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Uncertainty Quantification of Non-linear Oscillation Triggering in a Multi-injector Liquid-propellant Rocket Combustion Chamber PAVEL POPOV, ATHANASIOS SIDERIS, WILLIAM SIRIGNANO, UC - Irvine, Dept. of Mechanical and Aerospace Engineering — We examine the non-linear dynamics of the transverse modes of combustion-driven acoustic instability in a liquid-propellant rocket engine. Triggering can occur, whereby small perturbations from mean conditions decay, while larger disturbances grow to a limit-cycle of amplitude that may compare to the mean pressure. For a deterministic perturbation, the system is also deterministic, computed by coupled finite-volume solvers at low computational cost for a single realization. The randomness of the triggering disturbance is captured by treating the injector flow rates, local pressure disturbances, and sudden acceleration of the entire combustion chamber as random variables. The combustor chamber with its many sub-fields resulting from many injector ports may be viewed as a multi-scale complex system wherein the developing acoustic oscillation is the emergent structure. Numerical simulation of the resulting stochastic PDE system is performed using the polynomial chaos expansion method. The overall probability of unstable growth is assessed in different regions of the parameter space. We address, in particular, the seven-injector, rectangular Purdue University experimental combustion chamber. In addition to the novel geometry, new features include disturbances caused by engine acceleration and unsteady thruster nozzle flow.

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