Large-Scale Shock Unsteadiness in Over-Expanded Nozzles
by
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Rocket nozzles can experience large side loads at engine start-up and in over-expanded conditions. Internal shock waves in the diverging portion of the nozzle oscillate and separate the turbulent boundary layer. Asymmetries in the shock location and the separated boundary layer downstream of the shock give rise to dangerous lateral forces. However, the unsteadiness of the shock also leads to the desirable enhancement of mixing in the exhaust plume. Therefore, developing tools and methods to accurately capture the unsteady shock and shear layer is of great importance for understanding and controlling such phenomena.

Results from a series of Large Eddy Simulations (LES) are presented which capture the unsteady behavior of the shock motion and compared to those of experiments with similar geometries [1,2]. A candidate mechanism for the large-scale shock unsteadiness is identified [3] and tested using the LES data and one-dimensional conservation laws. A reduced order model based on this mechanism captures the large scale/low frequency unsteadiness in the shock. Developing low-order models for these complex interactions will aid in the development and control of such high-speed devices.