Day 4

Secondary Bifurcations and Explosive Synchronization in Turbulent Reacing Flow Systems

Invited Talk 17

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Abrupt transitions from a stable opera,on to oscillatory instability is a significant problem in engineering systems such as thermoacoustic systems. Earlier studies in turbulent combustors have reported that the onset of combus,on-driven oscilla,ons is always presaged by interminent bursts of high amplitude periodic oscilla,ons that appear in a near-random fashion amidst regions of aperiodic low-amplitude fluctua,ons. Intermi=ency leads to the appearance of a sigmoid-like transi,on to thermoacous,c instability in the root mean square (rms) of the acous,c pressure fluctuations. However, abrupt transitions via secondary bifurca,ons have been reported recently in turbulent thermoacousic systems. We present the observation of abrupt transition in three disparate turbulent thermoacoustic systems: an annular combustor, a swirl-stabilized combustor, and a preheated bluff-body stabilized combustor. Using a low-order stochas,c thermoacous,c model, we show that the reported abrupt transi,ons occur when an ini,ally stable, supercri,cal limit cycle becomes unstable, leading to a secondary bifurca,on to a large amplitude limit cycle. We show that the chao,c heat release rate fluctua,ons from turbulent flamelets synchronize explosively leading to an abrupt transition to a periodic state. Further, we discover that the nature of a transition evolves from continuous to discontinuous with a variation of an additional parameter of the system.