Blended Reduced Subspace Methods for Uncertainty Quantification of Unstable Stochastic Systems

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In the first part of this talk we give a brief overview of a recently developed order-reduction framework, the dynamically orthogonal field equations. We briefly go through their derivation and we discuss their connection to other UQ methods. We also present applications to 2D Navier-Stokes flows in setups that give rise to low-dimensional chaotic attractors and we provide a connection between the local geometry of the attractor and the energy exchanges that take place into the system. In the second part of the talk we will present some generic limitations of order-reduction methods for systems having intrinsic non-reducible features such as strong non-linear energy transfers, non-normal dynamics, and wide energy spectra. Based on these constraints we develop an inexpensive, statistically accurate, modified quasilinear Gaussian closure (MQG) for UQ of turbulent systems that takes explicitly into account the complete non-linear energy transfers and we illustrate its advantages in a turbulent system having a high dimensional attractor in strongly transient setups. If time permits we will discuss for the `marriage' of these two methodologies (i.e. order-reduction methods and second-order closures) which allows for the detailed stochastic modeling of specific subspaces within the high-dimensional attractor while it overcomes the limitations of order-reduction methods.