interdisciplinary Sciences
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Seminar

Intermittency as a precursor to self-sustained oscillations

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Unsteady combustion in a confined, compressible flow-field can lead to the spontaneous excitation of self-sustained periodic oscillations, provided the heat release rate fluctuations are in phase with the pressure fluctuations inside the confinement. These periodic oscillations termed 'combustion instability' or 'thermoacoustic instability' remain a major cause of concern in industrial applications as diverse as household burners which are used for cooking and heating, gas turbine engines used for propulsion and power generation, as well as rocket engines used for space exploration and defense applications. The research work of Dr. Vineeth Nair aims to identify the route through which combustion instability is established from stable operating conditions, when the underlying flow field inside the combustion chamber is turbulent. It was observed that combustion instability is presaged by an intermittent regime characterized by bursts of high-amplitude periodic oscillations that appear in a near random manner from a background of low-amplitude chaotic fluctuations. Since combustion instability is an undesirable state in combustors, early warning signals to an impending instability can be obtained by quantifying these intermittent states. Based on experimental insights, a mechanism was proposed which necessitates that when the underlying flow-field to be turbulent, the transition to combustion instability must happen via the intermittency route. A phenomenological model is introduced based on the mechanism that describes the onset of combustion instability as a lock-in between hydrodynamics and the acoustic field. The model qualitatively reproduces the intermittent behaviour observed in experiments and also provides early warning signals to an impending transition. It was also discovered that the transition to combustion instability results in a collapse of the number of relevant time scales in the problem, which leads to a loss of multifractality. This reduction in complexity can be quantified to act as yet another early warning signal to combustion instability.

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11:30 AM (Tea/Coffee at 11:15 AM)

Seminar Hall, TCIS